INTERNATIONAL ENERGY AGENCY

Gadgets and Gigawatts

Policies for Energy Efficient Electronics

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Gadgets and Gigawatts

Policies for Energy Efficient Electronics

By 2010 there will be over 3.5 billion mobile phones subscribers, 2 billion TVs in use around the world and 1 billion personal computers. Electronic devices are a growing part of our lives and many of us can count between 20 and 30 separate items in our homes, from major items like televisions to a host of small gadgets. The communication and entertainment benefits these bring are not only going to people in wealthier nations – in Africa, for example, one in nine people now has a mobile phone. But as these electronic devices gain popularity, they account for a growing portion of household energy consumption.

How "smart" is this equipment from an energy efficiency perspective and should we be concerned about how much energy these gadgets use? What is the potential for energy savings?

This new book, *Gadgets and Gigawatts: Policies for Energy Efficient Electronics*, includes a global assessment of the changing pattern in residential electricity consumption over the past decade and an in-depth analysis of the role played by electronic equipment. It reviews the influence that government policies have had on creating markets for more energy efficient appliances and identifies new opportunities for creating smarter, more energy efficient homes. This book is essential reading for policy makers and others interested in improving the energy efficiency of our homes.

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

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- To operate a permanent information system on international oil markets.
- To provide data on other aspects of international energy markets.
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- To promote international collaboration on energy technology.
- To assist in the integration of environmental and energy policies, including relating to climate change.

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FOREWORD

Amid increasing concerns regarding energy security, economic development and climate change, the need to switch to more efficient energy-using technologies becomes urgent. Previous IEA studies have estimated that residential appliances accounted for 30% of electricity generated in OECD countries and predicted further growth in appliance energy use. Retrospective analysis has shown that policy measures implemented to improve energy efficiency in appliances over the past fifteen years have been extremely effective. As a result, governments and inter-governmental organisations everywhere are beginning to give energy efficiency the attention it deserves, and develop new policy initiatives in this field.

Residential electricity consumption continues to grow and at a rate faster than earlier predicted. If we are serious about the issues of climate change and energy security, we have to understand why household appliances are using more electricity than ever before, and whether this trend is likely to continue. We then need to find further ways to ensure this energy is consumed efficiently.

This IEA publication, *Gadgets and Gigawatts* shows that electronic devices have made a major contribution to the recent growth in total residential electricity use and will become one of the largest end-use categories in years to come. The digital age has brought huge innovations in the way we communicate and access information and entertainment services at home, but has also heralded a new area of energy consumption. As electronic devices such as flat screen televisions and monitors, computers, printers and set-top boxes have become more affordable, numbers have increased dramatically in almost all countries.

Whether this will drive increased energy consumption and greenhouse gas emissions critically depends upon the policies which countries put in place to stimulate the uptake of more energy efficient products. Already, most of the technologies exist to cut energy consumption in this area by as much as 50% but there are many barriers which inhibit their wide scale adoption.

To date, new markets have sprung up at such a speed that policy development processes in most countries have struggled to keep pace. Furthermore, the global nature of these markets and the degree of innovation in product design pose particular challenges for policy makers.

As a result, the publication of this book is extremely timely, providing an insight into the technologies, barriers and energy efficiency policies for the digital age.

Nobuo Tanaka
Executive Director
International Energy Agency

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EXECUTIVE SUMMARY

Market failures and policy or policies' successes

Switching to the best technologies available today would save at least 40% of residential electricity consumption in most appliance categories. Moreover, additional savings are possible from the commercialisation of technologies that are now under development.

This potential is made up of many millions of individual opportunities dispersed amongst consumers and end-use equipment. When these are aggregated, the extent of savings is large; however the energy and financial savings on individual residential appliances often appear insignificant to consumers. This is one example of the many different factors which inhibit the uptake of cost-effective energy efficiency within groups of consumers and suppliers. Some of these issues, such as a lack of information and principal-agent problems, constitute market failures; while others, including the prevalence of complex supply chains, lead to diluted market signals and the sub-optimal allocation of resources.

Governments have responded by implementing policies designed to achieve long-term market transformation in the supply and adoption of energy efficient appliances. A wide range of policy measures have been used, generally targeted at different market participants and designed to overcome particular barriers. Minimum energy performance standards and energy performance labels have been the most widely employed measures, frequently supported by government procurement policies, financial incentives such as discounts and rebates, and general awareness raising programmes.

The success of these highly targeted programmes is evident: the per unit energy consumption of many major household appliances has fallen dramatically over the past decade in most economies, while at the same time products have increased in size, capacity and power (see Figure 1). Appliance prices have also fallen in real terms, confirming that the correlation between appliance prices and energy performance is generally very low or even negative.

New threats

However, global residential electricity consumption is still growing in all regions as the number and size of the energy-using appliances in the average household increases. While consumption in non-OECD countries has grown at twice the rate compared to OECD countries, the OECD still accounts for 65% of total residential electricity consumption (see Figure 2).

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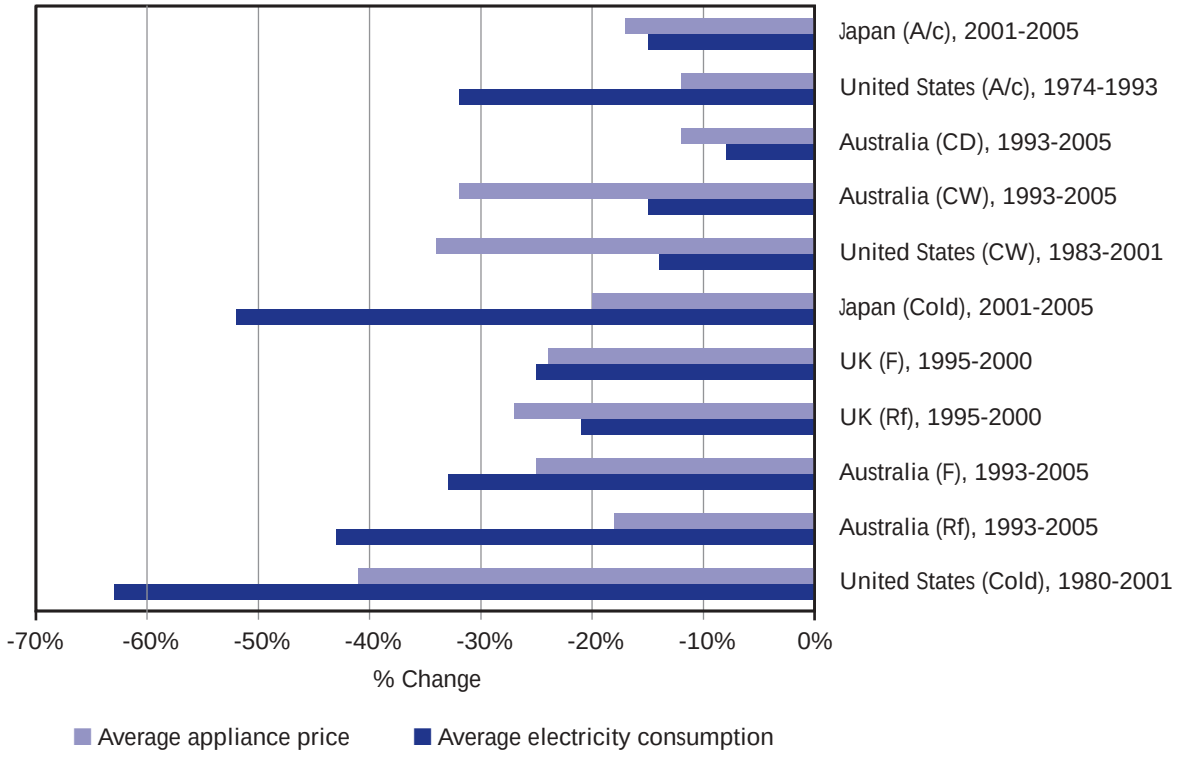
Figure 1 • Recorded fall in average electricity consumption and prices for several major appliance types in selected countries

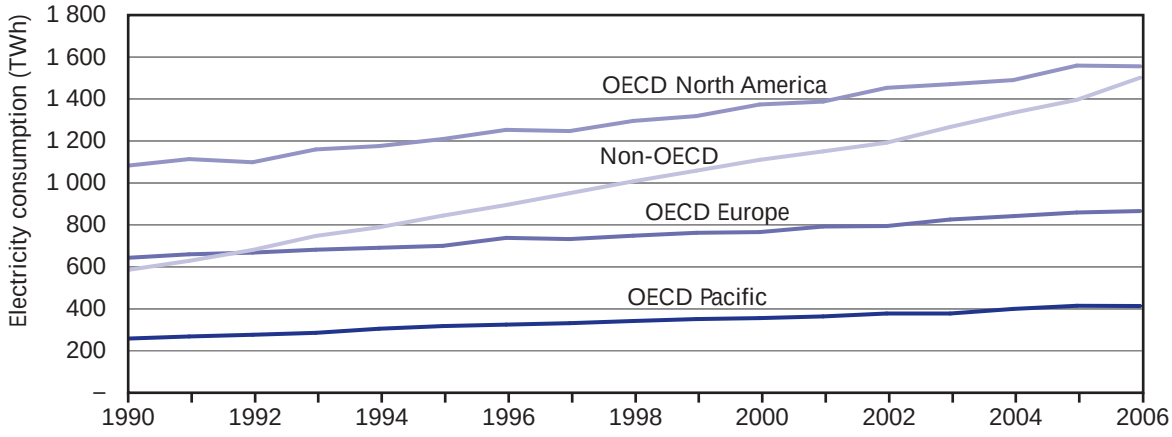


Source: IEA, 2007.

Key:

A/c	Air conditioners	Cold	Refrigerators and freezers	CD	Clothes dryers
F	Freezers	CW	Clothes washers	Rf	Refrigerators

Figure 2 • Residential electricity consumption by region, 1990-2006



Source: IEA statistics.

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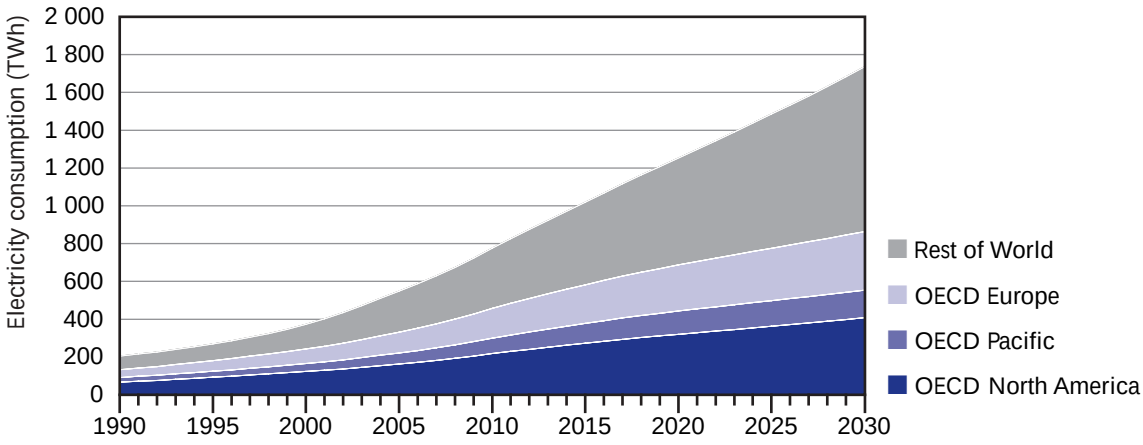
The way in which householders use electricity has also changed. In OECD countries those appliances which previously used the majority of electricity, such as refrigerators, clothes washers and water heaters, are close to saturation levels. As ownership rates have stabilised and the efficiency of these appliances improved (partly due to government policies), their share of residential electricity consumption has fallen. On the other hand, the ownership of air-conditioning and use of lighting equipment has increased in several regions.

In non-OECD countries, while the ownership level for major appliances is already high in urban areas, increased access to electricity in rural areas and growing urbanisation is driving up overall ownership levels and hence electricity consumption.

However, the growth of electricity consumption by small electrical and electronic devices has been the most rapid of all appliance categories over the past five years in both OECD and non-OECD countries. Quickly rising global ownership levels of information and communication technologies (ICT) and consumer electronics (CE) means that these products now account for approximately 15% of global residential electricity consumption. While efficiency improvements have been made, savings have been cancelled out by the demand for equipment which provides more functionality, or is larger or more powerful, and therefore uses more electricity.

Looking ahead, it is likely that ICT and CE equipment will take an even greater share of residential electricity consumption unless policy measures are introduced to increase energy efficiency. Under estimated market conditions, the IEA expects that energy use by these devices will double by 2022 and increase threefold by 2030 (see Figure 3). By the end of this period, global electricity use by household ICT and CE equipment could rise to 1 700 TWh, requiring the addition of approximately 280 GW of generating capacity. This level of consumption is equivalent to the current combined total residential electricity consumption of the United States and Japan, and would cost householders around the world USD 200 billion in electricity bills.

Figure 3 • Estimated electricity consumption by ICT and CE equipment in the residential sector, by region, 1990-2030



Source: IEA estimates.

Considered together with other areas of electricity growth in the sector, this scenario will lead to an increase in overall residential electricity consumption by most countries, posing a serious challenge

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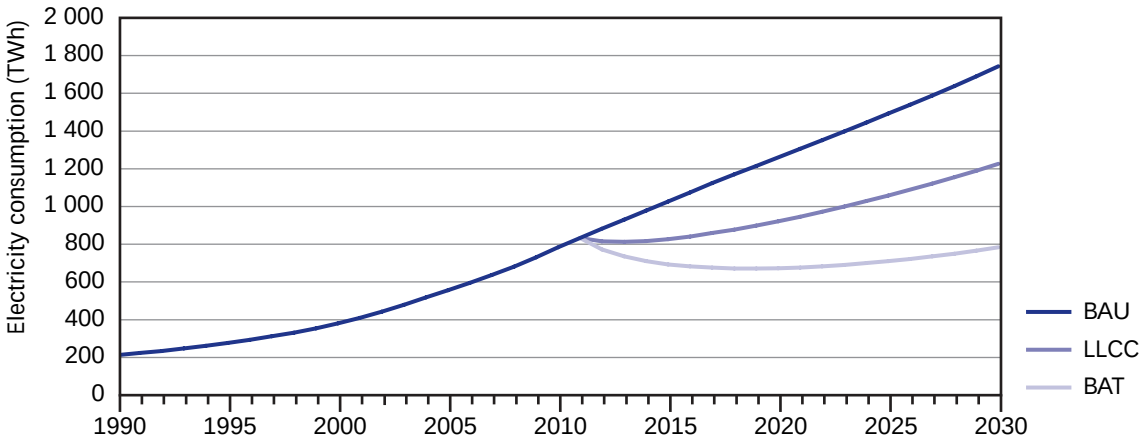
to all governments with policy ambitions to increase energy security and economic development, and to mitigate climate change. It suggests that in order to meet their policy objectives in these fields, governments will have to pay far closer attention to these new areas of electricity consumption or else implement policies to make rapid and deep cuts in other sectors. This situation demonstrates the need for energy efficiency policies to continually evolve and adapt to changes in markets, technological advancements and energy costs; and highlights the need for greater scrutiny of end-use trends so that governments are better able to make informed and timely policy decisions at a time when residential electricity consumption is undergoing rapid structural change.

An alternative future

Governments should take heart from the fact that alternative technologies exist now which could greatly reduce the impact of electronic equipment. As with many other categories of appliances, there is a large efficiency spread amongst products of similar price which perform equivalent tasks. In the few instances where clear market drivers for energy efficiency exist, such as with mobile devices where size, weight and extended battery life are valued features, the industry has demonstrated an ability to deliver large savings in energy consumption.

Figure 4 shows the potential impact on the business as usual (BaU) projection of switching to more efficient technologies which represent the least life-cycle cost (LLCC), and therefore impose no additional costs on consumers. The global adoption of LLCC technology would cut electricity consumption by an estimated 30% in 2030, compared to the business as usual scenario. Even more dramatically, by using the best currently available technologies (BAT),[1] electricity use could be cut by more than half, saving USD 130 billion in consumer electricity bills and avoiding the need for 260 GW of new generation capacity - more than the current generation capacity of Japan.

Figure 4 • Estimated electricity savings from adoption of least life-cycle cost (LLCC) and best available technologies (BAT)



Source: IEA estimates.

1. *BAT technologies and processes are not only currently available, but in many cases already have some penetration in commercial markets.*

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Understanding the problem and creating solutions

Governments have a range of policy tools available to help stimulate a sustainable market for more energy efficient technologies, many of which have already proven to be effective when fully implemented. New policies which internalise a carbon price will generally help to make energy efficiency more cost-effective, however they will not overcome the majority of specific barriers facing ICT and CE equipment. For example, motivated consumers still need to differentiate between the performance of products; and consumers that take equipment as part of a rental or service agreement will still have no say in the product's efficiency.

For governments to adequately respond to the new challenges posed by increasing residential electricity consumption, and particularly in the ICT and CE fields, they will need to build on the established infrastructure of existing programmes to deliver targeted policy measures. However, the current capacity of these schemes is already severely stretched.

Many programmes are already missing the opportunity to deliver 20% to 50% more savings due to poor attention to implementation. Designing good appliance policy initiatives and implementing them successfully requires on-going resources for (amongst other functions) data collection and analysis, for the protocols and infrastructure to test and publicise the performance of appliances, and for maintaining consumer confidence in the programme. Market surveillance needs to be undertaken as part of a comprehensive compliance regime, and programme requirements should be reviewed periodically to check that they keep pace with technological advances.

These detailed implementation issues demand constant vigilance because failure to address them can halve the level of savings achieved by policy measures. Even though appliance programmes have delivered significant quantities of energy and greenhouse gas savings at a lower cost compared to many other types of government programmes, there is evidence that they could achieve far more. Yet many national appliance programmes rely on low numbers of staff and small, fluctuating budgets which continue to impede their effectiveness.

For governments to expect energy efficiency programmes to extend to the delivery of new policies for ICT and CE equipment, while maintaining existing coverage, is unrealistic without a commensurate increase in the allocation of resources. Such expenditure would be fully justified because many of the same techniques which will save energy in ICT and CE equipment will also have application in other residential appliances, and other sectors of the economy.

Smarter electronics which match the energy used by appliances to the services demanded by the user can lead to large improvements in energy efficiency, particularly in the growing number of appliances connected in digital networks. Already many portable devices manage their energy consumption effectively and, with the implementation of some key policies, these same techniques would become more generally applied.

Key policy approaches

Long-term policy objectives

Governments should define long-term policy objectives for technology in the electronics field, setting performance targets for individual appliances categories and work with industry and other

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stakeholders to agree on implementation plans. This approach defines the desired outcome and therefore provides industry with the long-term view on which to base their business models. It allows all stakeholders the opportunity to agree on a range of activities which will be most effective in reaching government objectives.

Action by governments

Policy makers need to select combinations of measures which are best suited to achieve their policy objectives and overcome market barriers. For ICT and CE equipment, all layers of government can play a key role in establishing markets for high efficiency products by adopting strong procurement policies. Where principal-agent issues prevent investment in energy efficiency, governments can also include energy efficiency obligations within licensing agreements for third parties, such as TV service providers. These are some examples of the very direct actions that governments can take to stimulate a switch to a more energy efficient economy.

Horizontal policy approaches

One of the major challenges in establishing policies for ICT and CE equipment is the difficulty in closely defining individual devices as they vary functionality and new product categories enter the market. However, as further convergence occurs, products are increasingly defined by the functions that they perform, rather than by their product description. Policy measures should therefore attempt to be horizontal in nature and based on functionality, thereby spanning a cross-section of devices.

In practical terms, both mandatory and voluntary policy measures can incorporate this approach by establishing targets horizontally for common functions provided by any device. While the IEA has previously recommended this approach for standby power policies, it has application for all energy consuming activities, including times when devices are performing their primary function.

Power management

For ICT and CE equipment, the largest proportion of savings result from ensuring that products are able to modulate their power requirements according to the services they provide to users. All portable devices have very advanced power management processes which co-ordinate appropriate features within their hardware and software, demonstrating the technical feasibility of these systems.

Power management requirements, to ensure that electricity is not being consumed by functions not being used, are an example of policies that should be introduced horizontally for all new electronic appliances. Policies should specify that power management functions are fully automated so that input from consumers is not required for the device to work efficiently, and loaded as the default option within all products supplied. While consumers should be able to change power management settings, governments and industry might consider appropriate disincentives for disabling power management completely.

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Efficiency scaled to size

In the past, energy performance targets, thresholds or limits have included a scaling factor such that the energy which is allowed to be used by products is related to their capacity, size or volume. However, when this information is used as the basis for consumer information, consumers may infer that products with the same label rating, or which carry an endorsement label, consume similar quantities of electricity; which can be far from the truth. Policy measures would better reflect national policy objectives for energy and greenhouse gas reduction through re-structuring these thresholds so that larger or more powerful appliances are required to have higher, but attainable, efficiency levels.

International co-operation

Electronic devices are the most globally traded of all household appliances. Therefore international co-operation in the development of energy efficiency policies has many benefits that include the promotion of access to the best performing products, reduced compliance costs for product suppliers and the transfer of best practice in policy design and implementation.

Considerable progress has been made in recent years on the alignment of policies on ICT and CE equipment as a result of on-going dialogue between energy efficiency programme managers on test methodologies and future policy intentions. Further alignment is possible but will require governments to ensure that their strong support for harmonisation is reflected throughout the processes involved in standardisation and energy policy development.

Many further detailed policy options are outlined in this book that, if fully implemented will assist governments and industry to meet the challenges posed by mounting electricity consumption.[2] Many of the solutions lie in stimulating the potential within electronic appliances to be cleverer about the energy they, and all appliances, consume. To make this happen will require a scaling-up of government investment in the processes of policy development and implementation.

2. *Recommendations made in this publication are generally aimed at governments, their agents, energy efficiency programme managers and relevant industry stakeholders and cover policies for programme organisation and administration, as well as for particular appliance categories. As a result of new research undertaken for this publication it has been possible to extend the scope of recommendations beyond those previously made by the IEA. In particular, new recommendations have been added to the 25 provided to G8 leaders in 2008 (OECD/IEA, 2008b). The relevant sections of this publication reference both those included in the original 25 and additional recommendations supported by the latest analysis.*

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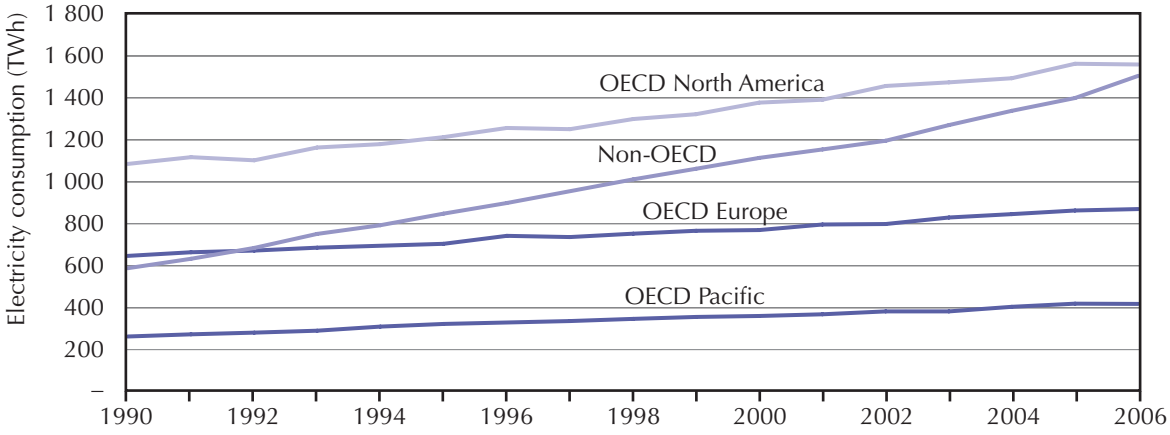
Chapter 1 • GLOBAL AND REGIONAL TRENDS IN RESIDENTIAL ELECTRICITY CONSUMPTION

Overall trends

Residential electricity consumption has been growing in all regions of the world at an average of 3.4% per annum since 1990, as shown in Figure 5 and Table 1. While total non-OECD and per capita consumption has increased at approximately twice the rate of OECD countries, the OECD still accounts for over 65% of total residential electricity consumption.

Some of this growth is a result of more people with access to electricity; however the majority is caused by the increased consumption of electricity by individual households.

Figure 5 • Rates of change of total residential electricity consumption, 1990-2006



Source: IEA statistics.

Table 1 • Rates of change of total and per capita electricity consumption

Region	Annual growth in total electricity consumption (1990-2006)	Annual growth in electricity consumption per capita (1995-2005)
OECD Europe	1.9%	1.4%
OECD Pacific	3.1%	2.6%
OECD North America	2.3%	1.0%
Non-OECD	6.1%	4.5%
World total	3.4%	2.0%

Source: IEA statistics.

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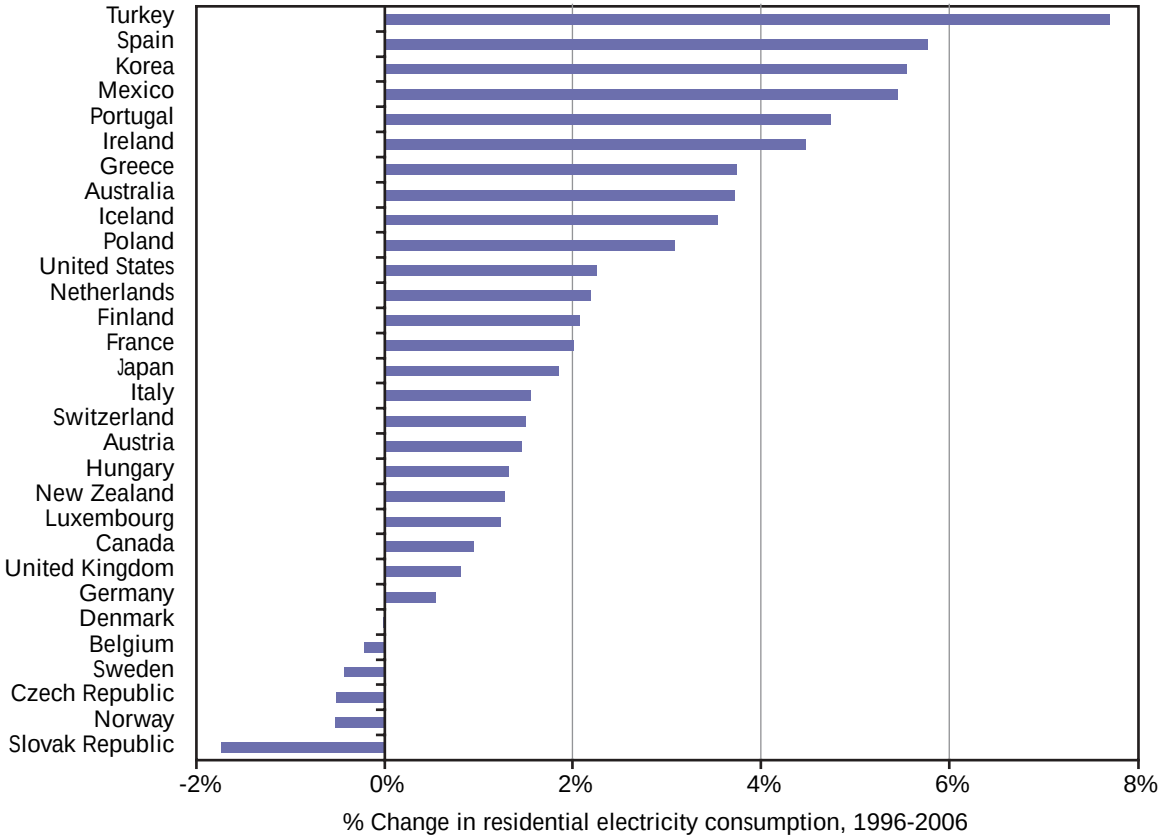
There is also considerable variation by individual countries within the OECD, with Turkey, Korea, Spain and Mexico experiencing particularly high growth rates of 5% to 8% per annum between 1996 and 2006. On the other hand, countries with zero or negative growth over this period include Denmark, Sweden, Norway, Czech Republic and the Slovak Republic (see Figure 6).

Figure 6 • Average annual change in electricity consumption amongst OECD countries, 1996-2006



Source: IEA statistics.

Household electricity consumption per capita has increased by an average of 2% per annum in the decade between 1996 and 2006 (see Figure 7). As noted previously, population increases have played a small role in driving up electricity consumption, although it has been more influential in non-OECD countries. Outside the OECD, household access to electricity has increased steadily over recent years. Between 1990 and 2005 the number of people without electricity fell by 400 million to 1.6 billion, and it is estimated to decline further to 1.4 billion people by 2030 under current policies (OECD/IEA, 2006a).

The differences between per capita electricity consumption shown in Figure 7 are partially due to climate and the availability of different fuels and technologies in each country. For example, there are clearly considerable differences between the demand for space heating, space cooling and lighting as a result of climate. Then, amongst countries which require space heating, the share of this demand that is met by electric appliances will also vary, as shown in Figure 8 (OECD/IEA, 2008a). There are also large differences in the penetration of electric cooking appliances by region, although the use of microwave ovens has increased rapidly in most areas.

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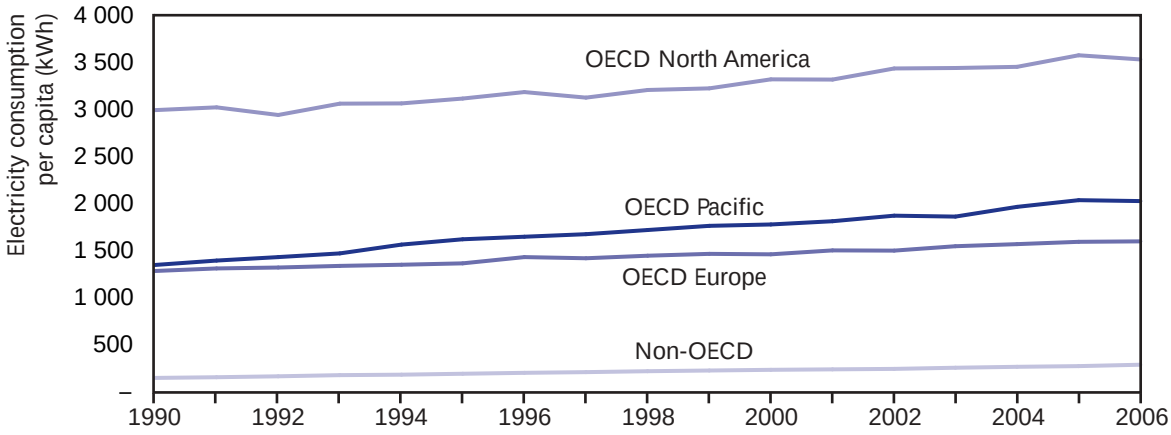
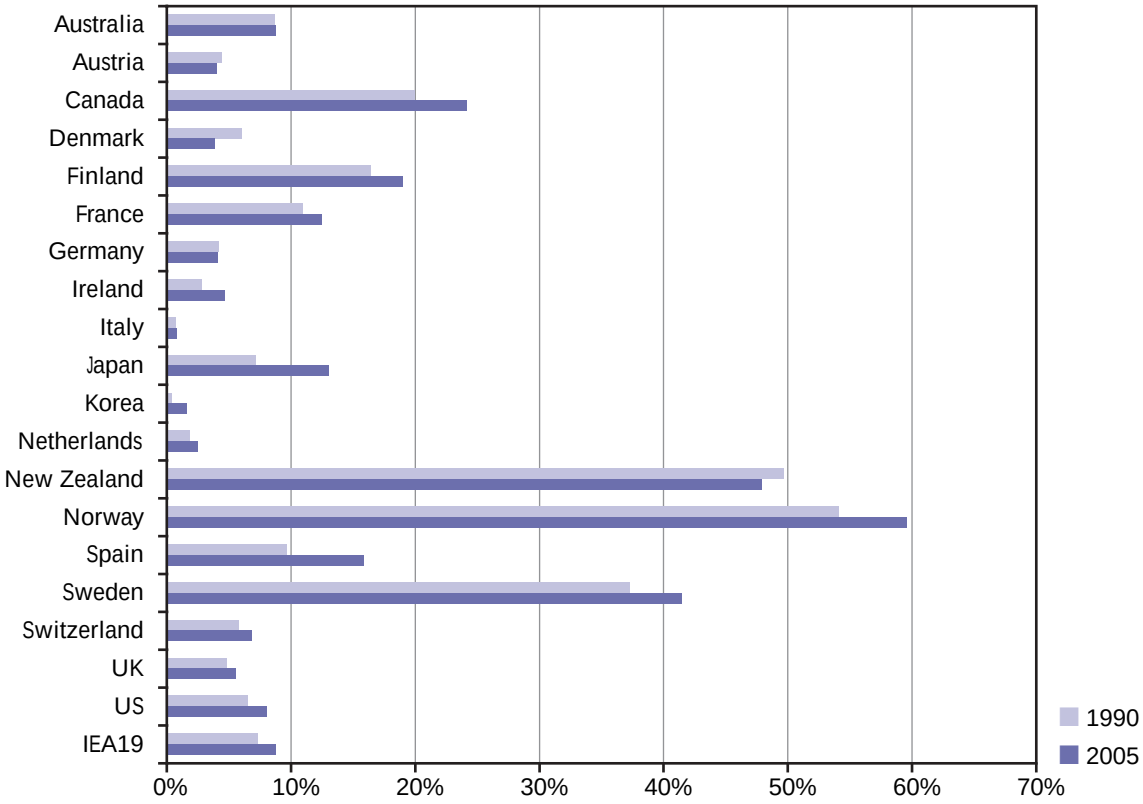
Figure 7 • Residential electricity consumption per capita, 1996-2006



Source: IEA statistics.

Figure 8 • Shares of space heating demand supplied by electrical appliances, IEA19, 1990 and 2005



Source: IEA Indicators Database.

Space cooling is another end-use which is strongly linked to geographical location and climate, but has seen increased usage as a result of growing affluence, falling costs and technology improvements. In some countries with relatively cool climates, reverse-cycle air-conditioners have become increasingly popular as a source of space heating, however their presence often leads households to take advantage of the space cooling facility where previously they did without.

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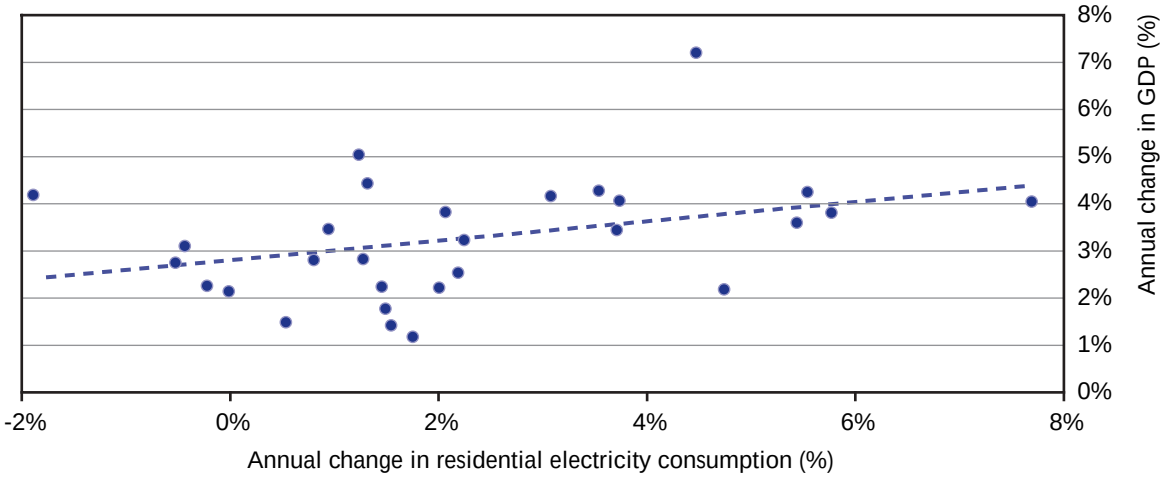
De-linking economic growth and residential electricity use

Economic growth which leads to increased household income can be another factor which can explain regional differences in residential energy consumption. This linkage can be explained by several factors, including the building of larger houses, the uptake of more space conditioning to improve comfort levels and the purchase of more energy consuming appliances associated with more affluent lifestyles. Taking the gross domestic product (GDP) as an indicator of household incomes, there appears to be only an extremely weak correlation between rates of change in residential electricity consumption and GDP for OECD countries between 1996 and 2006. As shown in Figure 9, national variations in electricity consumption trends do not consistently follow changes in GDP amongst OECD countries.

Figure 9 • Rates of change of electricity consumption and GDP for OECD countries, 1996-2006



Source: IEA statistics.

Comparing the major regions in the world over the past decade, GDP rose faster than residential electricity consumption in North America and Europe, while in the Pacific OECD and non-OECD countries there is less evidence of this decoupling. It is particularly noticeable that electricity consumption in the Pacific OECD region expanded at double the rate of GDP growth (see Figure 10). This analysis suggests that economic growth cannot be automatically assumed to provide the only, or even major, explanation for changes in residential electricity consumption.

Comparison of trends with earlier projections

In 2003, the IEA published Cool Appliances, an examination of electricity consumption by residential appliances in IEA countries, policies to promote increased energy efficiency and estimates for potential additional savings of energy and greenhouse gases. Based on a purpose-built bottom-up model, the book included estimates for appliance electricity consumption by

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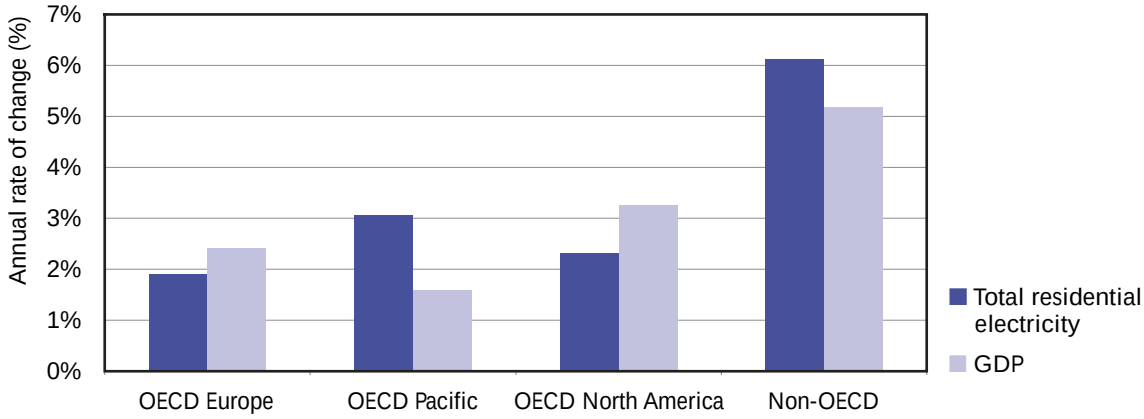
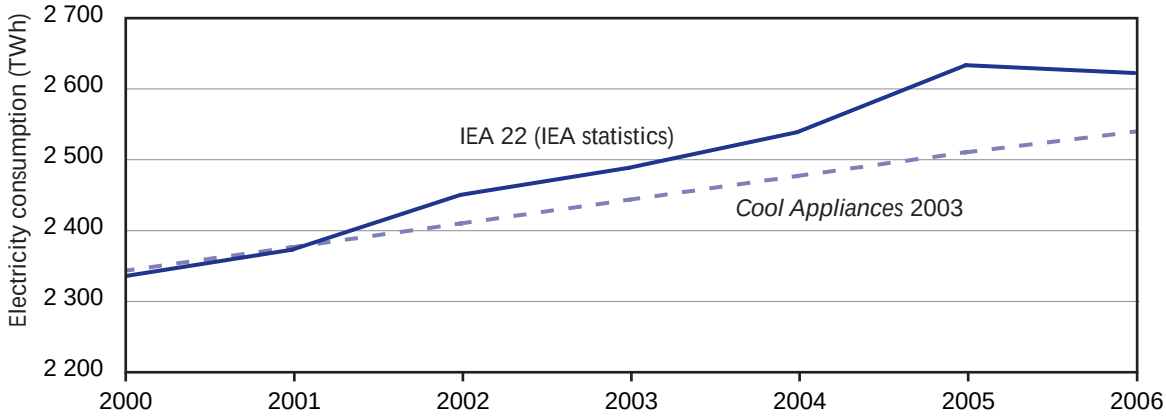
Figure 10 • Rates of change of electricity consumption and GDP for OECD regions and non-OECD, 1996-2006



Source: IEA statistics.

22 IEA countries to 2030.[1] After the impact of policy measures already implemented at the time of publication, it was estimated that residential electricity consumption would grow by 1.3% per annum between 2001 and 2006 to approximately 2 540 TWh. However, actual electricity consumption by these 22 countries grew by 2.3% per annum and exceeded the projection by over 80 TWh in 2006, or approximately 3.3% (see Figure 11).

Figure 11 • Comparison between Cool Appliance projection and actual residential electricity consumption, 2000-2006



Source: IEA statistics and *Cool Appliances* (OECD/IEA 2003).

Also noticeable in Figure 11: is a large rise in consumption in 2005, which is mainly due to the reported increase in electricity consumption in Japan. This has not been maintained in 2006, re-establishing the general trend of a steady divergence between actual consumption

1. *The following countries were included in this analysis: Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States.*

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and the projection made in *Cool Appliances* since 2001 (the date of the last official statistics used in this publication).

Forecasting energy demand is never easy and often inaccurate, however to understand the drivers for increased electricity consumption and the potential reason for the divergence, the following section explores electricity consumption by major end-use categories for countries where this detailed trend data is available.

Trends in electricity consumption by end-use category

Many countries estimate energy consumption at the level of end-use applications or major appliance types, usually based on bottom-up modelling. This is often done sporadically and countries model consumption in different degrees of detail. Where this information is collected and made available over a period of time, it provides a useful means of determining shifts in energy consumption patterns, caused by factors such as changing user behaviour and rates of technology ownership. Although there are always many elements which contribute to such trends, monitoring energy consumption by end-use category is also a useful tool in examining the impact of energy efficiency policies.

While it is not possible to make an exact comparison between countries due to differences in end-use categories and time-series, nevertheless the following section shows electricity consumption trends by end-use category for many major economies, and allows some general conclusions to be drawn. It should be noted that the change in absolute electricity consumption has a direct impact on national consumption trends, but the percentage change is also an important indicator. For example, a category with a low level of absolute electricity consumption but with a high growth rate will not have a large impact immediately, but could be increasingly important in the future.

In the United States, while energy consumption by many of the traditional appliances has only increased slightly or decreased, the major growth areas are in lighting, space cooling and various information and communication technologies (ICT) and consumer electronics (CE) (see Figure 12).

Although data isn't available at such a disaggregated level for Canada, there has been a similar transition where the traditional appliances, such as refrigerators, have taken a lower share of total electricity consumption compared to the sundry small appliances (see Figure 13).

This trend is highlighted in data from the United Kingdom which shows the dramatic rise in electricity consumption from the increased penetration of ICT and CE equipment (see Figure 14).

Japan has experienced growth in electricity consumption in most major end-use categories, although there was a small decline in cooling consumption in the period 1995 to 2005. General appliances, space heating, hot water and cooking have all increased, and although appliances have grown less quickly than other areas, the overall contribution by the appliance sector is the largest by a considerable margin.

In Australia, space cooling and lighting have both increased, although it is the appliance category, excluding refrigerators and freezers, which has contributed most to electricity growth in the past

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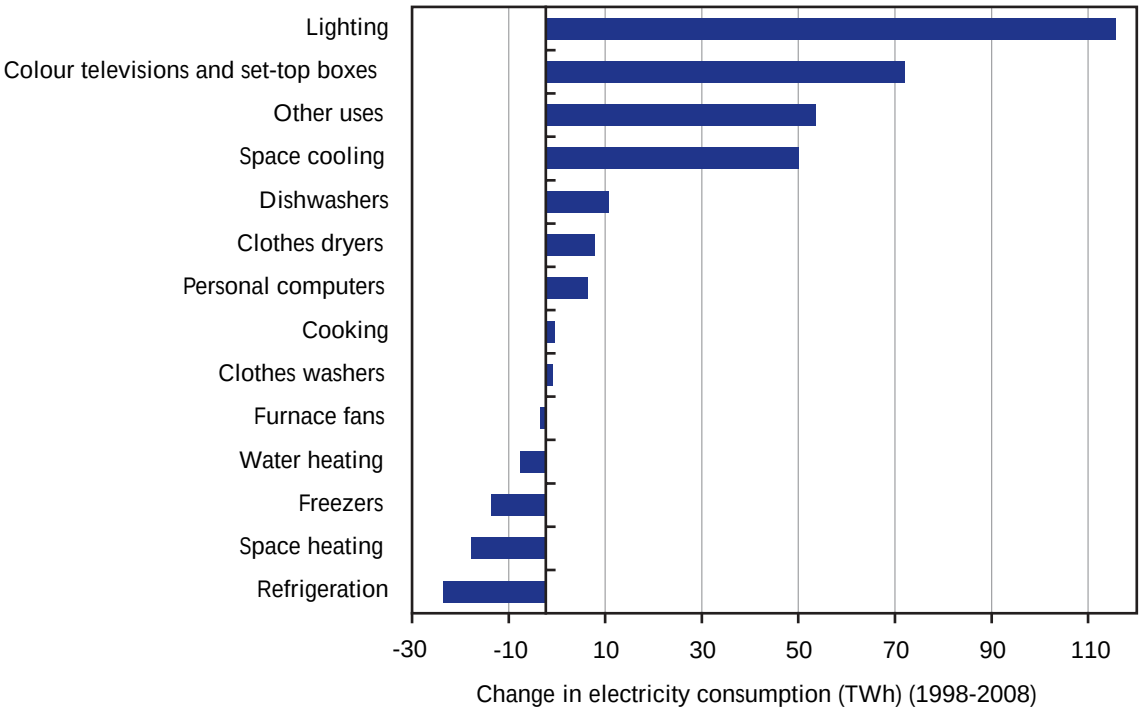
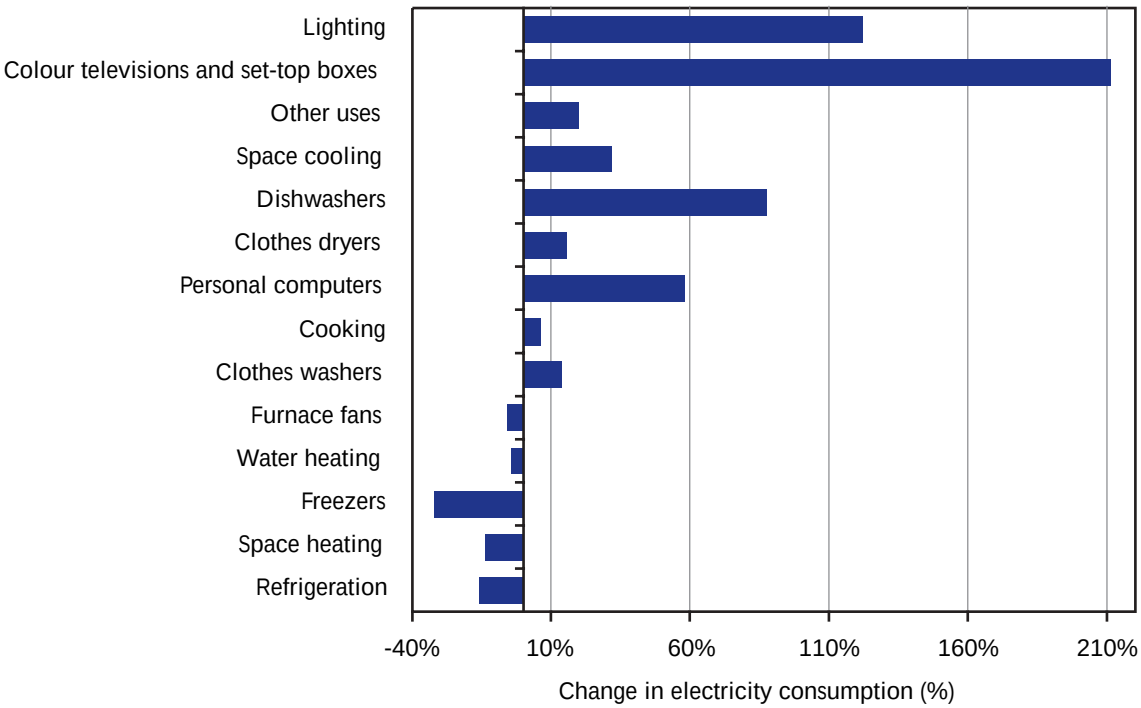
Figure 12 • Change in electricity consumption and % change by end-use category, United States, 1998-2008





Source: EIA, 2000, 2008.

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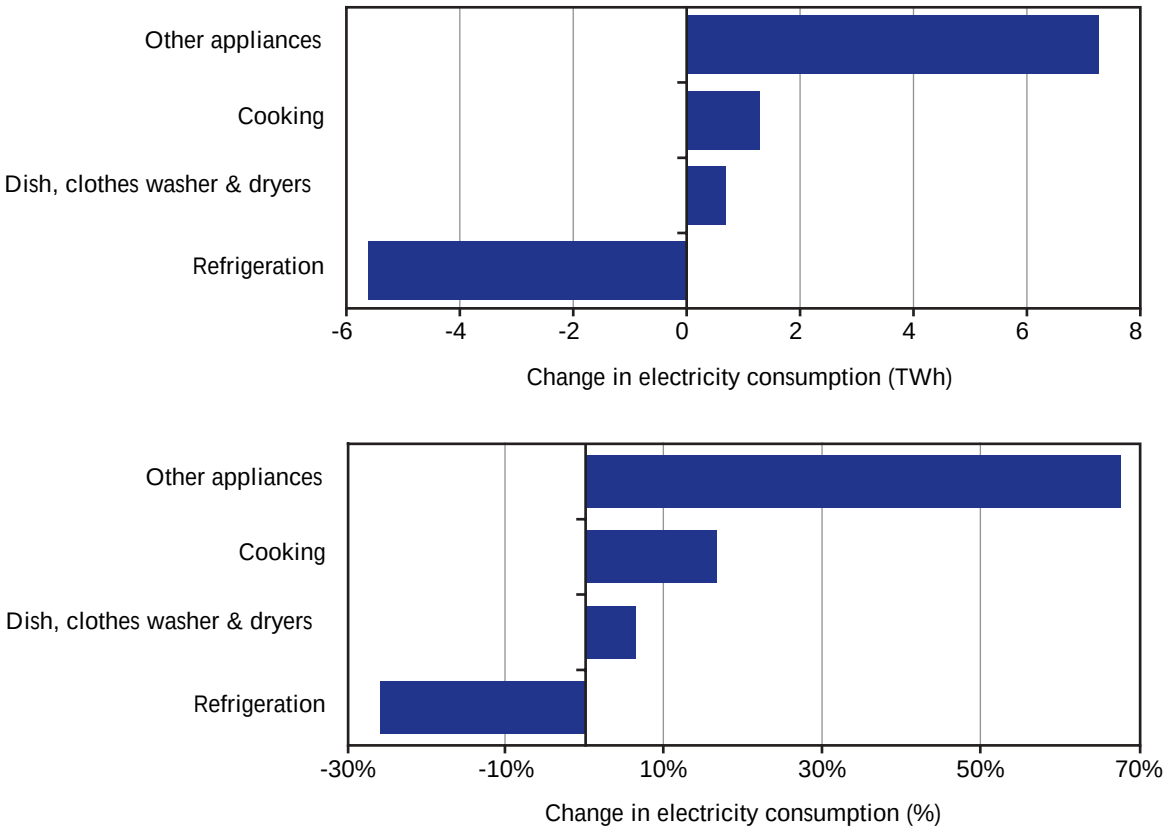
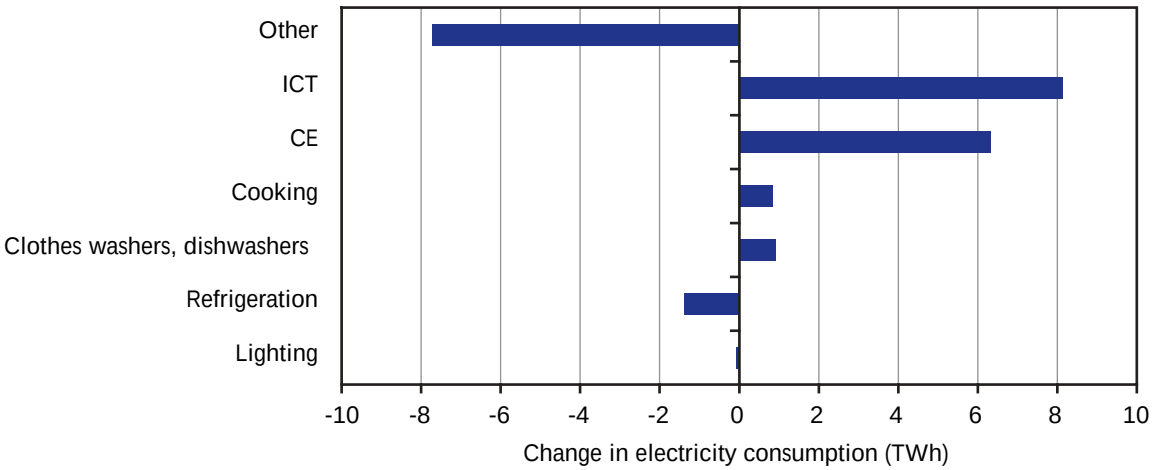
Figure 13 • *Change in electricity consumption and % change by end-use category, Canada, 1995-2005*



Source: NRCan, 2006.

Figure 14 • *Change in electricity consumption by end-use category, United Kingdom, 1998-2006*



Source: MTP, 2008. Note: Other category includes water heating, space heating and miscellaneous.

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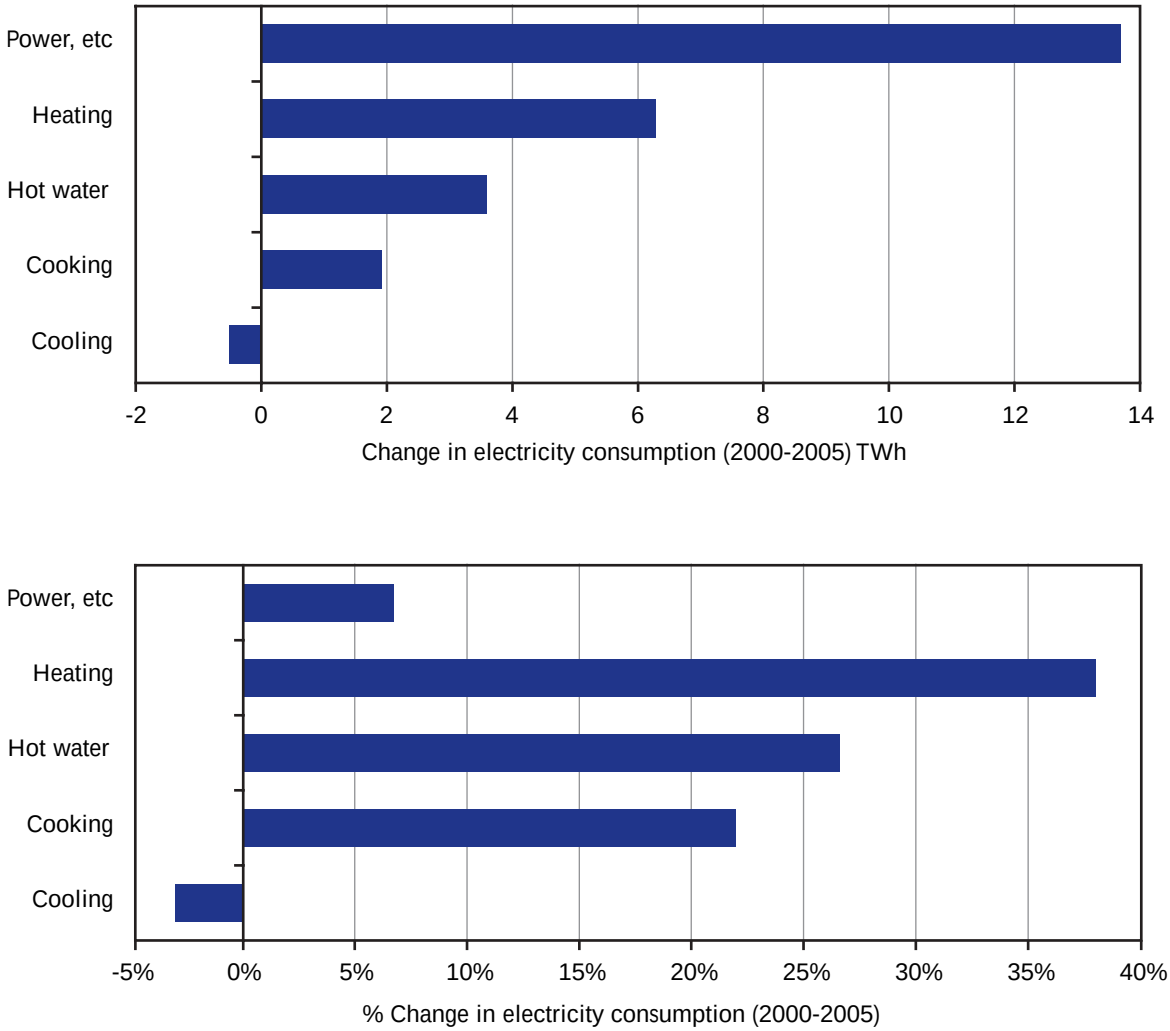
Figure 15 • Change in electricity consumption and % change by end-use category, Japan, 1995-2005



Source: ECCJ, 2007.

decade (see Figure 16). Both water heating and refrigerators/freezers have declining electricity consumption over this period.

Breaking down the appliance categories further, it becomes clear that it is the ICT and CE categories which are contributing most to total residential electricity growth in Australia (see Figure 17).

While incomplete, this data from several major economies offers strong clues as to why residential electricity consumption has increased markedly over the past decade. In regions with warmer climates, the greater penetration and use of air-conditioning is noticeable. Many of the larger household appliances such as refrigerators, freezers and clothes washers now contribute less to overall electricity consumption, as these appliances reach saturation, and technology

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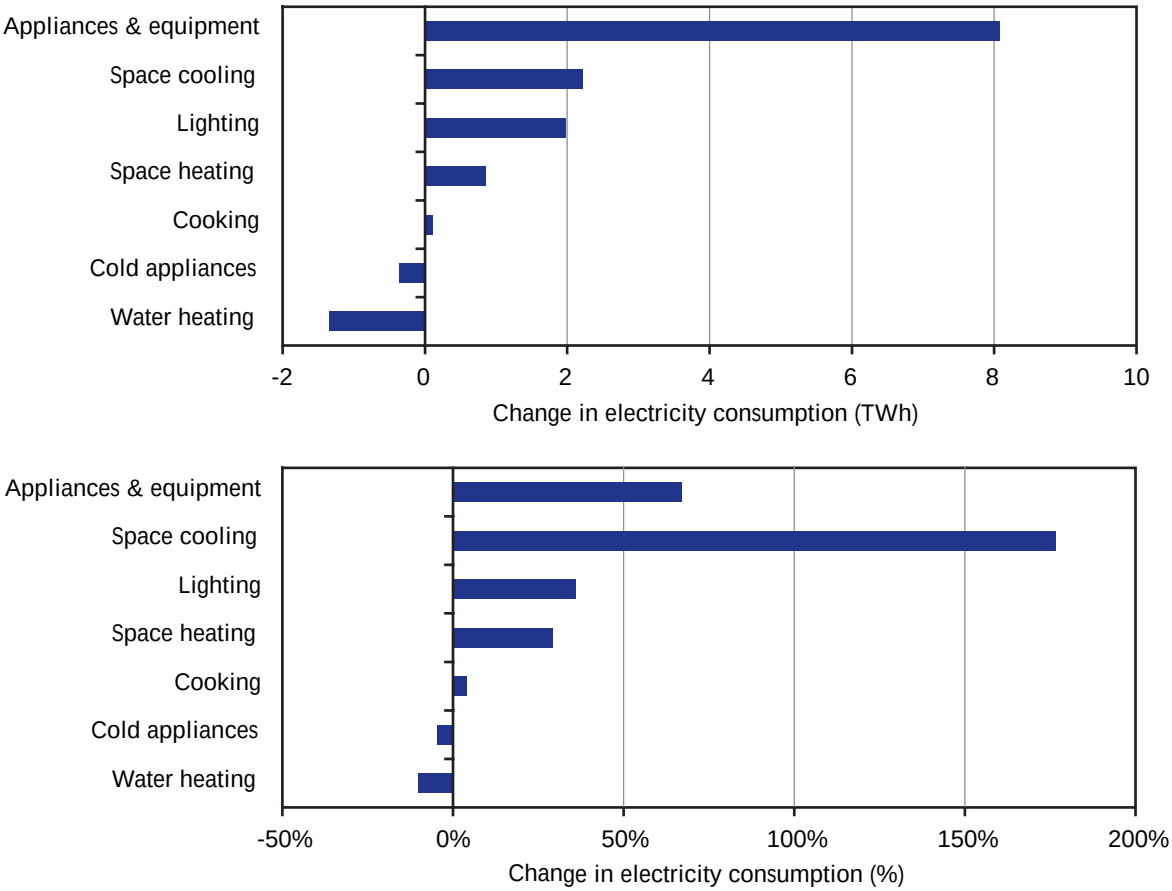
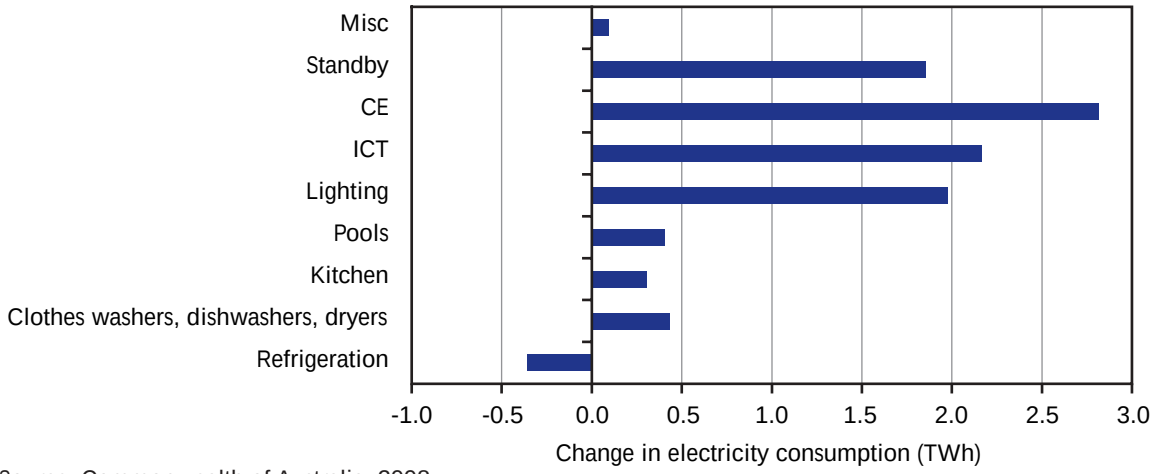
Figure 16 • Change in electricity consumption and % change by end-use category, Australia, 1998-2008



Source: Commonwealth of Australia, 2008.

Figure 17 • Change in electricity consumption by appliances, Australia, 1998-2008



Source: Commonwealth of Australia, 2008.

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improvements result in more efficient individual units. These appliances have been the primary target of energy efficiency policy measures in the residential sector over the past decade, and the success of these policies has been noted elsewhere (IEA, 2007).

Some countries have experienced large increases in lighting electricity consumption. The fact that it does not appear to be a widespread trend may indicate differences in the adoption rate of improved technologies between countries (*e.g.* a greater share of compact fluorescent lighting), changes in user behaviour (*e.g.* time spent at home) or measurement issues (*e.g.* inclusion of plug-in lighting). Some of these issues have been discussed in more detail in *Light's Labour's Lost* (OECD/IEA, 2006b).

A trend that is apparent in each country where data is available is that ICT and CE equipment is playing an increasingly important role in household electricity consumption patterns. In this case, not only is the growth rate of electricity consumed by these types of equipment expanding rapidly, but their contribution to overall electricity consumption is already significant in many countries. This shift is not a surprise to many experts, analysts and policy-makers, especially those who have been closely involved in national studies of electricity end-use. However, it is not necessarily evident to the wider group of stakeholders involved in public policy. In addition, the shift in residential electricity consumption has occurred more rapidly and has been larger than many people expected.

As governments around the world wrestle with the challenges of climate change, energy security and economic development, the growth in residential electricity consumption in all regions jeopardises many policy objectives in these fields. This analysis aims to shed more light on the underlying issues behind the growth in residential electricity consumption, and identify the opportunities to slow or reverse the trend. In view of its growing influence particular attention is given to ICT and CE equipment.

Recommendations made in this publication are generally aimed at governments, their agents, energy efficiency programme managers and relevant industry stakeholders and cover policies for programme organisation and administration, as well as for particular appliance categories. As a result of new research undertaken for this publication, it has been possible to extend the scope of recommendations beyond those previously made by the IEA. In particular, this publication recommends several new priority areas for action beyond those 25 policies provided to G8 leaders in 2008 (OECD/IEA, 2008b). The relevant sections of this publication reference both those included in the original 25 and additional recommendations supported by the latest analysis.

This book is organised as follows:

- Chapter 2 examines the need for policies to promote energy efficiency, and what results have been achieved by the range of measures which have previously been adopted by governments.
- Chapter 3 provides an in-depth review of progress with energy efficient appliance policy implementation in a range of IEA countries, including Australia, Canada, Japan, New Zealand, South Korea and the United States, as well as in the EU, and the major emerging economies including Brazil, China, India, Mexico and South Africa.

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- Chapter 4 looks closely at the specific case of electronic appliances, their overall electricity consumption and future trends. Policy options which would reduce electricity consumption from this end-use sector are also identified.
- Chapters 5 to Chapter 8 focus on specific categories of appliances including televisions, computers and monitors, set-top boxes, and other ICT and CE equipment. These chapters highlight the rapid evolution of these important appliances and consider the potential for efficiency improvements.
- Chapter 9 addresses some critical cross-cutting issues – including external power supplies, standby power, and digital networks – that can have a major impact on overall household electricity consumption.
- Chapter 10 provides a summary of the conclusions and recommendations made to improve the energy efficiency of ICT and CE appliances.

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Chapter 2 • EFFECTIVE POLICIES FOR ENERGY EFFICIENCY

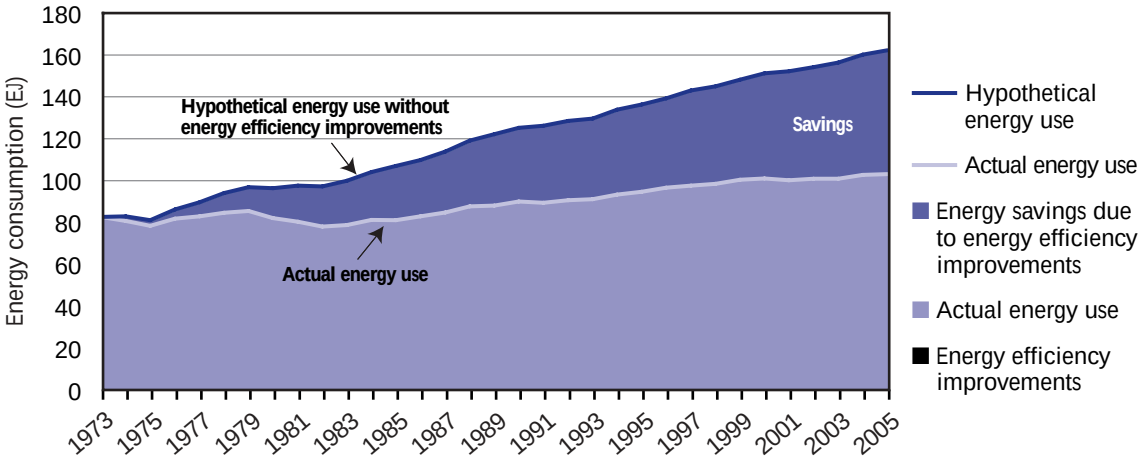
Introduction

Over the last three decades, energy efficiency policy measures in the end-use sector have made significant progress in generating energy savings. Between 1973 and 2005, 58% of energy demand from the IEA 11 was provided by energy savings, making it the largest single energy resource (Figure 18). Studies of the impact of policies on individual appliance categories, as shown later in this chapter, also demonstrate that considerable improvements have been recorded in the efficiency of many major appliances over recent years, at least in the order of previous savings estimates.

With continued efforts, the potential exists for even greater energy savings in the future. The technical potential to reduce energy consumption in equipment and appliances compared to business-as-usual projections is between 20% and 40%. The majority of these savings can be delivered by current technologies (McKinsey, 2007a). Additional savings are possible from the commercialisation of technologies which are now under development.

The evidence for these estimates is derived from various sources. There is a mounting volume of end-use assessments which base conclusions on an examination of the technical and market potential within a sector, and identify policies for improving energy efficiency. For example, McKinsey estimates that energy efficiency could reduce residential demand by 21% in 2020, (McKinsey, 2007b). Detailed studies by the IEA have shown that cost-effective energy savings of nearly 33% can be achieved in residential appliances by 2030, and a reduction of 40% can be made in the lighting sector by 2030 (OECD/IEA, 2003, 2006b).

Figure 18 • Long-term energy savings from improvements in energy efficiency, all sectors, IEA11, 1973-2005*



** IEA 11 comprises Australia, Denmark, Finland, France, Germany, Italy, Japan, Norway, Sweden, the United Kingdom and the United States.*

Source: OECD/IEA, 2008.

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Why is it so complicated to improve end-use energy efficiency?

In spite of these achievements, policy-makers often express frustration that the potential for energy efficiency in all sectors has not, and is not, being fully realised. Slow progress in making efficiency improvements does not however reflect the absence of potential, but relates to the complex nature of the end-use sector.

The end-use sector is made up of very many interacting components. There are industrial, commercial and residential consumers; there are also numerous energy applications including lighting, heating, refrigeration and many others which use different fuels. Within each sub-sector there are many different actors, including technology manufacturers, designers, retailers at the wholesale and consumer level, together with a multitude of third parties – all of whom have influence on the market and the energy efficiency of products.

Hidden within each of these areas are billions of separate opportunities for increasing energy efficiency. However, just as analysis has shown that many of these opportunities are not being taken; close examination also reveals that there are a wide variety of causes or barriers that are particular to different sub-sectors and market participants. Given the number of different participants, ensuring that the energy efficient option is taken therefore becomes a complex process.

Barriers to energy efficiency

The acknowledgement that there are barriers which prevent the uptake of energy efficiency options is central to policy discussions. A recent IEA publication, *Mind the Gap* (OECD/IEA, 2007), provides a useful explanation of the economic theory in relation to energy efficiency, and the rationale for policy intervention:

"**Market barriers** to energy efficiency occur as a result of three conditions:

- When energy costs are a low priority relative to other factors;
- When barriers in capital markets inhibit the purchase of energy efficient technologies; and
- When energy efficient markets are incomplete."

"**Market failures** occur when one or more of the conditions necessary for markets to operate efficiently are not met. According to neoclassical economic theory, markets operate efficiently (that is "perfect competition") when:

- There are sufficiently large numbers of firms so that each firm believes it has no effect on price;
- All firms have perfect information;
- There are no barriers to enter or exit the market place;
- Firms are rational profit maximisers;
- Transactions are costless and instantaneous."

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"When any of these ideal conditions are not met, there is a market failure, and markets are not achieving a Pareto optimal allocation of resources. In the context of energy efficiency, a market failure would imply that more energy is being consumed for the level of service than a rational allocation of resources would justify, in light of consumers and producers preferences.

"This is not to say that government intervention is only justified in the presence of market failures. For pragmatic reasons, governments may wish to intervene to address non-failure barriers in order to achieve a range of policy goals such as meeting a policy target, or to increase the rate of energy efficiency uptake to achieve environmental goals.

"Market failures provide a minimum justification for government policy intervention to improve efficiency". (OECD/IEA, 2007).

While the presence of market barriers and failures provide the rationale for policy intervention, an understanding of why energy efficient decisions are not currently made, and what is needed to change the dynamics of sets of interwoven relationships is needed to inform good policy development. In other words, the identification and targeting of barriers is likely to be the most effective and least disruptive means of achieving a level of energy efficiency which reflects the most efficient allocation of resources within an economy.

Mind the Gap cites many recent studies and reports into barriers and market failures which inhibit investment into energy efficiency (OECD/IEA, 2007). Some barriers apply to all areas of energy efficiency, and these include low energy prices, the exclusion of environmental externalities in energy costs and a lack of awareness of the potential savings. Other barriers are specific to certain markets where principal-agent issues or the lack of availability of low-energy technologies may inhibit investment in energy efficiency. For example, a section on barriers to energy efficiency in *Light's Labour's Lost* (OECD/IEA, 2006b, p.285) highlights both some of the key general barriers and those which apply particularly in the lighting market.

Later in this publication the barriers related to electronic equipment are discussed in more detail, together with appropriate policy measures that aim to provide new and sustainable market opportunities for more efficient equipment.

The potential to use energy prices to encourage energy efficiency is one of the key policy options often considered by governments, particularly as many countries are introducing systems which set a price for CO_2 and establish markets for greenhouse gas abatement measures. The impact of these types of policy measures is discussed below.

Will policy measures which internalise the price of carbon fix the problem on their own?

The price of energy plays an important role in the economics of efficiency, with higher prices making investment in low-energy technology more cost-effective for purchasers and therefore more attractive to manufacturers. Conversely there is less interest when energy prices are low. Setting energy prices so they realistically reflect all costs is therefore an important prerequisite for the efficient operation of an energy efficiency market.

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While the idea of using a single policy instrument, in this case the price mechanism, is very attractive, it will not overcome many of the barriers that exist in appliance markets. The reasons for this are as follows.

The impact on prices is likely to be small. For example, it was estimated that the first phase of the EU Emissions Trading Scheme (ETS) might increase residential electricity prices by up to 3% to 8% in 10 major European countries (ILEX, 2004).[1] A subsequent review of the impact of the ETS in Germany and the Netherlands found that residential prices rose during 2005 and 2006 by approximately these amounts, although these may be attributable to a range of factors including the ETS (ECN, 2008). While this may sound significant, in terms of total expenditures, this translates to an almost negligible increase since electricity costs are a very small part of the household budget (see Table 2). In the United Kingdom, a 6% increase in electricity prices would mean that electricity represented 1.7% of total household expenditure, compared to 1.6% with no ETS.

Table 2 • Energy and electricity as percentage of average household expenditure, selected countries

	Average energy expenditure as % of average household expenditure	Average electricity expenditure as % of average household expenditure
United States	4.0% (2006)	2.6% (2006)
United Kingdom	3.5% (2006)	1.6% (2006)
Japan	5.5% (2006)	3.1% (2006)
Australia	2.0% (2005/6)	Not available

Source: ECCJ, 2007; ABS, 2007; USDOL, 2007; NS, 2007.

From this example it is clear that the carbon price would need to be very large to make much of a difference on investment decisions in the residential sector. The Australian *Carbon Pollution Reduction Scheme* (CPRS) is projected to increase the cost of living by only 1.1% in 2010-11, at a carbon price of AUD 25 per ton, according to recent analysis (Australian Government, 2008).

Furthermore, the effects of uniform residential price increases will be distributed unequally since those with higher incomes pay a lower proportion of their household expenditure on energy bills. In the United Kingdom, the energy costs represent 6.6% of total expenditure for the lowest decile, while they represent only 2.4% for the top decile. Therefore those most affected will actually be those with the lowest disposable income and least able to respond to higher fuel prices by investing in energy efficient appliances.

A study by McKinsey in 2007 found that typical energy price elasticity in the residential sector varies between minus 0.1 and minus 0.4 as a result of the limited fuel switching options and high returns on capital expected by households, often close to 100% (McKinsey, 2007b). As shown in Figure 19, there is often a substantial gap between consumer expectations of financial savings from energy efficiency investments and actual returns.

1. If the full marginal cost of carbon is passed through to the electricity price.

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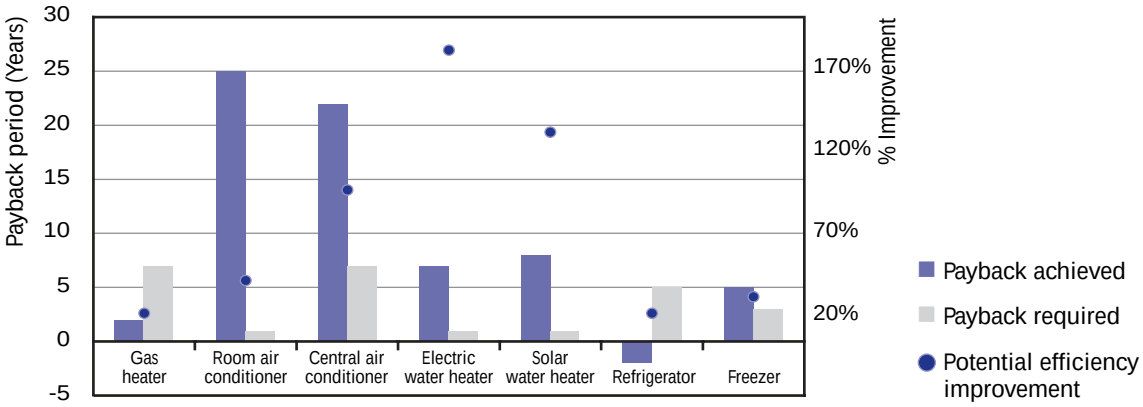
Figure 19 • Consumer payback requirements for energy efficiency improvements vs. achieved payback periods



Source: Derived from McKinsey, 2007b.

In addition, not all barriers are financial: even if consumers are motivated by price signals to look for energy efficient appliances, they still need information on which to base rational decisions, such as that provided by the range of appliance labelling programmes in existence now.

For many major items, the most cost-effective time to invest in a more efficient appliance is when an existing piece of equipment fails and/or requires replacing. For items such as water heaters, or space coolers and heaters, the primary consumer concern at this point in time is to have a functioning replacement installed as soon as possible. Investigating fuel switching or more efficient appliance options is often a time consuming exercise which adds delay and restrictions that take a back seat when speed of replacement is the priority.

Some choices are beyond the range of influence of individual consumers. The development of many energy efficiency services requires the alignment of several actors but because the supply chains are fragmented, the market signals are lost.[2] As a result governments have discovered that mandating outcomes is the most efficient means of ensuring these alignments.

The levels of energy savings involved for individual products are small and sometimes negligible: the cost of energy used by many appliances, and particularly the array of small electronic equipment, is so small in comparison to typical disposable income levels that the individual savings on efficiency hardly register. It is only when aggregated at the national level that energy consumption and savings become considerable.

Principal-agent barriers (commonly referred to as split incentives) also isolate energy users and/or energy technology purchasers from energy prices. Split incentives occur in the appliance sector, as well as in buildings (OECD/IEA, 2007).

2. *For example, the design of speculative buildings, and the integration of 'off the shelf' electronic components within final assembled products.*

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Some of these arguments have already been acknowledged within the broader discussion of carbon trading schemes, for example:

"... numerous barriers stand in the way of proper economic responses to price signals. Covering all energy-related CO_2 emissions with a single emissions trading system is possible in theory and may appeal to policy makers in search for policy efficiency. However, market imperfections abound that hamper rational energy choices – why would a landlord insulate windows when the tenant gets the benefits? The price of carbon may not trigger the expected efficiency improvements and least-cost GHG savings. Other policies and measures will be needed to bring about more rational energy uses, without a loss of service. The IEA has already widely documented best practice in energy efficiency policies that can deliver CO_2 reductions at negative cost: these should be implemented first, before introducing a price signal that will otherwise not deliver reductions." (OECD/IEA, 2005)

In summary, while energy prices can play a part in influencing the level of energy efficiency within an economy, they are a blunt instrument unable to overcome some of the many specific barriers which currently inhibit cost-effective investment by consumers in energy efficiency. Pricing mechanisms will need to be used as components of a package of targeted policy tools, many of which are currently in operation and will be referred to in subsequent chapters. A basic description of some of the major policy measures available to governments is provided below.

The policy toolbox

Governments have a wide array of possible policy tools to use in order to bring about long-term market transformation in addition to ensuring the energy price accurately reflects the full marginal cost. As noted above, the selection of policy measures needs to take account not only of overall policy objectives set by governments, but also be suited to overcoming particular barriers present in the market. There is extensive experience with most of these programmes in a number of countries, and examples are provided in later chapters of this publication. Further information can also be accessed through the *IEA Energy Efficiency Policies and Measures Online Database,*[3] or *Cool Appliances* (OECD/IEA, 2003) amongst other sources. The following list comprises most of the major types of programme which have been used to stimulate markets for energy efficient appliances.

Product energy performance labelling

Energy efficiency labels aim to provide consumers with information at the point of purchase and enable suppliers of energy efficient appliances to gain market recognition for the energy advantages of their products. The effectiveness of labels relies upon consumers having a good understanding of what a label represents, and valuing the information sufficiently for it to influence their purchasing decision. It is therefore important that labels have high brand recognition amongst consumers and are considered credible. There are two generic types of energy performance labels: endorsement labels and comparison labels.

3. http://www.iea.org/textbase/pm/?mode=pmd

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Comparison labels: show the energy efficiency of a particular model relative to similar models on the market, and are usually, though not always, mandatory to maximise consumer choice. For simplicity the rating of an individual model is typically displayed as a single number or star within a range. In addition to energy performance, comparison labels may also carry an estimate of the annual energy consumption of the appliance, and the associated electricity or energy costs, based on the tested energy consumption and the typical use of the appliance in the home. Comparative labels work best when models in the market-place exhibit a spread of performances, thereby providing a range of ratings for consumers to choose from.

Endorsement labels: identify the best performing models within an appliance category, so that consumers can easily differentiate them from others by the presence of the label. Participation by suppliers in these programmes is always voluntary. Similarly, ecolabels are endorsement labels which cover multiple environmental parameters, such as noise, water use, and energy use, usually associated with the manufacture, use and disposal of products.

Warning labels: are similar to an endorsement label except that their aim is to highlight poorly performing products. If a product qualifies for the label it is a mandatory requirement that the label is fixed to the relevant product, although the intention is that manufacturers will avoid having to use the warning label by improving the performance of their products.

Mandatory government programmes

Minimum energy performance standards (MEPS): MEPS are mandatory performance requirements for individual appliances set at a level to prohibit sale of the worst performing products in the marketplace. MEPS are not designed to promote the best performing products, but can be combined with policy measures that do have this aim, such as labels.

Mandatory fleet average: While MEPS apply to each product sold, some policies specify performance requirements based on the sales-weighted average of all products sold by a manufacturer or supplier over a year or similar period of time (for example, the Top Runner programme in Japan). As a result, this measure does not necessarily cause any products to be withdrawn from the market, although suppliers may choose to voluntarily retire poorer performing products in order to increase the average performance of their range.

Energy utility obligations: Known as Energy Efficiency Resource Standards (EERS) in the United States and typically as Energy Efficiency Obligation (EEO) schemes in Europe, these are mandates placed on energy utilities by governments or regulators. The mandate may be specified in terms of quantified amounts of energy savings, or greenhouse gas savings, or sometimes peak demand. Many EEO schemes allow utilities to secure resources at the lowest cost available by using specialised third parties (Energy Service Companies, ESCOs) to design and run programmes (Waide *et al.*, 2008). While such programmes may result in appliances savings, this cannot be guaranteed unless saving requirements include specific allocations.

In theory, EEOs can be introduced for other sectors of the community, and may be particularly effective where principal-agent or other significant barriers prevent the efficient allocation of resources. Obligations on TV service providers, discussed in chapter 7, are a further example

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of a third-party obligation. In some countries, most notably the United Kingdom, there has also been active discussion about the use of personal greenhouse allowances, tied to tradable certificate schemes (UKP, 2007).

Procurement: Governments can use their purchasing power to create markets for energy efficient appliances and equipment, and at the same time show a good example to their community. Collectively, the various layers of government and their associated agencies control sizeable budgets for procurement of appliances and equipment, particularly ICT. By specifying that they will purchase only the most energy efficient products on the market, governments are therefore able to establish a market foothold for suppliers, to the benefit of all consumers. The most effective procurement policies have generally been where tenderers are required to meet minimum energy performance specifications for products, in addition to meeting other performance requirements.

A second form of procurement policy may be used by governments to bring to the market products which are not yet developed. Governments can use their purchasing power to commit to orders for the development of new products with higher efficiency levels than currently are available.

Fiscal measures

There are a range of potential financial tools which can be used to encourage energy efficiency, targeted either at the consumer to provide a market pull or at the supply chain in order to reduce retail prices.

Examples of financial measures include:

- Capital rebates, discounts;
- Grants;
- Low interest loans;
- Variable consumption tax rates;
- Tax credits.

While the decision of where best to focus financial incentives depends on the particular market, initiatives aimed at consumers which increase transaction costs for goods with a low capital value are unlikely to succeed. As a result, measures such as point-of-sale discounts are usually most effective and can be used either as short-term promotions or over a longer period to reduce the pay-back time to levels acceptable to consumers. Loans and tax rebates are likely to work more effectively when directed towards the manufacturers. Removing consumption taxes for energy efficient goods is another means to lower capital costs.

Other programme types

Tradable energy or greenhouse gas savings schemes: Several governments have now established tradable greenhouse gas or energy saving certificates (also called white certificates) as an

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adjunct to energy or greenhouse gas obligations on utilities, creating a market where these certificates are traded amongst utilities and third parties. Although this potentially brings in new sets of players into the business of sourcing energy efficiency, as with EEOs, it provides no certainty that there will be an increase in programmes targeting appliances.

Retailer programmes: Although similar to endorsement labels for products, retailer programmes provide an endorsement for an individual store or chain based on their performance in selling high efficiency appliances. In addition to sales, indicators of performance can include: how well staff are trained to provide energy efficiency advice to customers and the profile of energy efficient appliances within stores and on marketing materials.

Voluntary agreements: Agreements between governments and suppliers (or their associations) can yield good results, particularly where the group of suppliers comprise a substantial part of the market. Typically such agreements take the form of a commitment to meet minimum or sales-weighted performance specifications for products over an identified period of time. The expansion of the global trade in appliances has made these essentially local arrangements more difficult, as suppliers face increasing competition from those not party to these agreements. Voluntary agreements with retailers is a further policy option, although to date there have been few examples.

Corporate commitments: Many governments have established programmes designed to enlist commitments from companies to meet energy or greenhouse gas emission targets. In return for acting as good corporate citizens, companies gain access to promotional materials. These commitments vary considerable in their scope, for example some cover the company's premises while others also include products sold by that company. As with other endorsement type programmes, the success of such initiatives depends upon successfully building brand awareness such that customers recognise and value the endorsement.

Personal commitments/pledges: Environmental NGOs have tended to use the concept of personal pledges by their membership to increase sales of energy efficiency products and demonstrate that there is latent demand for the most efficient products. Notable examples include commitments to purchasing CFLs, and the most efficient residential appliances.

Promotional activities

Awareness raising and information provision: General information programmes are designed to target consumers, or subgroups of consumers, with information relevant to their purchasing decisions. Traditionally they have taken the form of leaflets distributed via retail outlets or mass mailings, but with the high level of access to the internet, web-based information provision is becoming increasingly popular. This provides consumers with easy access while enabling the information to be kept up to date.

Awards and competitions: Many programmes offer annual awards for product supply companies and major end-users as a reward for high levels of achievements in energy efficiency. This provides an opportunity to gain media attention for energy efficiency as well as promotional opportunities for the winners.

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Policy combinations

In many cases, policy measures are used in combinations to increase their impact. There are numerous examples shown in following chapters including:

- MEPS and performance labels: minimum performance standards are used to remove the worst performing products in the market, while the labelling is designed to promote the better products. Where comparison labels are used, the two can be co-ordinated so that the lowest rating is equivalent to the MEPS level. These combinations are often referred to as Standards and Labelling programmes (S&L).
- Endorsement labels and procurement policies: governments with policies for purchasing the most energy efficient products can use the criteria used by endorsement labels to help identify eligible equipment.
- Labels, retailer programmes and customer discounts: both comparison and endorsement labels provide a means for targeting financial measures, at the most efficient products. Programmes which involve retailers can therefore provide in-store cash back or discounts at the point of sale for the most efficient products.

The following section looks at examples of these policies and the impact they have had in a number of different countries.

The effectiveness of existing policies

Previous IEA publications have noted numerous examples where energy efficiency policies have been evaluated and shown to have contributed to significant energy savings. For example, *Experience with Energy Efficiency Regulations for Electrical Equipment* included a summary analysis of international appliance programmes, as follows:

"MEPS and mandatory labels have been used by several economies increasingly since the 1980s on a range of residential equipment including refrigerators and freezers, clothes washer and driers, and air conditioners. This analysis of programmes in Europe, United Kingdom, United States, Australia and Japan shows that all products examined have experienced a decline in real prices of between 10% to 45%, while energy efficiency increased by 10% to 60% over the periods when data was collected. These gains have been made without sacrificing levels of service, since in all but one case the size or capacity of the equipment monitored has either remained the same or increased." (IEA, 2007).

These examples demonstrate that energy efficiency policy measures for appliances have been extremely cost-effective from the consumer point of view, yielding considerable savings in electricity consumption (and consumer costs) as well as real reductions in capital prices.

But what do these policy measures, and the programmes and schemes that deliver them, cost governments to run, and how cost-effective are these demand-side activities compared with alternatives on the supply-side?

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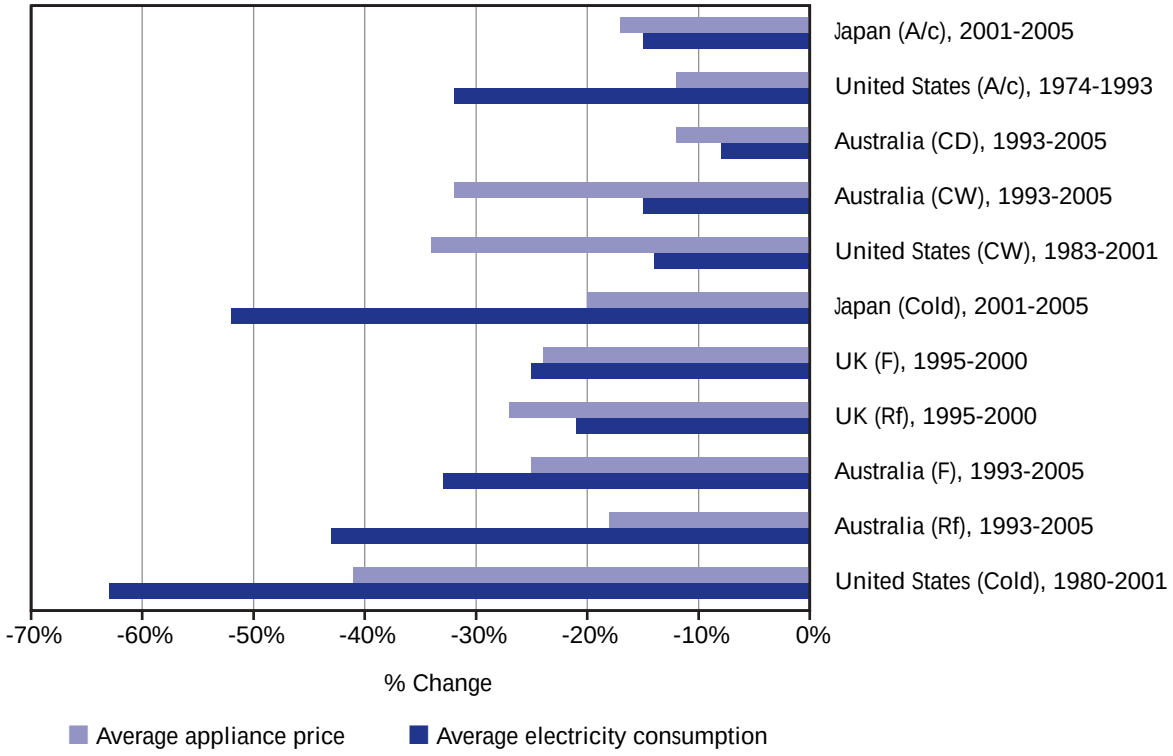
Figure 20 • Recorded fall in average electricity consumption and prices for several major appliance types in selected countries



Source: IEA, 2007.

Key: A/c: Air conditioners; Cold: Refrigerators and freezers; CD: Clothes dryers; F: Freezers; CW: Clothes washers; Rf: Refrigerators.

Are energy efficiency programmes cost-effective?

Answering these questions is complicated by the many different types of programmes which have been undertaken and the variation in assumptions made by evaluation experts. As a result, although several studies have attempted to collate and summarise information on the effectiveness of programmes separately for Europe and the USA,[4] there have been few attempts at comparing evaluations internationally.[5] However, international meta-analysis is needed in order to draw some general conclusions about the cost-effectiveness of demand-side policies.

A study undertaken by the IEA for this publication has drawn on 16 case studies from eight countries covering a range of different policy measures relating to appliances. These comprise:

- A set of 8 case studies for which we have detailed data in a consistent format;
- Another set of 8 relevant evaluations for which we have less consistent data.

The full list of programmes analysed is presented in Table 3.

4. For example, see Ecofys (2007) and Gillingham (2004).
5. One exception being Lund (2007) although this study did not focus on appliances.

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Table 3 • Summary of 16 energy efficiency programme case studies

	Policy	Country	Appliance type	Policy category	Programme cost to government (2006 USD millions)
Case studies for which direct comparisons are possible					
1	Netherlands appliance labelling	Netherlands	Household electrical appliances	Package (R + F + I)	340
2	KFW soft loans	Germany	Appliances for new buildings	F	4,256
3	British energy efficiency commitment (AID-EE)	UK	Lighting (24% of funding), appliances (11%), heating (9%) and insulation (56%)	U	2,143
4	New York ENERGY STAR market support program	USA	Appliances	Package (VA + F + P + I)	41
5	New York EmPower program - low income	USA	Energy-efficient lighting, appliances, electric-resistance space and water heating, and demand management	I	24
6	Thin Tube CFL program	Thailand	Fluorescent lamps	U (VA)	13
7	Danish kitchen appliance	Denmark	Kitchen appliances	F	5
8	California multi-family rebate program	USA	Energy efficient equipment	F + I	22
Other case studies which cannot be directly compared					**Millions (nominal)**
9	Thailand DSM Program (4 programs relating to the residential sector)	Thailand	Refrigerators/ Air conditioners/ lighting	Package (I + F + P)	USD 53
10	Danish Energy labelling + associated campaigns	Denmark	Refrigerators/freezers/washing machines/tumble dryers/ dishwashers	Package (R + I + F)	NA
11	Refrigerant charge and airflow verification program	California	Air conditioners	F	USD 1.65
12	Barrier removal for the widespread commercialisation of energy-efficient CFC-free refrigerators in China	China	Refrigerators	Package (R + F + I + P)	USD 40.884
13	South Australia energy efficiency program for low-income households	South Australia	Refrigerators/washing machines/microwaves/ lighting/insulation	F	AUD 2.05
14	South Australia interest-free loan for low-income households	South Australia	Refrigerators/washing machines/microwaves/ lighting/insulation	F	NA
15	UK Energy advice centers	UK	Behavioural changes in relation to home energy use	I	NA
16	US department of energy sub-CFL procurement program	US	CFL's	P	USD 1.342

Source: IEA estimates.

Key: F : Financial Incentive; VA : Voluntary Agreement; P : Procurement; U: Utility Regulation; R : Regulation; I: Information

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Detailed description of comparable case studies

The eight case studies chosen for detailed comparative analysis all address appliance energy efficiency, either directly or indirectly. Seven out of the eight case studies are from North America and Europe. This is not surprising, given that evaluation of energy efficiency policies is much more embedded in the policy process than in other parts of the world (this is particularly the case in the United States).

In terms of programme types, five of the case studies provided financial incentives; four case studies used information transfer. Two case studies were utility-based energy efficiency programs, and two case studies included voluntary agreements. Only one case study used a regulatory measure to achieve energy efficiency improvements (the Netherlands appliance labelling programme). With only one regulatory-based programme in the eight case studies, this cannot be taken as a representative sample since regulatory measures are the most common policy measure taken worldwide.

One differentiating factor among the case studies is the magnitude of funding. Programmes ranged from USD 4.2 billion (KfW) to the more modest USD 5 million (the Danish kitchen appliance programme).

The Netherlands appliance labelling

This evaluation studies the effectiveness of the Netherland's comparative energy labelling for household electrical appliances and the associated subsidy programme (Luttmer, 2006). Energy labelling of refrigeration appliances was first introduced in the Netherlands in 1995 to stimulate both the demand side of the market (creating awareness and influencing purchase behaviour) and the supply side (creating awareness and influencing design and production). Since 1995, several other energy consuming appliances have been included; washing machines and electric tumble dryers in 1996, washing and drying combinations in 1998, dishwashers in 1999 and lighting in 2001. In 2003, ovens and air conditioners were added to the list (Luttmer, 2006).

Other policy instruments included in the package considered by the evaluation were the economic instruments MAP (*Environmental Action Plan*, 1991-2000) and the EPR (*Energy Premium Regulation*, 2000- 2003).

KfW soft loans

This evaluation covers the KfW programme to provide low-interest loans for energy saving measures implemented in German households (Korytarova, 2006). Established in 1996, the programme has been restructured many times. The current evaluation focuses on two aspects of the programme:

- CO_2 Reduction Programme: established in 1996, this programme originally made soft loans available to Eastern Germany and East Berlin only. In 1999, the programme was expanded to cover the whole of Germany. The programme initially supported individual renovations in existing buildings, and then from 1998 the programme was extended to cover new buildings. The programme also made available finance for the introduction of renewable energy sources in new and existing houses;

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- CO_2 Building Rehabilitation Programme: established in 2001, this programme provided loans for retrofits of buildings built before 1979 as well as demolition of empty residential rental buildings. The programme offered 6 different packages of measures (some of which covered the replacement of household heating equipment).

Over the evaluation period (1996 - 2004), the USD 4.2 billion programme saved between 22 and 32 PJ (depending on how free rider effects were addressed).

British Energy Efficiency Commitment (EEC)

The UK government EEC requires gas/electricity suppliers to achieve mandatory energy efficiency targets in the residential sector (Forfori, 2006). To encourage the least-cost solution for obliged parties, the EEC gives the option to suppliers to trade their obligation or energy savings on a bilateral basis with other suppliers. Supplier savings are accredited on an *ex ante* basis.

The overall energy savings target set by the Department for Environment, Food and Rural Affairs (DEFRA) was 62 TWh which equates to 442.4 PJ (excluding free-riders and the comfort effect). At least half of this target was to be achieved in households who spend more than 10% of their income on heating their homes.

The EEC gave suppliers freedom with respect to how they would comply with the obligations. Nevertheless, the EEC did encourage some specific measures (see Forfori, 2006, p.5). Suppliers' activity mainly affected lighting (24%), appliances (11%), heating (9%) and insulation (56%).

New York Energy Star market support programme

This USD 41.3 million programme provides support services to New York's building performance and low-income energy efficiency programmes by increasing the availability of energy-efficient products and consumer demand for services (NYSERDA, 2007). There are three major components to the Market Support Program:

- The ENERGY STAR Products Initiative;
- The Program Marketing Initiative;
- The GetEnergySmart.org website.

The programme provides a range of initiatives to support energy-efficient product uptake including cooperative promotion and market-share incentives to mid- and up-stream partners, sales staff training, free point-of- purchase materials, website listings, and participation in statewide/national initiatives. Consumer demand is built through extensive multi-media campaigns. The marketing also supports other NYSERDA residential programmes such as the ENERGY STAR® Products and Residential ENERGY STAR® Marketing Programs.

New York EmPower programme

EmPower was launched in 2004 to provide energy efficiency measures and on-site energy-use management education to participants in the Niagara Mohawk and New York State Electric

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and Gas (NYSEG) low income programmes. By March 2007, the programme had led to evaluated net savings of around 180 194 GJ. The programme is now available to customers of Central Hudson, Consolidated Edison, Orange and Rockland and Rochester Gas and Electric. The programme provides cost-effective electric reduction measures, particularly lighting and refrigerator replacements, as well as insulation and health and safety measures.

Under the latest round of New York Energy Smart funding, EmPower was merged with the Weatherization Network Initiative to simplify the programme structure and provide more comprehensive services to eligible participants (NYSERDA, 2007).

Thailand Thin Tube programme

The two-year Thin Tube programme began in 1993 with the objective to transform the fluorescent lamp market from 40W and 20W (thick tubes) to 36W and 18W (thin tubes) (Agra Monenco and Hydro, 2000). The programme had an evaluated savings of 1 553 GWh. The Electricity Generating Authority of Thailand (EGAT) negotiated directly with manufacturers to switch production to the more efficient globes. In return, EGAT focussed on the delivery of an advertising campaign to promote new energy saving lamps. Production technology was available and the incremental cost minimal, therefore, no additional financial incentives were offered. Within two years, all manufacturers had completely switched production to thin tubes.

Danish Kitchen Appliance programme

In the Spring of 2004, the Danish Energy Saving Trust carried out a campaign to increase the sales of energy efficient refrigerators/freezers (Danish Energy Association, 2006). A subsidy of 500 DKK (USD 100) was offered to consumers when purchasing A+ or A++ appliances. For the period June 2004 to September 2005, the programme cost DKK 52.4 million (USD 10.3 million) and saved 298 800 GJ (projected to be 1 585 440 GJ over the lifetime of the appliances).

California Multi-family Rebate programme

The 2004-2005 California Statewide Multifamily Rebate Programme was designed to address the unique barriers faced by the multifamily sector, primarily the split-incentive barrier (KEMA, 2006). The rebates helped reduce, and in some cases totally eliminate, the higher first costs for energy-efficient equipment. The programme also helped to encourage the participation of multifamily property owners and managers by offering rebates for energy-efficient measures installed in common areas.

The programme cost utilities a total of USD 19 million and targeted apartment dwelling units and in the common areas of apartment and condominium complexes and mobile home parks across all of California. Property owners (and property managers, as authorised agents for property owners) of existing residential multifamily complexes with five or more dwelling units could qualify for rebates for installing a variety of energy efficiency measures. These included:

- Apartment improvement measures (e.g. interior and exterior hardwired fixtures, ceiling fans, compact fluorescent lights (CFLs), clothes washers, and dishwashers);
- Common-area improvement measures (e.g., exit signs, occupancy sensors, photocells, high-performance dual-paned windows);

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- Mechanical improvement measures;
- High-efficiency heating and cooling equipment.

The programme saved 184 864 GJ over the two-year period (with projected lifetime savings (2004-2012) of 1 382 332 GJ) (KEMA, 2006).

Comparing evaluations

Different evaluation approaches are used within countries, and even more so at the global level, since there is no single agreed method for conducting energy efficiency policy evaluations. The heterogeneity of appliance policies means that evaluations adopt different boundary definitions, and various methods for measuring energy savings to suit their individual context. For example, not all studies attempt to take account of free-rider issues; and some studies examine costs and benefits by sector (government, industry, end-user, society). In addition, there is a huge variance in the degree of detail provided in evaluation reports (some simply providing totals of their calculations without background data, while others provide detailed annual breakdowns of costs and energy savings).

In this study we have attempted to standardise assumptions as far as permitted by the data available. As a result, some of the information presented may vary from previously published source data. Further information on the methodology used is provided in Annex II.

Results and conclusions

This analysis found that the average cost-effectiveness across all programmes, taking into account all costs and all benefits, was USD 0.6/GJ. In other words, on average, the programmes delivered USD 0.6 of net benefits for every GJ of energy saved. Table 4 summarises the lifetime energy impact and total cost effectiveness of the eight programmes.

The eight programmes clearly delivered significant energy savings, and most are extremely cost-effective; a finding that is corroborated by many other energy efficiency policy evaluations that could not be standardised into a comparable format. For example, other elements of the Thailand DSM programme and the New York load reduction programme all report energy savings at a benefit cost ratio of around 2:1 or higher (Agra Monenco and Hydro, 2000; NYSERDA, 2007).

The most effective programme, from the perspective of net benefits per GJ saved, was the New York Energy Star Market Support Programme. This programme promoted Energy Star appliances and equipment through a package of measures, and therefore benefitted greatly from leveraging off the strong national Energy Star scheme and pre-existing brand awareness. Given the relatively small size of this programme it is likely that some of its success is owed to the appropriate targeting of a package of instruments.

As shown in Figure 21, in general the larger programmes tend to have lower cost-effectiveness than the smaller programmes. Indeed, the Pearson Correlation coefficient (a measure of the linear relationship) between the energy impact (GJ) and cost effectiveness is negative (- 0.3). This suggests in general that the larger the programme (in terms of energy savings), the lower the cost-effectiveness.

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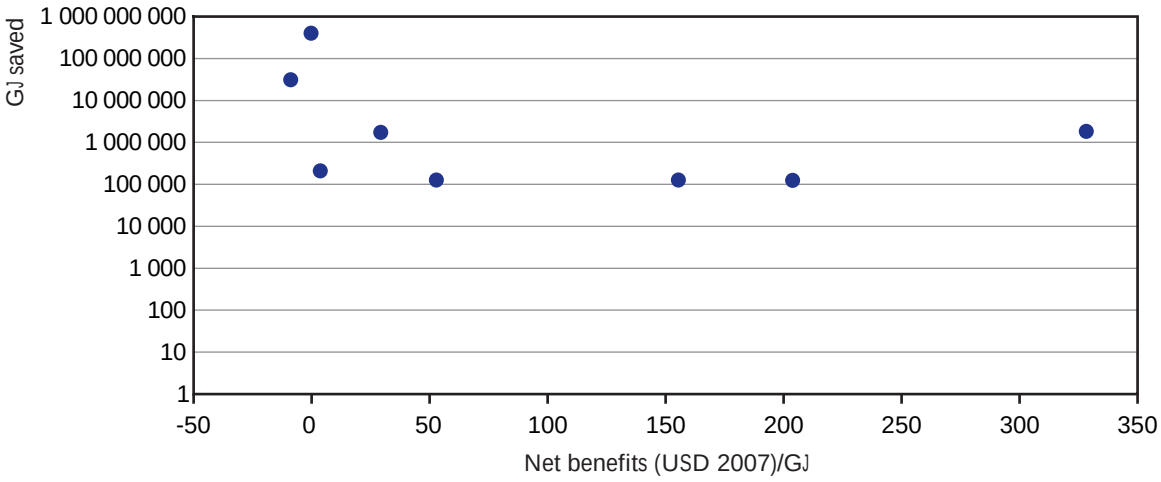
Table 4 • Lifetime impact and cost effectiveness of eight evaluated energy efficiency programmes

	Policy	Lifetime energy impact (TJ)	Policy total cost effectiveness (USD net benefit/ GJ)	Period of programme (years)	Programme cost to government (2006 USD millions)
1	Netherlands appliance labelling	1 700	29	17	340
2	KFW soft loans	31 500	(9)	16	4,256
3	British Energy Efficiency Commitment (AID-EE)	402 000	(0.4)	10	2,143
4	New York ENERGY STAR market support program	1 856	328	12	41
5	New York EmPower program - low income	122	204	7	24
6	Thin tube CFL program	123	53	4	13
7	Danish kitchen appliance	212	3	1	5
8	California multi-family rebate program	125	155	6	22
Average			95	9.1	
Weighted average (weighted by energy impact)			0.6		
Correlation coefficient (with cost-effectiveness)		–0.3	1	–0.022	–0.50

Source: IEA estimates.

Figure 21 • Summary of energy savings versus cost effectiveness for eight evaluated energy efficiency programmes



Source: IEA estimates.

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It is difficult to identify why this negative correlation may exist given the small sample of programmes analysed. It may be related to the size or ambition of the programme (the correlation co-efficient between cost-effectiveness and cost of the programme is -0.5). This makes sense as smaller programmes tend to focus on "low hanging fruit" (*e.g.* kitchen appliances or CFLs where significant gains can be made quickly) and build on existing programmes; whereas larger programmes tend to attempt more difficult market transformation. Another reason for this result may be related to the complexity of the instruments used to achieve the energy savings.

Clearly further detailed investigation is needed to be able to answer questions about why some particular programmes are more successful than others. However, what is clear is that all programmes analysed were able to deliver energy savings at a competitive cost with the long-run costs of supply-side alternatives, even without factoring a cost for carbon emissions.

Evaluation in context

Extending this meta-analysis beyond the case studies presented above has been all the more difficult because of a range of issues associated with energy efficiency evaluation. Many of these were highlighted at an IEA workshop on the subject in 2007 (see IEA, 2008 for further details), and are summarised below.

The importance of evaluation

Effective evaluation procedures, together with monitoring and verification procedures, are key aspects of sound policy implementation. Evaluation plays a key role in helping to determine whether energy efficiency policies have met their goals. In fact, there are several reasons to evaluate energy efficiency programmes, including:

- Ex-ante analysis of energy efficiency policy options can help to ensure that the most appropriate policies are selected;
- Evaluation during policy implementation allows policy makers to address policy design problems along the way and for updates to the policy measure to be made as necessary;
- Ex-post analysis of energy efficiency policies allows for an assessment of whether a measure has achieved its intended objectives or not, how and why, and thus can enhance learning from the effectiveness or otherwise of past measures;
- Evaluation is essential for verifying tradable units of energy conservation, such as in White Certificate Trading programmes and government commitments to reduce greenhouse gas emissions.

Evaluation helps to answer several core questions that provide a rationale for energy efficiency policy evaluation:

- What types of energy policies have been implemented?
- How well has each of these policies worked in terms of saving energy and/or meeting the overall objective of the programme?

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- How much have these policies cost the public and the private sector and how cost-effective have they been?
- If the policy has not met its objectives, why not? If it has, what were the features of its success?

Evaluation: patchy practice

Despite the value of evaluating energy efficiency policy measures, many policies go unassessed in a quantified manner for a number of reasons. Scant resources, methodological difficulties, inadequate expertise and political interest all contribute to the lack of evaluation.

Even where energy efficiency policy evaluation is carried out, it is done so in a rather ad hoc manner. For example, much historical evaluation effort has been focussed on a few policy areas and within relatively few jurisdictions. The one exception is the United States, where evaluation is more widely undertaken than in many other regions, 3 to 5% of energy efficiency programme costs are typically allocated for evaluation, and up to 8% in California. This has led to the development of substantial capacity and expertise.

Much work remains to ensure that energy efficiency policies are adequately evaluated. A review by the IEA of *ex-post* evaluation practices worldwide made four key recommendations (IEA, 2008):

- Lack of common agreement on evaluation method: Many publications offer direction on the appropriate methods for conducting energy efficiency policy evaluation. Notable examples of such guides include the IEAs DSM Evaluation Guidebook (2005), the Energy Charter Working Party on Energy Efficiency's Evaluating Energy Efficiency Policies and Measures (2006) and the International Performance Measurement and Verification Protocol (IPMVP) (EETD Newsletter 2002). However, there is a need for international agreement on a common method and use of common terminology.
- Uneven sectoral and spatial coverage: Present evaluation of energy efficiency policies and programmes focusses on a handful of policy types within a few sectors and countries. For example, from a sectoral perspective, transport-related programmes have received less attention than most other sectors, followed by industry. From a policy perspective, public investment and RD & D have received less evaluation attention than appliance standards. There is a clear need to extend energy efficiency evaluation to all policy areas.
- Few meta-analyses: There is a clear gap in the literature with respect to robust, international meta-analyses. Covering a range of policies, the analysis by Gillingham et al., 2004, is nonetheless limited in two aspects. First, it is restricted to experience in the United States. Second, it is not always clear whether the methodologies of the reference studies on which they based their meta-analysis are compatible, opening the possibility of comparing apples and oranges. There could be significant value in extending such a meta-analysis to the international scale.
- Analysis of the cost and value of evaluation: There is little in the way of documented benefit: cost analyses on energy efficiency evaluations themselves. Anecdotal evidence from the United States suggests that the benefit: cost ratio can be high. Analysis of the cost and value of evaluation would be useful for promoting the importance of evaluation to policymakers.

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Conclusions

Differences in types of energy efficiency programmes and their relationship to other initiatives gives rise to a large diversity in quantities of energy saved and associated costs. The design of a programme will also influence the distribution of costs and benefits among participants. The above examples provide some indication of these variations and demonstrate that large savings at low (negative) net costs have been achieved by several different types of programmes.

To continue to provide accurate information and analysis to policy makers and programme managers on the relative impacts of different types of policy measures, it is important that transparent evaluations are undertaken on a routine basis for energy efficiency schemes.

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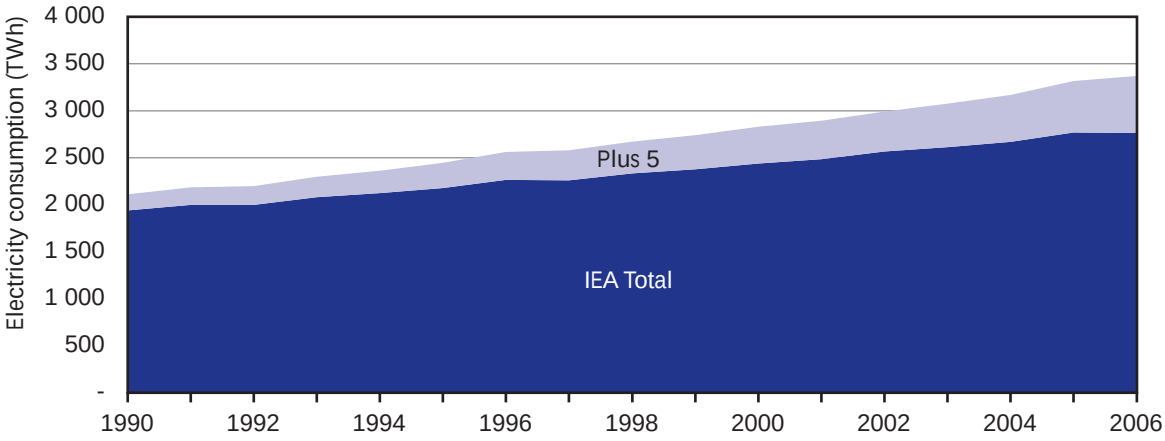
Chapter 3 • COUNTRY AND REGIONAL REVIEWS

Introduction

Policies for residential electric appliances form a prominent part of all national and regional energy efficiency strategies, responding to the widespread growth in energy consumption from this sector (see Figure 22). Since the publication of Cool Appliances in 2003, programme evaluations have confirmed that appliance efficiency policies, such as standards and labelling schemes (S&L), continue to be amongst the most cost effective means of reducing energy consumption and greenhouse gas emissions (McKinsey, 2007).

Figure 22 • Total residential electricity consumption, 1995-2006*



** The Plus 5 countries = Brazil, China, India, Mexico and South Africa.*

Source: IEA statistics.

Although S&L type programmes form the core of most country's energy efficiency policies, national programmes for appliances typically comprise a portfolio of measures, which often include financial mechanisms, requirements within building codes, procurement policies and information provision, amongst others. This chapter summarises the most significant national or regional policies designed to promote efficient electrical appliances in IEA and the five large developing economies of Brazil, China, India, Mexico and South Africa. In many cases further initiatives occur at a sub-national level and although some examples have been included in this review, in general only the major national programmes have been covered. Also excluded from this review are types of programmes which are designed to have a long-term impact, such as general educational and information programmes and research and development activities.

Many national energy efficiency programmes have been in operation for at least ten years, and a large number of lessons have been learnt in the process. Previous IEA publications, which

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have highlighted some of the key issues in the design and implementation of product policies in varying degrees of detail, include the following:

- *Experience with Energy Efficiency Regulations for Electrical Equipment* (IEA, 2007);
- *Light's Labour's Lost: Policies for Energy-Efficient Lighting* (OECD/IEA, 2006);
- *Energy Efficiency Labels and Standards: A Guidebook for Appliances, Equipment and Lighting,* Collaborative Labelling and Appliances Standards Program (CLASP, 2005);
- *Cool Appliances: Policy Strategies for Energy-Efficient Homes* (OECD/IEA, 2003);
- *Energy Labels and Standards* (OECD/IEA, 2000).

The IEA also conducts regular country reviews of energy performance and policies for each member country, and in recent times greater emphasis has been given to the topic of energy efficiency. As part of the work undertaken since 2005 for the G8, the IEA has also tracked progress with the implementation of specific energy efficiency policy recommendations made by the IEA Secretariat to the 2006, 2007 and 2008 G8 summits.

Building on this body of experience, the aim of this current review is to focus on the factors which are known to be critical in reaching successful policy outcomes: in this case the increased efficiency of electricity used by residential appliances and equipment.

Indicators of effective energy efficiency programmes

To continue to be effective, policy measures need to evolve in response to the changing environment. For example, the impacts of previous policies and natural technological development have made most major appliances more energy efficient year by year. Changing fuel prices will also alter the cost effectiveness equation. Such changes mean that performance thresholds and comparative label ratings need to be reviewed periodically to maintain impact. In addition to these maintenance activities, new product categories will almost certainly need to be added to the portfolio to reflect changes in consumption patterns, requiring the adoption of appropriate test methodologies and performance thresholds. Lastly, but equally important, changes in consumer and political awareness may alter the range of what is possible.[1]

For this reason, the regular assessment of performance thresholds against the market, the additional of new product categories and refinements to test methods are all good indicators of a dynamic energy efficiency programme which attempts to maximise energy efficiency opportunities. Therefore, in the following review, such activities are highlighted.

The quantity of resources available is also an important indicator of the potential effectiveness of energy efficiency programmes. As described above, the maintenance functions of policy measures already implemented are considerable and require an on-going effort, while the expansion to cover new product categories will also consume staff resources. As programmes mature, seeking to add refinements and include new products and aspects, the task often

1. *For example, during 2007-8 all OECD countries adopted policies designed to phase-out incandescent lamps – a measure which was inconceivable a few years previously.*

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becomes more onerous, for example where international test methods are not readily available and methodologies must be developed. As a result, the human and financial resources required by energy efficiency programmes in order to perform adequately will tend to increase over time. Where feasible, staffing levels and budgets for national programmes have been indicated in the following chapters. However it should be noted that there is considerable variation in the organisational structure of national programmes so that the data presented may not always capture all related activity by other agencies, organisations or consultants. Work on the inclusion of energy efficiency requirements for appliances and equipment in building regulations, which is typically managed separately from appliance energy efficiency programmes, is a good example.

The legal, institutional and policy frameworks which exist within governments defines how the different policy areas effecting appliances are co-ordinated and the scope of energy efficiency policies. For example, the identification of clear policy aims, the allocation of appropriate powers and responsibilities, and the use of expert agencies, are all necessary to support a successful appliance efficiency programme. Therefore as policy aspirations grow, these frameworks may need to be changed in order to better deliver increases in efficiency. Where possible, significant changes to appliance legislation, policy and organisational structures are identified in this review.

As the number of internationally traded appliances grows, the need for formal and informal linkages between programme managers and policy-makers from different countries and regions becomes more important. Such liaison provides the opportunity for countries to fast-track the development process by considering measures already adopted elsewhere, which at the same time assists in promoting international alignment. Of course, measures suitable for one country may not always apply to others because of market or other factors; however an understanding of what policies are used elsewhere and their effectiveness is always a good place to start the development process. For these reasons, examples of projects involving linkages between national programmes have also been provided in the following review.

Evaluation is an important process for any type of programme in order to demonstrate achievements, justify continuing resource allocation and provide feedback on how to improve implementation. For appliance energy efficiency programmes, evaluation can occur on many levels and include gathering information on consumer awareness of energy labels, manufacturer awareness of performance requirements, actual monitoring of appliance performance, and many other issues which affect the overall impact of the programme (IEA, 2008a). For S&L programmes in particular, an assessment of their impact raises questions about the degree to which the rules and requirements are followed; and therefore verification is an important aspect of these programmes. Because it has a direct effect on energy saving, the IEA has drawn attention to the need for effective compliance regimes, including legal structures, verification and enforcement activities, and therefore information on national efforts in this area are highlighted in this review (IEA, 2008).

Following the detailed review of each country or region, a number of general conclusions and recommendations are presented at the end of this chapter.

It should be noted that while every effort has been made to ensure that the information presented in this review is accurate at the time of going to press, changes are occurring to appliance energy efficiency policies on a daily basis.

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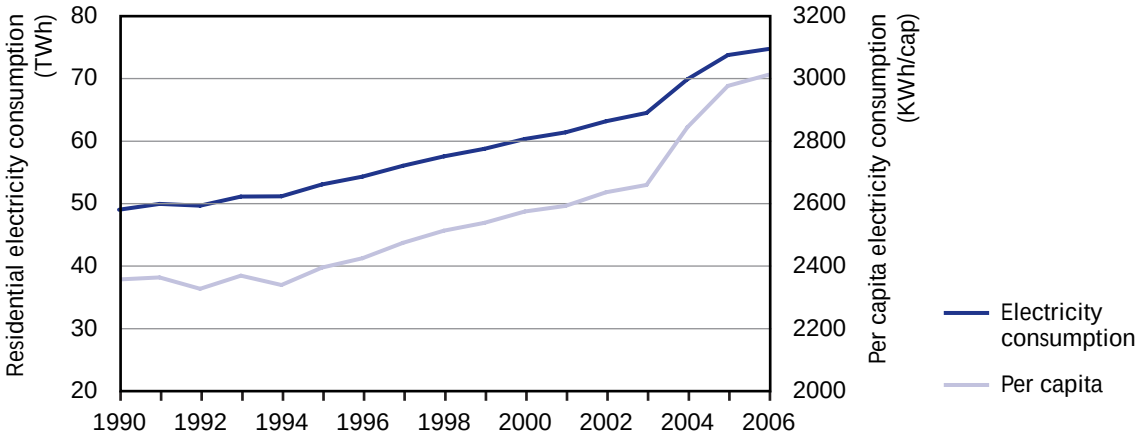
AUSTRALASIA

Residential electricity consumption in Australia and New Zealand grew by 2.7% per annum between 1990 and 2006, with the combined population rising by 1.1% per annum over the same period. The annual per capita electricity consumption grew at 1.5% over these 16 years, with a sharp rise between 2003 and 2005, largely driven by the increase in electronic equipment, lighting and use of air-conditioning in Australia.

Figure 23 • Total residential and per capita electricity consumption, Australasia, 1995-2006



Source: IEA statistics.

The distribution of residential electricity consumption in Australia, shown in Figure 24, shows that water heater, refrigeration and lighting represented 51% of total consumption in 2005. This should be compared to 1990 when these end-uses were responsible for 66% of total electricity use, illustrating the changes in the profile of energy use (see Figure 25).

Australia and New Zealand continue to make strong progress with their ambitious energy efficiency programme for appliances. Since 2002, notable developments have included:

- Improvements in the co-ordinating structure and increase in staff allocations.
- A government mandate to go beyond 'no regrets' measures.
- Updating of labels and MEPs for several product categories.
- Substantive progress on Labels and MEPS for new categories of products, including televisions and set-top boxes.
- Increased focus on compliance issues.
- Increased engagement and leadership within the world community.
- Leading the world in announcing a regulated horizontal 1 Watt standby power limit by 2012 (November 2006) and the phase-out of inefficient incandescent lights by 2009-2010 (February 2007).

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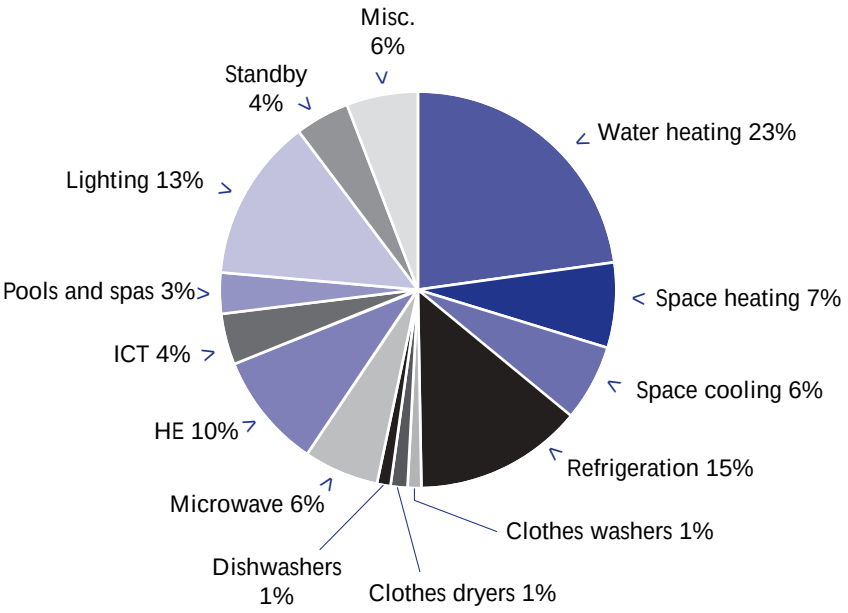
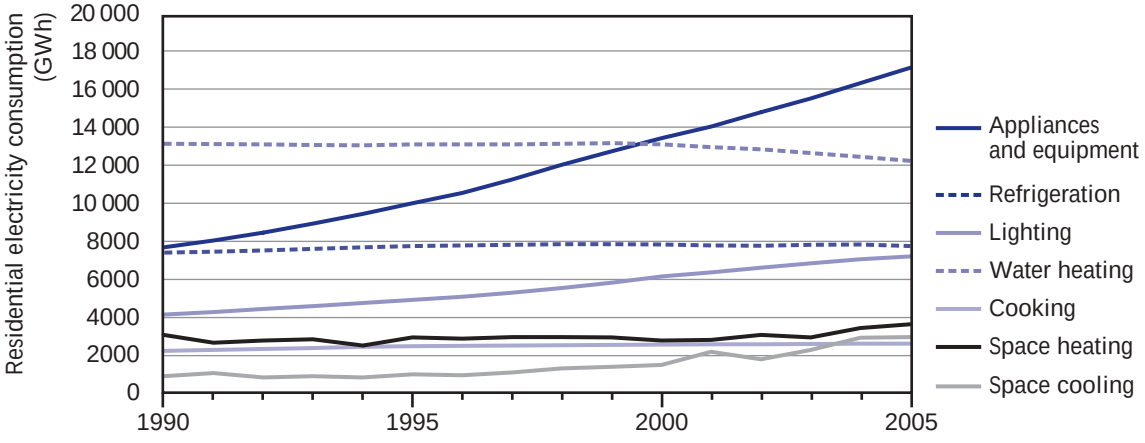
Figure 24 • Distribution of electricity consumption in Australia by end-use in 2005



Source: Commonwealth of Australia, 2008.

Figure 25 • Change in electricity use in Australia, 1990-2005 by major end-use



Source: Commonwealth of Australia, 2008.

Institutional organisation, policies and financial issues

In 2005 the Equipment Energy Efficiency Committee (E3) replaced the National Appliance and Equipment Energy Efficiency Committee (NAEEEC) as the co-ordinating body for the national appliance energy efficiency programme. The E3 Committee, which comprises officials from federal, state and territory government agencies, and representatives from New Zealand, reports through the Energy Efficiency Working Group to the Ministerial Council on Energy (MCE). These

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changes reflect the growing profile of the programme and have helped to further formalise the links with New Zealand.

In October 2006, the Ministerial Council on Energy (MCE) adopted new criteria for the assessment of policy measures. MCE agreed to consider any new energy efficiency measures which are less costly than alternative actions to reduce greenhouse emissions, even when they impose a net cost to the community. This is an important change from the previous criteria which limited options to those measures which demonstrated a net financial benefit (excluding environmental benefits) (E3, 2007a).

Budget

Resources have expanded steadily over recent years to keep pace with the growing scope of the energy efficiency programme to cover an increasing number of electrical products, and further involvement in gas appliances. There are currently 17 full-time staff positions within the Australian federal government appliance energy efficiency team.

Table 5 • National budget for electrical appliance energy efficiency programmes in Australia, AUD million, 2003-4 to 2006-7

Financial Year	2003-4	2004-5	2005-6	2006-7
MCE	1.45	1.55	1.533 0.3 (gas)	1.528 0.4 (gas)

Source: NAEEEP 2005a; E3 2006b; E3 2007a.

In 2007-2008 there is now an operating budget of AUD 2 million (USD 1.95 million) in a special energy fund administered by a national committee. There is a further AUD 2 million in funding from in-kind support from states and other jurisdictions. These projects do not include staff resources from the 10 jurisdictions involved. This investment in public sector expenditure is projected to save the community AUD 4.8 billion (USD 3.8 billion) by 2020.

In addition, the residential programme is also likely to gain resources as a result of Australia's participation in the Asia Pacific Partnership on Clean Development and Climate (APP). Australia has allocated AUD 8.5 million (USD 7.6 million) towards projects under the Buildings and Appliances Task Force (see below), and there are considerable synergies among at least four of these projects and the domestic programme. In particular, the domestic programme will benefit from the AUD 4 million (USD 3.9 million) allocated for work on Standby Power and Harmonisation of Test Procedures for computers, heating and cooling systems, lighting and electronic motors.

Energy performance labelling

Comparison label

The Energy Rating Label is a category-type label and is mandatory for all relevant appliances sold in Australia and New Zealand. It awards appliances 1 to 6 stars (1 star being the most inefficient, and scaling up to 6 being the most efficient appliance) based on their energy consumption.

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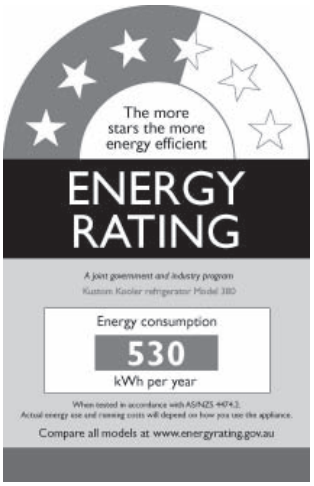
Although Energy Labels have not been introduced for any new products for a considerable period, Australia and New Zealand place considerable emphasis on maintaining the effectiveness of the programme for existing products. Studies have been regularly undertaken to assess consumer awareness of the label and to monitor market penetrations, leading to a major revision of ratings being undertaken in 2000.



From April 2007 the standby power consumption in clothes washers and dishwashers was included in the energy label for these products, following a revision to the respective test methods in 2005. Analysis of the impact of this revision estimated that it would save 3.2 Mt CO_2 and AUD 40 million (USD 39 million) in the period to 2020, for an increase in appliance costs of AUD 2.8 m (USD 2.7 million).

With the introduction of increasingly stringent MEPS in 2005 for refrigerators and freezers, 1 star and 1.5 star products were eliminated from the market, requiring the rating scale to be revised. This new algorithm for determining the star rating of refrigerators and freezers will be introduced in late 2009 (E3 2007e; EES 2005).

A revision to the energy label for air conditioners (mandatory for single phase non-ducted units since 2000) has also been proposed and is currently under consideration.

New energy performance labels for televisions,[2] personal computers and monitors (covering both standby and on mode consumption), have also been proposed for adoption from 2009.

In order to determine consumer attitudes in Australia and New Zealand towards the Energy Rating Label, a major market research project was undertaken in 2005. The study determined that the energy rating label is recognised by 94% of consumers unaided, rising to 96% when prompted. This level of consumer awareness is usually encountered only with the market leading brands, and has grown considerably from a level of 45% in a 2001 survey. Seventy five percent (75%) of consumers regard the energy rating label as important in the appliance purchasing process (E3, 2006c).

Further market research was undertaken in 2007 to determine consumer attitudes towards labels for televisions and home computers; to determine the extent to which such information might influence consumer purchasing decisions as well reactions to specific designs (Winton, 2007). In 2008, following further market research, the Department of the Environment, Water, Heritage and the Arts has decided to adopt a modified 10-star rating scheme in order to better reflect the range of product performance in the market place, and to provide an increased incentive (Winton, 2008). This new label will be introduced progressively to integrate with the revision of labels for existing product categories, and the introduction of new categories to the scheme.

2. *Labelling for televisions will commence as a voluntary initiative and become mandatory in 2009 subject to ministerial approval (E3, 2008).*

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Endorsement label

Since 2002 Australia and New Zealand has experimented with a number of new approaches for endorsement labels; however there has been limited success in gaining the necessary support from consumers, industry or government in order to gain the required market presence.

Following extensive consultation with industry leaders, and consumers during 2003, the TESAW Top Energy Saver Award was launched in 2004 for refrigerators, freezers, clothes dryers, clothes washers, dishwashers, and air conditioners (O'Neill, 2003). This label recognised the top performing products covered by the comparative energy label.

Australia continued to use the U.S. based Energy Star label for home electronic products and office equipment, many of which were identical to those made for the U.S. market and therefore carried the Energy Star label in any event. Historically the profile of Energy Star in Australia has not been high and it has been difficult to expand the list of products. In 2005, E3 made the decision to move towards the use of the Energy Star label as the primary endorsement label for appliances and equipment in Australia and to discontinue TESAW as an endorsement label. This decision followed an agreement with the United States EPA and DOE that Australia and New Zealand could set local Energy Star criteria for products that were sold in the Australasian market, such as white goods where the USA had their own domestic criteria.

In a related development, a new website called Energy Allstars designed to promote the most efficient products in Australia was launched in 2005. Primarily aimed at government and commercial procurers, but with open access to consumers, the site lists individual products which match high efficiency criteria. The website also enables users to calculate lifetime energy costs for any product listed, using whatever energy prices, discount rates and other parameters they chose to specify.

During 2006, a cost-benefit analysis was undertaken which showed that Australian Governments would save AUD 727 million by 2020, with a net present value of over AUD 300 million (at a discount rate 10%) if they selected their purchases from Energy Allstars. Nevertheless efforts to require all relevant government purchases to meet Energy Allstars criteria where feasible have proved unsuccessful (GWA, 2005).

Despite these many attempts to develop and refine new endorsement initiatives in Australia, the future of endorsement labelling and Energy Allstars still appears uncertain and, up to the end of 2007, there has been no commitment from government or industry to undertake the type of marketing plan needed to underpin a successful endorsement programme.

On the other hand, New Zealand took the decision in 2005 to use Energy Star as the national endorsement label, and have targeted resources towards increasing brand awareness. Market research undertaken in 2007 showed nearly one-third of consumers were aware of the Energy Star mark; a 60% increase in awareness compared to 2006. It also demonstrated that for every NZD 1 spent on advertising by EECA in 2006/07, Energy Star partners spent NZD 1.39 (EECA, 2007).

Products covered by Energy Star in New Zealand include:

- heat pumps and air conditioners;
- televisions;

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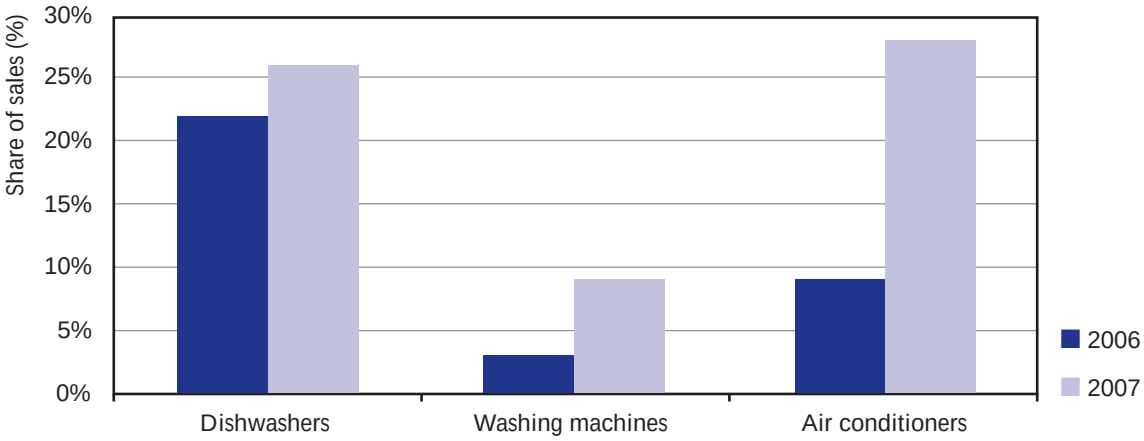
- DVD players and recorders;
- VCRs;
- audio equipment;
- printers and fax machines;
- dishwashers;
- clothes washers;
- computers and monitors;
- copiers and scanners;
- specifications for fridges, freezers and compact fluorescent light bulbs are under development.

The promotional efforts have helped enable sales of Energy Star labelled products to grow considerably over a very short period of time, as indicated in Figure 26.

Figure 26 • Progress in share of sales for Energy Star registered products in New Zealand, 2006-2007



Source: EECA, 2008.

Minimum energy performance standards (MEPS)

The Australia and New Zealand MEPS programme has been very active both in maintaining the stringency of its regulations and in expanding the coverage to include new products.

As well as the requirements for linear fluorescent ballasts and lamps (2003 and 2004), MEPS for water heaters, refrigerators and freezers were all updated in 2005, and for single-phase air-conditioners in 2006.

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Introducing new MEPS in Australia and New Zealand, as in many other countries, takes a considerable period of time in order to ensure that regulations are technically robust and widely understood; and that industry has sufficient advanced notice. To assist industry planning, E3 have issued a number of 10 year strategy documents which present governments' policy aspirations and provide a basis for consultation. These look at end-use applications rather than single appliances, and identify a range of appropriate policy tools. In 2002 the National Standby Strategy was released, followed in 2005 by Greenlight Australia, a report covering lighting issues. Ten year plans are being developed for air conditioning, demand side-management and swimming pool equipment.

Following on from these strategy documents, as a result a number of new regulations are in the pipeline. Regulatory Impact Assessments (RIS), a detailed cost-benefit analysis of the proposed MEPS required before new regulations can be adopted, were issued during 2007 for the following residential electrical products:

- external power supplies;
- set-top boxes;
- home entertainment equipment;
- incandescent lamps;
- halogen lamps;
- compact fluorescent lamps;
- personal computers and monitors.

In addition to consultation amongst stakeholders, each economic justification of regulatory intervention is subject to review by the Office of Best Practice Regulation (OBPR). In recent years, the OBPR have required an increasingly exhaustive examination of policy options and potential impacts. This examination occurs despite a growing body of evidence of the successful implementation of regulatory intervention both in Australasia and elsewhere and despite general support from Ministers, industry and other stakeholders for regulation. The result too often is delay and uncertainty adding costs and risk to business and difficulty for policy-makers and programme managers delivering the government's policy objectives in this area.

Of major international significance have been two ministerial announcements on energy efficiency. In November 2006, following an international conference on standby power held in Canberra, the government made a commitment to ensure that all electrical appliances are regulated to meet a one watt passive standby target by 2012.

Then in February 2007, the government, with the support of the lighting industry in Australia, also committed to the phase-out of inefficient lamps by 2009/10.

Both of these have provided a strong message to rest of the world, and have led to other countries following with similar policy commitments.

A summary of the major national policies for residential electrical equipment is shown in Table 6.

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Table 6 • Summary of major national policy measures for residential electrical appliances, Australasia

	Comparison label	Endorsement label	MEPS
Refrigerators	M (1992,2000)	V	M (1999, 2005)
Freezers	M (1992, 2000)	V	M (1999, 2005)
Clothes washers	M (1992, 2000)	V	
Clothes washers/dryers	M (1992, 2000)		
Clothes dryers	M (1992, 2000)	V	
Dishwashers	M (1992, 2000)	V	
Air conditioners			
– Single phase	M (1992)	V	M (2004, 2006)
– three phase			M (2001)
Space heaters		V	
Water heaters		V	M (1999, 2005)
Ballast for linear fluorescent lamps			M (2003)
Linear fluorescent lamps			M (2004)
Office equipment		V	
Consumer electronics		V	

Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary.

In 2004 Australia undertook an exercise to examine the coverage of the existing programme, in terms of the percentage of total energy consumption and by sector.

Table 7 • Coverage of sectoral energy use by NAEEEP (by % fossil fuel primary energy), Australia

	Mandatory coverage	Voluntary coverage	Hot water strategy	Total active coverage (a)	Research coverage	No coverage
Residential	41%	6%	20%	67%	19% (b)	14%
Commercial	37%	7%		43%	52%	5%
Manufacturing (c)	21%			21%	4%	75%
Coverage all sectors	29%	3%	5%	37%	17%	46%

Source: GWA, 2004. (a) Sum of Mandatory, Voluntary and Special Strategies (b) Coverage of wood-fired heaters, which represent 81.4 PJ of non-fossil primary energy, is additional (c) ANZSIC Division C.

Standby power

Australia undertook one of the first national surveys of standby power in 2000, involving direct measurements in 64 houses in three metropolitan centres and 801 telephone surveys. This

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revealed that 11.6% of residential electricity consumption was used by appliances in standby mode equivalent to 760 kWh per annum. In 2002 a National Standby Strategy *Money Isn't All You Are Saving* was launched with the aim that all products would meet a target of 1 watt in their lowest standby mode by 2012.

Detailed 'product profiles' were released during 2003/4 for 22 individual product categories to identify specific standby power targets, excluding home entertainment equipment to be covered separately by MEPs. To track progress towards these targets, eight store surveys spanning over 7 000 new products have been undertaken on a regular basis (annually or bi-annually) since 2001.

During 2005 a second national survey was undertaken based on direct measurements in 120 households, which found that standby contributed 10.7% of residential electricity consumption, equivalent to 807 kWh per annum per household. These findings suggest an increase of 12% in standby power consumption per household over the 5 year period (equivalent to an increase of approximately 2.3% per annum) (EES, 2006).

On 1 April 2007 the standby power consumption in clothes washers and dishwashers was included in the energy label for these products. Standby power requirements have also been included in the proposals for MEPS for each of the following products currently in the process of adoption:

- external power supplies;
- home entertainment equipment;
- televisions;
- set-top boxes;
- personal computers & monitors.

Carbon cap-and-trade scheme

Launched in 2003 in the largest Australian state, the New South Wales Greenhouse Gas Abatement Scheme has led to a substantial increase in energy efficiency activity in the residential sector and provides one of the models for consideration under the proposed national emissions trading scheme.

The NSW scheme comprises an obligation on electricity retailers to meet annual CO_2 per capita benchmark limits. The 2003 benchmark was 8.65 tonnes per customer and this has dropped progressively to 7.27 tonnes in 2007 and remains at this level until 2021. The regulations specify that failure to meet these benchmarks will be penalised by a fine of AUD 11.50 per tonne CO_2 (USD 11.24) (this was increased to A$12.00 [USD 11.74] in August 2007) (IPART, 2006).

The Electricity Supply Amendment (Greenhouse Gas Emission Reduction) Act 2002 also establishes a tradable certificate, known as a NSW Greenhouse Abatement Certificate (NGAC) which represents the avoided emission of one tonne of carbon dioxide equivalent (tCO_2-e). These can be created through reducing the greenhouse gas intensity of electricity generation; generating low emission intensity electricity; demand side abatement (DSA) activities which

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involve reducing, or increasing the efficiency of the consumption of electricity; or through carbon sequestration activities.

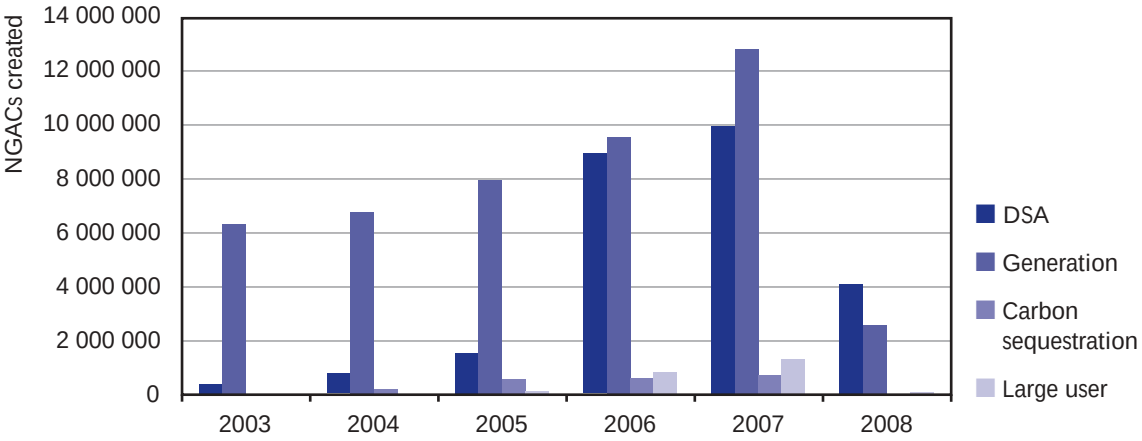
The Independent Pricing and Regulatory Tribunal (IPART), in its role as scheme administrator and compliance regulator, approves each provider and project able to create NGACs and oversees auditing activities.

For energy efficiency projects in the residential sector, which typically involve the installation of end-use equipment in many households, the number of certificates created is based on average energy savings values per installation. Typical projects in the residential sector include:

- The installation of CFL lamps and energy efficient showerheads;
- The replacement of electric hot water systems with gas or gas-boosted solar systems;
- The sale of energy efficiency clothes washers;
- The removal of old, inefficient refrigerators.

Figure 27 shows how demand side activities have expanded under the scheme, saving 25 Mt CO_2 and accounting for 34% of reductions from all accredited projects in the period 2003-2008. It is also noteworthy that 83% of these end-use savings have occurred in the residential sector between 2003 and 2006 (see Table 8 below), which has included the distribution of 24.1 million CFLs throughout NSW.

Figure 27 • Source of New South Wales greenhouse abatement certificates (NGACS) created between 2003 and 2007



Source: IPART 2007a, 2007b, 2008. Note: 2008 shows only part year data.

Table 8 • Number of residential demand side NGACS created between 2003 and 2007

Year	2003	2004	2005	2006
Residential DSA	8 387	315 425	953 879	8 325 861

Source: IPART 2007a, 2007b.

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The announcement at the end of 2007 by the Australian government that it intends to introduce a national emissions trading scheme made the future of the NSW scheme uncertain, and caused a downturn in trading activity and a sharp fall in the market price for certificates. However, with the publication in July 2008 of the Green Paper on the proposed *Carbon Pollution Reduction Scheme*[3] (CPRS), and agreement that transitional arrangements to a national scheme will be negotiated, the market is buoyant. It is intended that the national CPRS will commence in 2010.

Building regulations

In 2003 the Building Code of Australia was extensively updated to include new provisions for energy efficiency; primarily in terms of insulation levels, shading, lighting systems and controls and hot water systems. These were further extended in 2006 so that the total impact was estimated to be a saving of 1.8 Mt CO_2 in 2010 (Commonwealth of Australia, 2006).

Evaluation and enforcement activity

Energy efficiency programme impact evaluations are undertaken periodically to reflect the growing scope of activities. The first Australian evaluation in 2000 estimated a greenhouse gas reduction of 69.5 Mt CO_2-e for the period 2003-2015, while the second in 2003 estimated 91.2 Mt. The most recent study in 2005 has increased the previous savings estimate to 107.1 Mt by 2015, rising to 204.3 Mt by 2020. In this latest study, the savings in the residential sector are estimated to reduce national greenhouse emissions by about 117.5 Mt CO_2-e over the period 2005 to 2020 (NAEEP 2005b).

An assessment of the cost-benefit of the programme shows a net benefit from 2005 to 2020 of between AUD 16.6 billion (undiscounted) to AUD 4.8 billion discounted at 10% (USD 16.2-4.7 billion). The cost of the programme is estimated to be from negative AUD 81 to negative AUD 23 per tonne CO_2 saved (depending upon the discount rate assumed).

These savings can be predicted with a reasonable degree of accuracy as a result of the enforcement framework which has been built up over many years in Australia and New Zealand. The rules and technical processes are clearly articulated, and the results used to publicly identify any infringing parties. Where appropriate settlements have not been negotiated, the government has pursued further sanctions, including legal actions resulting in heavy fines.

Compliance and enforcement activities are shared between the national and state jurisdictions and coordinated by the E3 committee. A basic requirement of all mandatory programmes in Australia is to register all products to be offered for sale with one of the State-based regulators or in NZ. Most suppliers register on-line, where they must provide information on the characteristics and energy performance of each product. Often, but not always, this information must be supported by energy performance test reports. The requirements for participants in mandatory programmes are described in detail in a document called 'Administrative Guidelines' which is updated periodically and is available from the energyrating.gov.au website.

3. For further details see http://www.climatechange.gov.au/greenpaper/index.html

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Periodic market surveillance activities are undertaken to ensure that all relevant products are registered and where appropriate, display an energy label. For example, national surveys of whitegoods and air-conditioner labelling compliance were undertaken in 1998, 2000/2001, 2004/5 and 2006/07 (NAEEEC, 2004c, 2004b). The latest survey covered 473 stores, and over 37 000 products in metropolitan and regional areas around Australia. For whitegoods 96% of products displayed the correct energy rating label while 80% of air-conditioners complied. Manufacturers of appliances failing to display a label, or displaying the wrong label were asked to explain or withdraw products from the market.

Market surveillance is also undertaken by the State-based regulators, who may undertake store inspections, visit trade fairs and survey trade literature to check compliance. The powers vested in each state regulator vary; however some have the ability to impose on-the-spot fines of between AUD 150-200 for each non-compliant product on offer. These fines are levied on the retailer, so that while the sums in themselves are not large, they may off-set most of the retail profit margin and ensure that the retailer is wary of stocking further non-compliant products.

To test whether individual appliances conform to minimum energy performance requirements and/or energy label values, check-tests are undertaken by independent laboratories, accredited by the national testing authority. If products are found to be non-compliant, suppliers may withdraw the products from the market, or a process involving further tests is available. Since 1991, nearly 800 products have been individually tested, with a failure rate of almost 35%. Products are selected for testing on the basis of a number of criteria, including third party information, a previous record of non-compliance or volume of sales, and the age and star rating of models, which explains the high rate of failure. The number of check-tests undertaken in recent years is shown in the following table.

Recently, and in an effort to maximise the budget available for further compliance activities, E3 has obtained agreement from some suppliers to buy tested products and test reports from the government, on the understanding that funds raised by this means will be directed back into the testing programme.

Table 9 • Record of check tests and the results undertaken between 2004 and 2007

Year	Number tests	Failed screen test	Deregistered
2004 (Au)	58	28	11
2005 (Au & NZ)	40	24	10
2006 (Au & NZ)	18	13	9
2007 (Au & NZ)	85	35	10

Source: NAEEEP, 2005a; E3, 2006a, 2007b, 2007c.

Products which are de-registered are publicly identified in the E3 Annual Reports, which are made widely available. In addition, from October 2006 E3 has published four editions of a Compliance Newsletter designed to provide feedback on specific details of enforcement processes to stakeholders.

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E3 also has the ability to refer cases to the Australian Competition and Consumer Commission (ACCC) for further action, including legal sanctions. For example, after proven failure to comply for five separate models, LG was referred to the ACCC and in September 2006 agreed to compensate customers for increased electricity costs to a value of up to AUD 3.1 million (USD 3 million). In addition, LG made undertakings to publish corrective notices and improve their in-house compliance regime (ACCC 2006).

Demonstrating that a little enforcement action goes a long way, following publicity regarding the LG case, two major suppliers have voluntarily announced incidents of non-compliance during 2007. As an indication of corporate responsibility, Mitsubishi Electric and Carrier Air-Conditioning informed the Greenhouse Gas Office that a small number of models had been incorrectly labelled, and that they were withdrawing them from the market and recompensing consumers to the value of additional operating costs (E3, 2007d).

International engagement

Communities of practice

During 2003, Australia became engaged with groups in the United States, China and Europe interested in developing a single international test method for external power supplies. Over 350 local products were tested using the draft test method produced by an ad-hoc group drawn from these countries, and the results were used to finalise the methodology. This test method has subsequently been adopted by Energy Star, EU Code of Conduct and Standards Australia. In addition, the group suggested a set of tiered performance requirements and marking requirements suited for adoption by national authorities, either for mandatory or voluntary specification.

This project has provided a model for the concept of 'Communities of Practice' – a process for engaging with major stakeholders from the international community on individual products. Australia has led a similar initiative on Compact Fluorescent Lamps since May 2005 in an attempt to improve the test methodology and hence performance, of products on the market. An international round-robin testing programme involving seven laboratories in six countries has been undertaken, and the draft test method was submitted (September 2006) to the IEC as a proposed set of revisions to IEC 60969. Work on performance tiers is still underway.

Asia Pacific Partnership

Australia has been a significant supporter of the Asia Pacific Partnership on Clean Development and Climate (APP), and has a major role in supporting projects under its eight task forces:

- Cleaner Fossil Energy;
- Aluminium;
- Coal Mining;
- Steel;
- Cement;

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- Buildings and Appliances;
- Power Generation and Transmission;
- Renewable Energy and Distributed Generation.

In January 2006, the Australian government announced a commitment of AUD 100 million to the APP, of which AUD 95 million was available for projects. Since this announcement, the Australian government has fully allocated the AUD 95 million to approximately 62 projects across the eight APP Task Forces.

The Australian government is now focussing on implementing these projects, and in participating actively in APP Task Forces. This will include advocating for funding from APP partners to new and worthy project proposals, including those put forward by Australian proponents.

While no further direct funding is available, the Australian government will examine requests for in-kind support to projects on a case-by-case basis.

For more information about APP projects please visit www.asiapacificpartnership.org.

Table 10 • Australian financial support for Asia Pacific Partnership on Clean Development and Climate (APP) projects

Title	Australian financial contribution AUD million at 2007
Harmonisation of Appliance Testing Procedures	2.00*
Alignment of National Standby Power Approaches	2.00*
Energy Efficiency: Enabling Mechanisms - Residential Smart systems	0.25*
Utility Regulation and Incentives	0.30*
High Performance Buildings and Developments	0.5*
Improvements to Existing Buildings - Low Energy High Rise Framework for Energy Upgrades	0.25*
Enhancement of Building Energy Codes	0.60*
Energy Efficiency: Enabling Mechanisms - Green Lease Schedules	0.25*
Total	**6.15**

Source: Australian Government, 2007.

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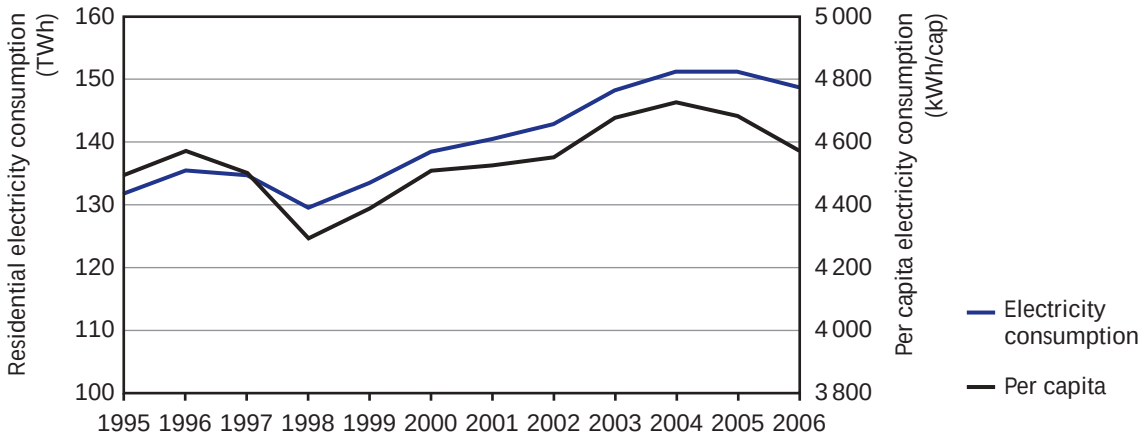
CANADA

Total residential electricity consumption in Canada grew by 1.1% per annum between 1995 and 2006, mainly due to a corresponding growth in population. However, per capita consumption also increased by 0.2% during this period (see Figure 28).

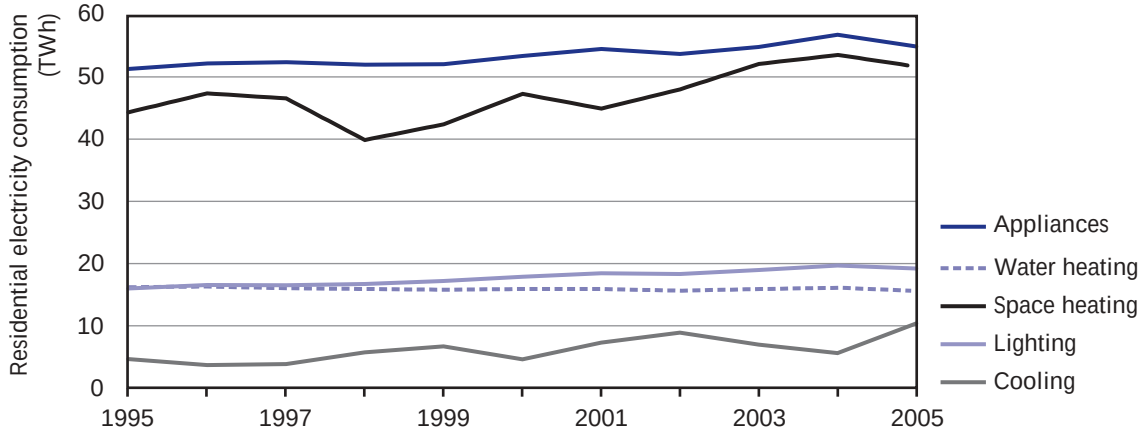
Figure 28 • Total residential and per capita electricity consumption, 1995-2006



Source: IEA statistics.

Electricity use actual fell quite sharply from 1996 to a low in 1998, primarily caused by a decrease in space heating consumption (see Figure 29). In Canada, electric heating accounted for 33% of all heating energy in 2002 (see Figure 30) and represents a major part of residential consumption. The dip in heating consumption was driven primarily by low demand as illustrated by the number of heating degree days. Reference to Figure 31 shows the high correlation between changes in the number of heating degree days and heating consumption, and similarly for cooling.

Figure 29 • Residential electricity consumption by major end-use equipment, 1995-2005



Source: OEE, 2008b.

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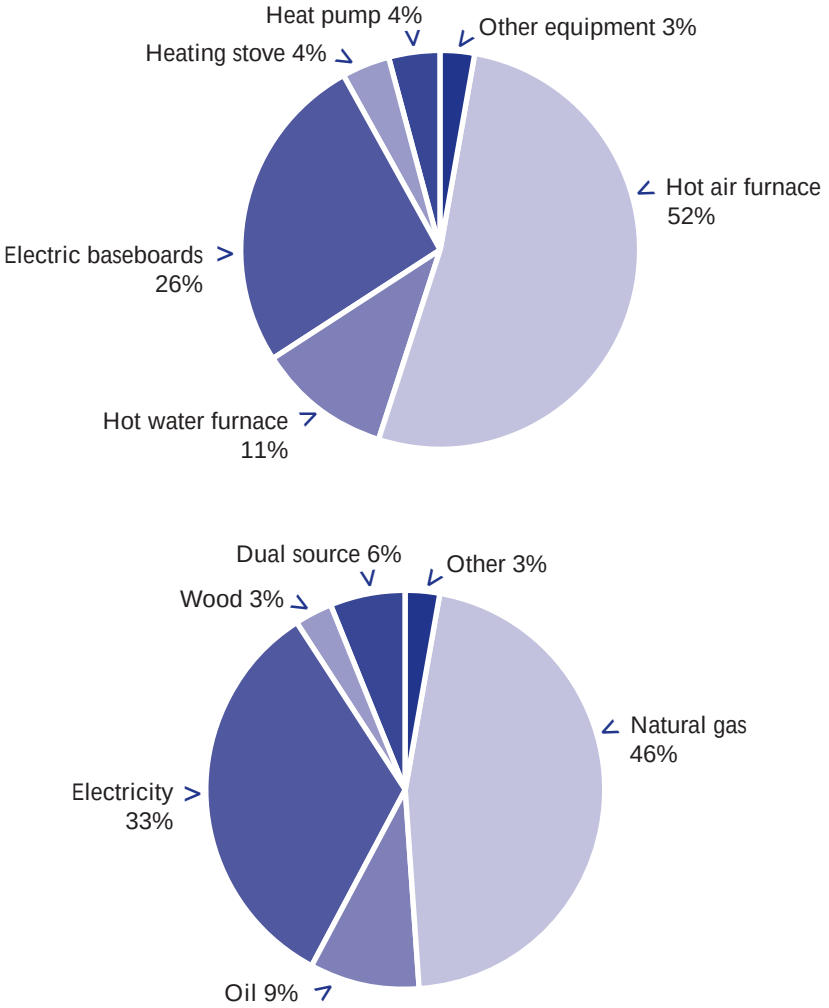
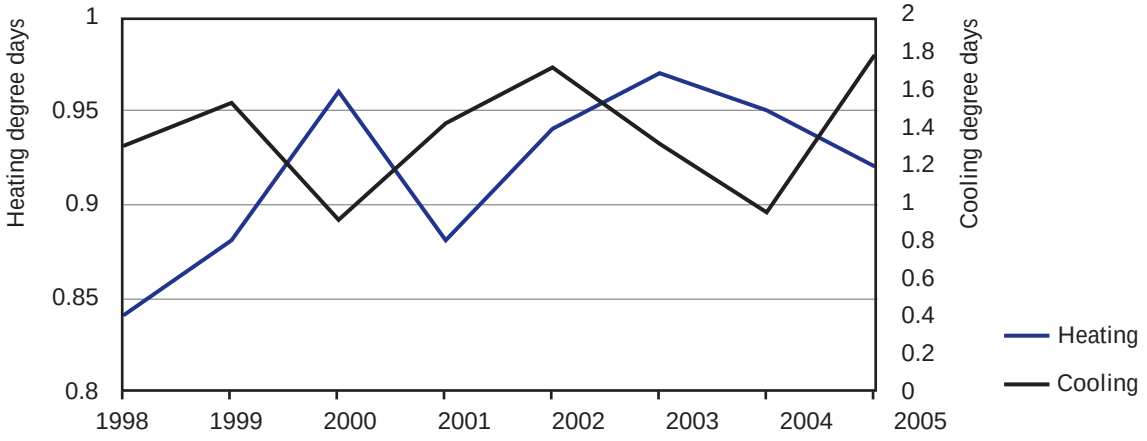
Figure 30 • Energy use by type of heating appliances and by fuel, 2002



Source: NRCan, 2005.

Figure 31 • Heating and cooling degree days, 1998-2005



Source: OEE, 2008b.

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Commencing in 1978 with the EnerGuide label, Canada has not only one of the longest running but also one of the most comprehensive examples of an appliance energy efficiency programme. Canada's approach to improving the energy performance of appliances and equipment combines the mechanisms of regulation to support minimum energy performance standards, and mandatory and voluntary labelling, information and promotion activities. Although this report focusses on appliances which use electricity, Canada also has many polices targeted towards gas and oil fired residential equipment.

Notable developments since 2002 include:

- Updating of MEPS for several product categories;
- Significant increase in range of products eligible for the Energy Star label;
- Release of a new federal action plan to take an integrated, nationally consistent approach to reduce greenhouse gas and air pollution, based on the new Clean Air Regulatory Agenda;
- Commitment to increased intergovernmental cooperation in advancing regulatory efficiency;
- Commitment to improved trilateral regulatory cooperation between North American Governments.

Institutional organisation, policies and financial issues

The Office of Energy Efficiency (OEE) was established in April 1998 as part of Natural Resources Canada (NRCan) to communicate the importance of energy efficiency and to manage programmes aimed at the residential, commercial/institutional, industrial and transportation sectors.

On 19 October 2006, the Canadian government issued a formal Notice of Intent in the Canada Gazette committing to raise the bar on energy efficiency standards for a range of consumer appliances and equipment Canada Gazette, 2006). Changes to the Energy Efficiency Regulations are estimated to raise the amount of energy use covered by regulations to 80% of energy used in homes and businesses.

These improvements are reflected in the strategy document *Turning the Corner: An Action Plan to Reduce Greenhouse Gas Emissions and Air Pollution*, released in April 2007 (Government of Canada, 2007). This commits the government to increase the stringency of energy performance standards for 10 products that are currently regulated, while another 20 products will be subject to regulation for the first time between 2007 and 2010. In addition to strengthening product energy efficiency standards, this strategy will introduce mandatory greenhouse emissions targets for industry for the first time and fuel efficiency regulation for cars and light-duty trucks.

Individual territories and provinces have the power to legislate for energy efficiency in Canada, and currently jurisdictions representing 75% of Canada's population have regulations in place that are harmonised to varying degrees with the federal regulations. These provinces include British Columbia, New Brunswick, Nova Scotia, Ontario and Quebec. Natural Resources Canada

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(NRCan) and these five provinces continue to work towards standards harmonisation via various intergovernmental fora. Non-regulatory energy efficiency activities and/or programmes are delivered by all Canadian jurisdictions.

In 2004, the federal, provincial and territorial energy ministers established a national consultative body on energy efficiency with representation from all Canadian territorial/provincial governments, the federal government, and members from industry and environmental non-government organisations. Known as the ADM Steering Committee on Energy Efficiency (ASCEE), this body is tasked with establishing a coordinated agenda for energy efficiency policy in the buildings, industrial and transport sectors.[4] Already this initiative has led to cooperation on energy codes, equipment standards, and lighting efficiency (CREA, 2006).

The National Advisory Council on Energy Efficiency (NACEE) is a second national advisory body on energy efficiency which was established earlier on in 1998. The NACEE are responsible for providing guidance to NRCan's Office of Energy Efficiency (OEE) by commenting on its business plan and associated programmes. Its membership comprises representation from all economic sectors,including territorial/provincial officials and representatives from gas and electricity utilities.

Budget

Federal budgets for energy efficiency programmes have doubled in the period 2003/4 to 2005/6, with particular growth in the Housing and Buildings sector. The overall budget in the 2006/7 financial year showed continued growth. Financial year 2006/7 was a year of interim funding in which a number of programmes were completed. A new suite of four-year ecoENERGY programmes was announced in January 2007, to begin operations on 1 April, 2007. The CAD 300 million ecoENERGY Efficiency initiative is part of the new set of programmes.

OEE has maintained a staff level of approximately 25 people over recent years.

Table 11 • Annual expenditure for energy efficiency programmes, CAD million, 2003-2007

Financial year	2003-4	2004-5	2005-6	2006-7
Equipment	22	9.2	16.5	19.2
Housing and buildings	41.5	76.8	107.4	128.8
General	10.7	26.8	16.4	5.8
TOTAL	**74.2**	**112.80**	**140.30**	**153.8**

Source: OEE, 2004, 2005a, 2006a; Laplante, 2008. "General" includes outreach, energy-use database and other activities.

Energy performance labelling

Labelling activities consists of rating, labelling and promotion to encourage greater production and uptake of more energy efficient products. Canada's EnerGuide label enables buyers to compare the energy consumption of different products, while the Energy Star label identifies

4. Note that the ASCEE replaces the former Demand-side Management Working Group (DSM WG) which began work in 2003 to identify the potential for DSM and regulatory processes and frameworks.

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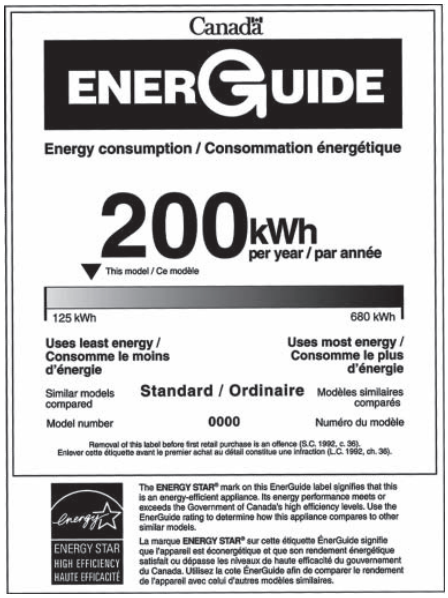
the most energy efficient models on the market. In some cases the Energy Star symbol may also appear on the EnerGuide label.

Comparative label: EnerGuide



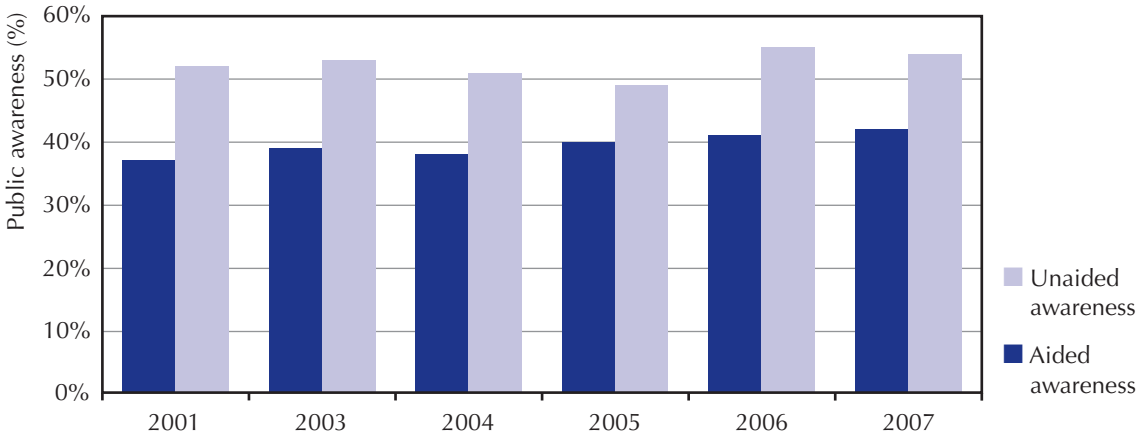
Canada's EnerGuide comparative label is a range-type tool which communicates the products energy use or efficiency in numerical terms as well as the products ranking on an energy use scale of all similar models available in Canada. The label is required to be applied to all relevant products and made visible to consumers.

There are, however, instances where products are typically purchased from a product brochure. As a result, manufacturers are encouraged to include an EnerGuide rating to product brochures or catalogues. In 2006, it was reported that 85% of products in the marketplace participate in the EnerGuide rating programme and publish the ratings in marketing material (OEE, 2006a).

Since 2002, the EnerGuide label has not been introduced for any new products. There were, however, changes to the energy consumption rating on the EnerGuide label for clothes washers and dishwashers in 2004. New energy performance standards and testing procedures were introduced to align with the United States and to accommodate more efficient technologies introduced to the marketplace; with the effect of lowering the rated energy consumption of tested models. Labelling will be introduced for various lamp types by 2010, include incandescent lamps, CFLs, ER and BR lamps (Wilkins, 2008).

Regular polls have been conducted to assess the level of public awareness of the EnerGuide label since 2001. Consumer awareness of the label has not grown substantial during the period 2001 to 2007, as shown in Figure 32, even though it has been used on major appliances since 1995 (NRCan, 2007).

Figure 32 • Consumer awareness of EnerGuide label, 2001-2007



Source: NRCan, 2007.

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Endorsement label: Energy Star

Canada generally follows the U.S. lead in selecting products and criteria for Energy Star, thereby harmonising requirements across the two countries. Since 2002, NRCan's Office of Energy Efficiency has significantly increased the list of products eligible for Energy Star certification. Over 20 new products have been added including: home appliances; heating, cooling and ventilation; additional lighting products, and; consumer electronics (OEE 2005b, 2006c, 2008a). For appliances and space conditioning equipment, the efficiency criteria are based on the same test methods as those applied under the Energy Efficiency Regulations (OEE, 2006a).

Specifications for many existing Energy Star products have also been updated to maintain the relevance and credibility of the Energy Star endorsement as the market penetration of efficient products increases. More stringent qualifying levels have been implemented for products such as central air conditioners and heat pumps (2006), and for clothes washers and dishwashers in 2007 (OEE, 2006c). Other changes include the removal of the Energy Star specification for programmable thermostats from 1 May 2008 in favour of an Education Program (OEE, 2007b).

The Energy Star label has also been combined with the EnerGuide label for major appliances and room air-conditioners to help consumers to identify the best performing products (OEE, 2006a).

Numerous Provincial and Territorial Governments, as well as energy suppliers are working hard to promote the Energy Star programme in their jurisdictions and increase the uptake of the most energy efficient appliances. Energy Star has become the new criterion to meet for many rebate and incentive programmes (OEE, 2006a). At the time of writing, three examples of major regional incentives programmes include:[5]

- The government of the Northwest Territories Energy Efficiency Incentive Program offers a CAD 200 rebate off the purchase price of a new Energy Star refrigerator or front-loading clothes washer for customers using diesel or natural gas. Note that the rebate is reduced to $100 for customers with grid supplied electricity.
- A number of Provinces, including British Columbia, Saskatchewan and Ontario, provide a point-of-sale retail sales tax (RST) exemption for Energy Star qualified appliances, such as light bulbs, refrigerators, dishwashers, clothes washers, freezers, dehumidifiers and room air-conditioners. In most cases, these also apply to installation costs where relevant. In Ontario, the RST exemption is expected to provide approximately $36 million in savings to Ontario consumers in 2007-08 and a further CAD 15 million in 2008-09 (ONT, 2008).
- The Ontario Power Authority Every Kilowatt Counts programme (spring 2008) follows previous initiatives and is an awareness and incentive programme running between April and June 2008. Incentives are provided through rebate coupons redeemable in eligible stores for a number of products (see Table 12). Coupons are made available in stores, downloadable from the webpage and in community newspapers (OPA, 2008).

5. *Details of rebates and incentives for selected Energy Star products across Canada can be found at Natural Resources Canada's Office of Energy Efficiency website at http://oee.nrcan.gc.ca/energystar/english/consumers/rebate.cfm?PrintView=N&Text=N*

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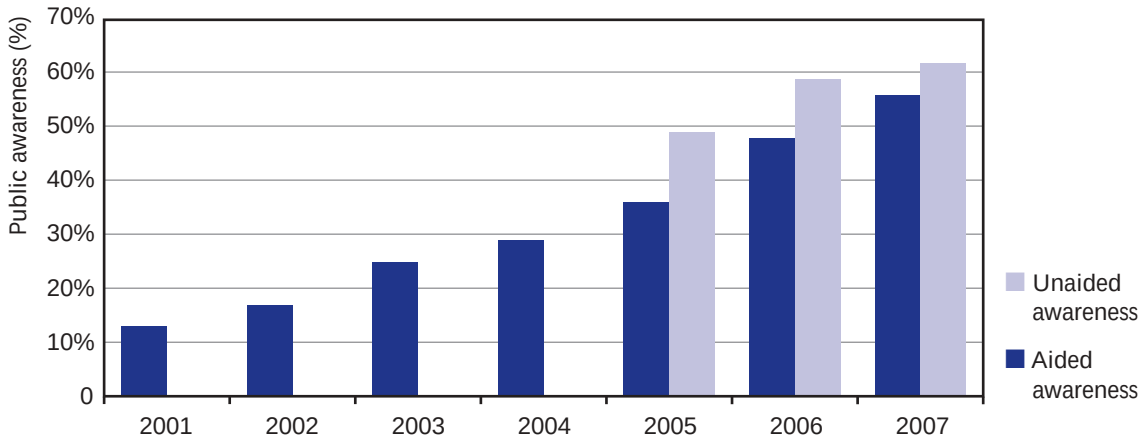
Table 12 • Ontario Power Authority 'Every Kilowatt Counts' programme, 2008

Item	Rebate value (CAD)
ENERGY STAR® qualified light fixtures	15
ENERGY STAR qualified CFL flood and spotlights	4
T8 fluorescent tube light fixtures and ballasts	8
Plug-in heavy-duty timers for above-ground pools & spas	5
Electrostatic or pleated fabric furnace filters	3

Source: OPA, 2008.

The government has undertaken regular market research to track consumer awareness of the Energy Star label and better understand the impact of promotional programmes. This research shows that (unaided) consumer recognition of the Energy Star label has increased steadily from 13% in 2001 to 56% in 2007. When prompted by a description of the label, 62% of consumers were aware of it, compared to 49% in 2005 (see Figure 33) (NRCan, 2007).

Figure 33 • Consumer awareness of Energy Star label, 2001-2007



Source: NRCAN, 2007.

The market penetration of Energy Star products also grew between 2001-2005; for example the penetration of Energy Star dishwashers increased from almost zero to 81% (OEE, 2006a).

Minimum energy performance standards (MEPS)

Minimum Energy Performance Standards (MEPS) apply to energy using products imported or shipped intra-provincially for sale or lease in Canada. By 2006, the Canadian government had adopted MEPS for over 30 products that consume over 70% of residential energy use (OEE, 2006a, 2006b). Since 2002, Canada has worked effectively to maintain the stringency of MEPS for existing products through changes to the Energy Efficiency Act, 1995. Performance requirements have been strengthened for the following products:

- lamps (2003);
- room air-conditioners (2003);

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- electric storage water heaters (2004);
- fluorescent lamp ballast (2005);
- central air-conditioners (2006);
- heat pumps (2006);
- clothes washers (2004 and again in 2007).

For the first time MEPS have also been introduced for ER and BR reflector lamps (2003) and two new types of residential refrigerating appliances - chest freezers with automatic defrost and bottom mounted refrigerator-freezers with automatic defrost and through the door icemakers (2006).

New testing and verification procedures are now applicable to electric ranges, clothes washers and dishwashers. For clothes washers and dishwashers, this has resulted in reduced efficiency ratings, consistent with ratings that appear on the EnergyGuide label in the United States. The main difference between the two test procedures for dishwashers relates to the number of loads used to calculate a dishwasher's estimates annual energy consumption. From 1 January 2004, standby power consumption has also been incorporated to determine the rated energy performance.

Under the government's Action Plan to reduce greenhouse gases and air pollution, MEPS will be introduced for a further 20 currently unregulated commercial and residential products and more stringent requirements for 10 products currently regulated between 2007 and 2010. Note that a commitment to reduce standby power consumption was announced by government on 23 July 2007 and is included in the regulatory agenda. The following residential products using electricity will be targeted:

New products to be regulated (2007-2010):

- TV set-top boxes;
- external power supplies;
- digital TV converters;
- battery chargers;
- standby power;
- pre-rinse spray valves;
- line voltage thermostats
- portable torchiere lighting fixtures (1 Jan 2007);
- ceiling fans and ceiling fan light kits (1 Jan 2007);
- residential wine chillers (1 Jan 2008) - for MEPS and labelling.

Products subject to more stringent standards (2007-2010):

- dishwashers (1 Jan 2010);
- refrigerators;
- freezers;
- automatic ice-makers (1 Jan 2008);
- residential dehumidifiers (1 Jan 2012).

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In April 2007, the federal government also committed to the phase-out of inefficient lighting by 2012. New packaging requirements will be introduced for general service incandescent lamps, general service fluorescent lamps and medium-base CFLs. Mandatory labelling, verification, test data, reporting and importing requirements for these lighting products will follow after amendments to Canada's energy efficiency regulations are approved by the government likely in 2008. Product packaging will provide information on light output in lumens, energy used in watts and average lifetime in hours. This will allow consumers to purchase lighting products that provide the lumens required at the lowest wattage rating.

A summary of the major national policies for residential electrical equipment is shown in Table 13.

Table 13 • Summary of major national policy measures for residential electrical appliances

	Comparison label	Endorsement label	MEPS
Refrigerators	M (1995,2001)	V (2001,2004,2008)	M (1995,2001)
Freezers	M (1995,2001,2006)	V (2001)	M (1995,2001,2006)
Clothes washers	M (1995,2004,2007)	V (2001, 2007)	M (1995,2004,2007)
Washer/dryers	M (1995,2004)	V (2001, 2007)	M (1995,2004)
Clothes dryers	M (1995)		M (1995)
Dishwashers	M (1995,2004)	V (2004,2007)	M (1995,2004)
Room air conditioners	M (1995,2003)		M (1995,2003)
Central air conditioners	V (1997)	V	M (1995,2006)
Single packaged air conditioners	V (1997)	V	M (1995)
Split system air conditioners	V (1997)	V	M (1998)
Ceiling fans		V	
Ventilating fans		V	
Dehumidifiers		V	M
Space heaters		V	M
Furnaces		V	M
Heat pumps		V (2006)	M (1995)
Programmable thermostats		V*	
Water heaters	M (1995,2004)		M (1995,2004)
Ranges/ovens	M (1995,2003)		M (1995,2003)
Residential light fixtures		V	
Lamps (several types)		V	M
Ballasts		V	M
CFLs		V	
Decorative light strings		V	
Office equipment		V	
Consumer electronics		V	

Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary.
* Note that Energy Star certification for this product will cease as of 1 May, 2008 (OEE, 2007a)

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Canada's ecoEnergy initiatives

On 1 April 2007, Canada's government launched a suite of ecoEnergy Initiatives to complement its Clean Air Regulatory Agenda. Aimed directly at promoting smarter energy use across all sectors of society, the ecoEnergy Efficiency Initiative is an investment of approximately CAD 300 million across 3 targeted programmes including: ecoEnergy Retrofit; ecoEnergy for Building and Houses, and; ecoEnergy for Industry.

Table 14 • Grants available under the EcoEnergy retrofit programme

Eligible improvements / retrofits	Grant amounts (CAD)		
	Single family home		MURB (per building)
	for 1st system	for 2nd system	(*per unit)
Replace your heating equipment with:			
• an ENERGY STAR® qualified gas furnace that has a 90.0% (AFUE) or better	300	150	Same as single family home
• an ENERGY STAR® qualified gas furnace that has a 92.0% AFUE or better, and a DC variable-speed motor	500	250	
• an ENERGY STAR® qualified oil or gas boiler that has an 85.0% AFUE or better	600	300	
• an ENERGY STAR® qualified oil furnace that has an 83.0% AFUE or better	300	150	
• an ENERGY STAR® qualified oil furnace that has an 85.0% AFUE or better, and a DC variable-speed motor	500	250	
• a CAN/CSA-C448 compliant ground- or water-source heat pump	3 500	N/A	
Install an ENERGY STAR® qualified air-source heat pump. (*per unit)	400	N/A	* 400
Install a minimum of 5 electronic thermostats for electric baseboard heaters. (**for each set of 5 installed)	30	N/A	** 30
Wood-burning appliance that meets either CSA-B415.1-M92 or the EPA standards (40 CFR Part 60)	300	150	* 300
Install a heat recovery ventilator (*per unit)	300	N/A	* 300
ENERGY STAR® qualified central air conditioner unit	200	N/A	200
ENERGY STAR® qualified window air conditioner(s) unit(s)	* 20	N/A	* 20
Solar domestic hot water system	500	N/A	500
Instantaneous gas water heater that has an energy factor (EF) of 0.80 or better	200	N/A	* 200
Condensing water heater that has an EF of 0.80 or better	300	N/A	* 300
Install a drain-water heat recovery (DWHR) system. Grants are based on the length of the pipe installed			
• three quarter (3/4) metre to one (1) metre (* per unit installed)	* 50	N/A	* 50
• over one (1) metre (* per unit installed)	* 100	N/A	* 100

Source: OEE, 2008c. MURBs = low-rise multi-unit residential buildings.

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The ecoEnergy Retrofit programme, scheduled to end in March 2011, provides grants up to CAD 5000 to home and property owners for energy efficiency improvements. A list of energy efficiency measures covered by the programme is shown in Table 14 over. The average grant is expected to yield an average of 30% reduction in energy use and 4 tonnes of CO_2 emissions per house (OEE, 2008c).

Building regulations

R-2000 standard and EnerGuide for houses

The R-2000 standard is a voluntary technical performance standard that encourages the construction and uptake of more energy efficient homes in Canada. The standard requirements are more stringent than current building codes with the result that new houses use at least 30% less energy than conventional new houses.

In addition to technical requirements for air-tightness, insulation, building materials and water use, R-2000 specifies the type of ventilation systems, space and water heating which can be installed. The standard itself is continually updated to include new technologies as they become established in the market place. Licensed R-2000 homebuilders are required to undertake training in specific construction and installation techniques and practices. This training is offered by NRCan who also provide third-party quality assurance by testing and certifying R-2000 homes.

Over 10,000 homes have been built and certified to the R-2000 standard (OEE, 2006d). Between 2003 and 2006, over 6000 builders and other professionals received R-2000 training (OEE, 2004, 2005a, 2006a).

EnerGuide for New Houses is an independent evaluation service for home-owners to assist with identifying energy efficiency improvements in existing homes that was introduced in 2003 and is based on the R-2000 standard and associated training. This programme specifically targets large-volume, mass market builders.

The EnerGuide for Houses label and associated report offers information to potential buyers about where energy is used and the potential for efficiency upgrades in the home. Between October 2003 and May 2006, a retrofit incentive was available as part of the programme offering homeowners a non-taxable grant for energy efficiency improvements in the home. In its final year between 2005-2006, CAD 24 million was awarded in energy grants, reducing energy consumption by an average of 28% in homes that were evaluated post-retrofit (OEE, 2006a). This programme has now been replaced by the ecoEnergy Retrofit Program.

International engagement

North America Security and Prosperity Partnership (SPP)

In June 2005, the North American Energy Working Group (NAEWG), which was established in 2001, became part of a broader trilateral initiative when the Governments of Canada, the United States and Mexico launched the Security and Prosperity Partnership (SPP) (DoE, 2007). The partnership is a voluntary framework with three primary goals: to strengthen regulatory

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cooperation; streamline regulation and regulatory process, and; encourage the compatibility of regulations where appropriate and feasible.

The energy component of this partnership builds on existing efforts by NAEWG to cooperate on energy efficiency standards. This group meets twice a year and has recently focussed on harmonisation of energy standards for refrigerators, air-conditioners and large electric motors (NAEWG, 2002). In July 2007, Energy Ministers from the three jurisdictions endorsed a work programme which will see strengthened cooperation on standby power consumption and further harmonisation of energy standards. Products for consideration include gas and oil water heaters, clothes washers, dishwashers, fluorescent lamps, incandescent reflector lamps and single package central AC and heat pumps (NAEWG, 2007).

MOU with China

Energy efficiency is among the areas of cooperation identified in two Memorandums of Understanding (MOU) between Canada and China: the *MOU on Energy Cooperation*, signed in February 2001, and; the *MOU on Climate Change and the Clean Development Mechanism*, signed January 2003 (OEE, 2004).

Asia-Pacific Partnership

Canada became an official participant in the Asia-Pacific Partnership on 15 October, 2007, during the 2nd Ministerial meeting in New Delhi, India.

Evaluation and enforcement activity

Evaluation

The Office of Energy Efficiency has for a number of years collected and published data on end-use energy consumption and trends as a means of evaluating the impact of policy measures.

Every two years the Office of Energy Efficiency publishes trends in energy use for the major household appliances which are published in a technical report *Energy Efficiency Trends* in Canada. The 2006 report shows that between 1992 and 2004, cumulative savings as a result of energy efficiency improvements in major household appliances equate to 25.16 PJ or CAD 615 million in energy costs (OEE, 2006b).

An assessment of market trends over a similar period, 2000-2003, reveals that the stock of major appliances increased by 33%, however, the energy consumption decreased by 12% (OEE, 2006a).

The OEE *Report to Parliament* for the fiscal year 2005-2006 year estimates savings of 25.6 Mt CO_2 by 2010, or 178.15 PJ as a result of all energy efficiency regulations implemented to date. These figures are determined using values derived from the relevant regulatory impact statement analysis (OEE, 2006a).

Energy use by fuel and sector, and end-use category, is also published in the *Energy Use Data Handbook*, providing a time series from 1990 to 2004.

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Enforcement

Energy efficiency reports and import documents provide the relevant information to Natural Resources Canada (NRCan) to monitor compliance. Energy Efficiency reports are provided by dealers when marketing a new product. The Energy Efficiency Act also requires that dealers provide to Canada Border Services Agency (CBSA) officials specific product information on customs documents for all shipments. Information provided is sufficient to allow verification that corresponding energy efficiency reports are available. Over the 2005-2006 fiscal year alone, NRCan processed over 501 108 records relating to the importation of regulated products to Canada and entered over 95 877 new or revised model numbers into the equipment database (OEE, 2006a). Note that all products prescribed under Energy Efficiency Regulations are subject to third-party verification by certification organisations accredited by the Standards Council of Canada. Product testing is conducted by NRCan on a compliant driven basis.

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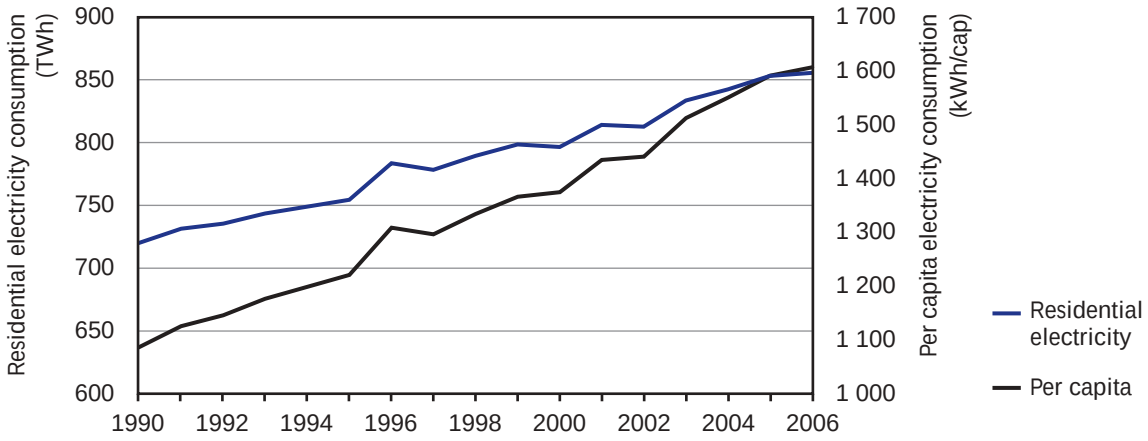
EUROPEAN UNION

In OECD Europe, total residential electricity consumption grew by 1.9% per annum between 1990 and 2006. One quarter of this was the result of an increase in population, while per capita electricity consumption grew by 1.4% over the same period (see Figure 34).

Figure 34 • Total residential and per capita electricity consumption, OECD Europe, 1995-2006



Source: IEA statistics.

Between 1996 and 2006 residential electricity consumption in OECD Europe grew by 18.5% with considerable variation between individual countries, as shown in Figure 35. Over this period, consumption ranges from -18% (Slovac Republic) and 125% (Turkey).

The estimated overall distribution of electricity consumption by end-use is shown in Figure 36, although there is considerable variation amongst member states.

There have been a wide range of appliance energy efficiency policy measures implemented in Europe since the early 1990s, including regulations and voluntary programmes across all member states, and many additional initiatives taken by individual countries. Despite variations in the implementation of minimum energy performance standards and labelling between countries in Europe, these programmes have proved to be highly successful. However, during the early 2000s insufficient attention to updating requirements in-line with technological improvements and overseas programmes meant that their effectiveness was reduced. A significant new impetus has been given to appliance energy efficiency with the adoption of the *Energy Efficiency Action Plan* in 2006 and work on the development and improvement of a number of specific directives, particularly the Ecodesign Directive approved in 2005. While many of the new policy initiatives will not be fully implemented until 2010 and some will take longer, there now appears to be a greatly improved framework for the development of progressive policies on appliances across Europe.

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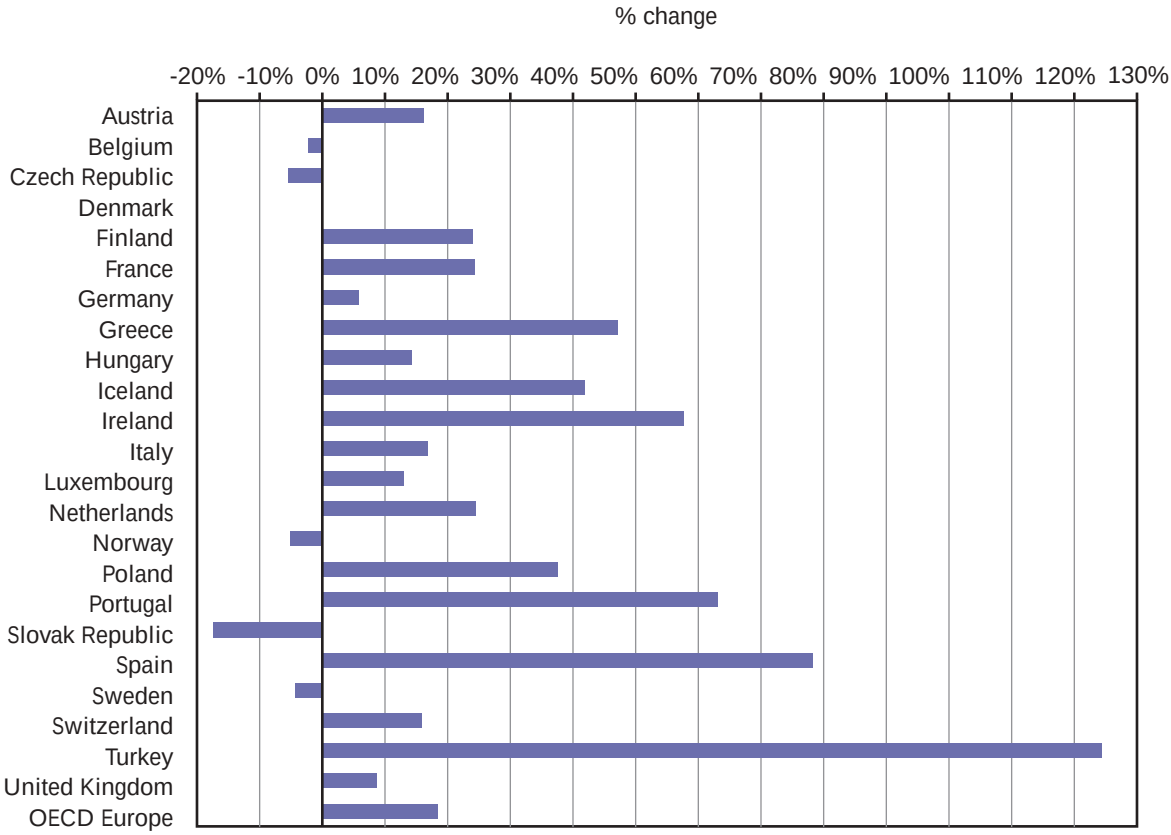
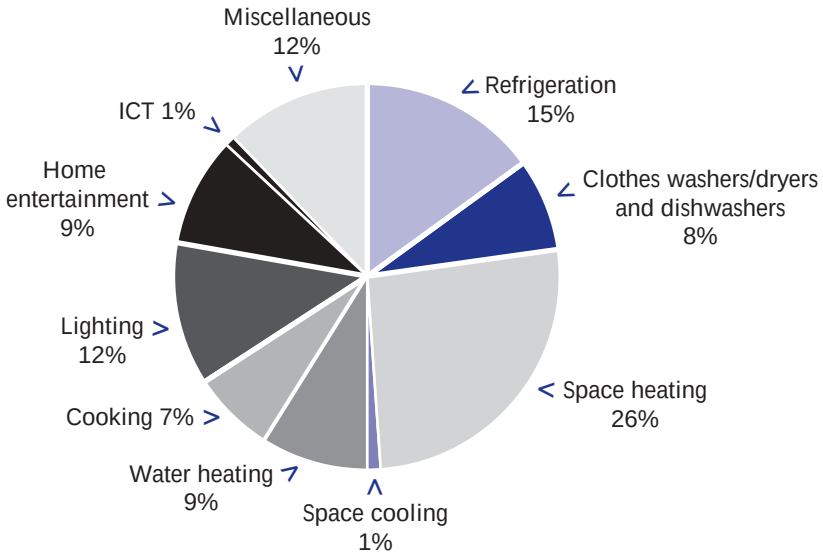
Figure 35 • Change in residential electricity consumption, OECD Europe, 1996-2006



Source: IEA statistics.

Figure 36 • Distribution of residential electricity by end-use, EU-15, 2004



Source: IES, 2007.

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Major significant changes in recent years include:

- The adoption of the European Energy Efficiency Action Plan aiming to reduce 20% reduction by 2020;
- Adoption of Directive on eco-design of Energy-using Products (EuP) covering an initial range of 18 appliance categories and the horizontal issue of standby power;
- Renewed agreement on Energy Star endorsement label use in Europe;
- Adoption of mandatory public sector procurement requirements for office equipment;
- Movement away from industry support voluntary agreements towards regulatory approaches;
- Growth in staff allocation to work on energy efficiency within Directorate-General for Energy and Transport (DG TREN).

Institutional organisation, policies and financial issues

In recent years, the European Parliament and Commission have given substantial and renewed attention to energy efficiency in general, much of which relates directly to appliance energy efficiency policy.

In 2005, the Commission issued a Green Paper: *Doing More with Less*, COM (2005)265. This was followed by a further Green Paper on *A European Strategy for Sustainable, Competitive and Secure Energy COM* (2006)105 in early 2006.

These gave rise to an EU *Action Plan for Energy Efficiency* released in October 2006 which outlined a framework of policies and measures designed to achieve an estimated 20% energy saving by 2020 compared to business as usual projections. This is equivalent to an estimated 1.5% improvement in primary energy intensity per annum up to 2020, in addition to a 1.8% business as usual annual improvement. To reach this target, more than 100 measures have been identified to be introduced at the European, national and local levels, including dynamic energy performance requirements for products, buildings and services to keep pace with technological advances; improving energy production, reducing transport's energy footprint; financing this market transformation; and changing consumer behaviour (EC, 2006).

The major elements of the Action Plan with regard to appliances include:

- The Eco-Design Directive lays down energy and environmental requirements which energy-using products must meet in order to be sold in the EU. These requirements also apply to imported products;
- Strengthening the Labelling Directive and its 8 implementing Directives. Prepare additional labelling implementing measures and revise existing labels, with a view to re-scale them every 5 years with only 10 – 20 % having A-label status;
- Renew agreement on the use of Energy Star in Europe for office equipment and consider regulations on public procurement practices;

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- Eco-labelling, which was introduced in 1992 and revised in 2000, is a voluntary scheme aimed at promoting products which have a reduced environmental impact over their lifecycle compared to other products in the same group;
- The 2006 Energy End-Use Efficiency and Energy Services Directive (ESD) aims to encourage energy efficiency through the development of a market for energy services and the delivery of energy efficiency programmes. The Directive, among other things, requires member states to develop National Energy Efficiency Action Plans (NEEAPs) which detail how they will reach a target of 9% less final energy consumption in 2016;.
- The 2002 EU Energy Performance of Buildings Directive (EPBD) sets minimum efficiency requirements for the energy performance of large buildings. Provisions with particular impact on appliances energy performance include the regular inspections of boilers and air conditioning systems. As part of the Energy Efficiency Action Plan the Commission will consider extending the EPBD through the inclusion of binding requirements to install passive heating and cooling technologies;
- Strengthen energy efficiency in energy and trade treaties, agreements, dialogues and other cooperation frameworks. This is to include voluntary agreements (commitments) with export industries on information, minimum efficiency requirements and labelling; and co-operation on measurement methods for minimum efficiency requirements and labelling.

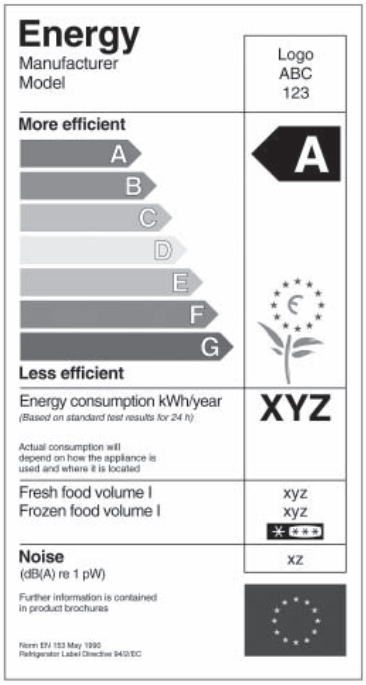
In order to implement the *Action Plan for Energy Efficiency*, the European Commission has added about a dozen posts to the energy efficiency policy units in DG-TREN, bringing the total to 18 statutory staff, supported by six detached national experts and some contract agents.

Energy performance labelling

Comparison label

The A to G comparative energy performance label used in Europe was established by the Framework Directive (92/75/EC) in 1992, which requires further implementation directives to identify performance thresholds and test methodologies for specific products. Accordingly, labelling programmes have been implemented for the following products to date:

- electric refrigerators and freezers and their combinations (94/2/EEC: 2003/66/EC);
- clothes washers (Directive 96/89/EC),
- washer dryers (Directive 96/60/EC);
- tumble dryers (Directive 95/13/EC);
- dishwashers (Directive 1999/9/EC);
- electric ovens (2002/40/EC);



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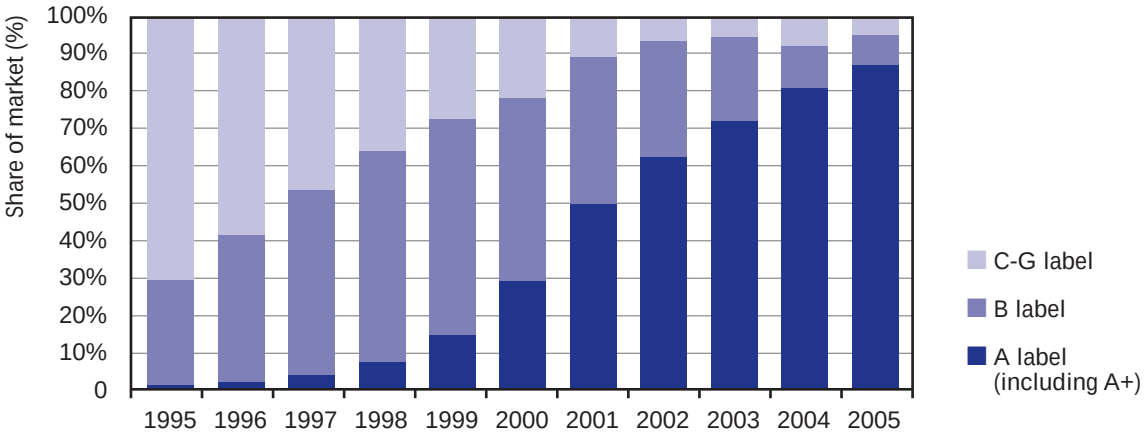
- lamps (Directive 98/11/EC);
- room air conditioners (2002/31/EC).

Despite differences between the rate at which these directives have been acted on and enforced by member states, sales of the most efficient products have grown considerably. By 2003, the majority of refrigerators and freezers fell within the A category providing consumers little ability to select between models, and hence the label was extended to include two new categories at the top of the scale: A+ and A++ (EC, 2003). As an example of the growing penetration of more efficient appliances in Europe, Figure 37 shows the development in the market for cold appliances in Denmark.

Figure 37 • Sales of cold appliances in Denmark, 1995-2005 by energy rating



Source: DEA, 2006.

Data from 2005 sales suggest that due to improvements in energy efficiency, a substantial proportion of the market for labelled products is now bunched towards the top of the labelling scale (see Table 15). At the same time, the success of the scheme has led to questions of whether it should not be extended to cover further products, for example boilers, water heaters and motors (EC, 2008a).

Table 15 • Energy rating of household appliance, percentage of sales, EU 15, 2004-05

Appliance	A or above	B	C
Refrigerator	61%	30%	9%
Freezers	47%	26%	27%
Washing machine	79%	11%	10%
Dishwasher	81%	11%	8%
Oven	47.1%	37%	16%
Lighting (household)	54% households with some CFLs		

Source: EE, 2007.

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As a result, the European Commission initiated a process for the revision of the Labelling Directive, issuing a consultation document in 2008. In addition to the expansion of the programme, issues which have been raised for consideration include:

- Reinforce dynamic labelling with periodic reviews;
- Provide additional product information as part of the label, such as CO_2 emissions or annual running costs;
- Request tighter tolerances in the measurement standards;
- Better enforcement of the labelling requirements in respect of both manufacturer declarations and retailers display of correct information;
- Legal protection of the label against unauthorised use;
- Implementation through regulations or decisions rather than directives in order to ensure equal implementation across the internal market (EC, 2008a).

Endorsement label: Energy Star

In mid-2001, the European Community agreed with the U.S. government to adopt the Energy Star programme for office equipment – computers, monitors, copiers, printers, scanners and fax machines. This agreement was extended for a further five years in June 2006.

Endorsement label: Eco-label

The EU eco-label scheme is designed to stimulate both the supply and demand of products with a reduced environmental impact. Initiated in 2000 (Regulation (EC) No 1980/2000), the EU Eco-label has a clear objective of encouraging businesses to market greener, officially licensed products. On the demand side, the scheme provides consumers with the means to make informed environmental choices when purchasing.

While the following 9 categories of energy consuming appliances are covered, at the current time the only electrical products labelled to date have been lamps (11 models) and televisions (62 models).

- dishwashers;
- light bulbs;
- personal computers;
- portable computers;
- refrigerators;
- televisions;
- vacuum cleaners;
- clothes washers;
- heat pumps (criteria under development).

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A review undertaken in 2005 concluded that:

- The scheme is a useful tool for policy makers, industry and consumers; with particular application to the public sector;
- More attention to the harmonisation of criteria would enable it to co-exist with national labels;
- Current application procedures and fees put off potential applicants;
- The EU Eco-label is actively used by most of the participants in their marketing campaigns; more than 50% of the Eco-label companies experienced an increase in their market share or in the number of new customers thanks to the adoption of the Flower.

Information and promotion campaigns and other actions aimed at increasing the knowledge and the demand of the EU Eco-label are perceived as the most effective measures for supporting the scheme and endorsing its success as a marketing opportunity (EVER, 2005).

In response, the Commission has proposed a number of amendments to simplify the application process and harmonise with other initiatives. Other improvements proposed include increasing promotional activity (EC, 2008b).

Group for Energy Efficient Appliances (GEEA)

Since 1996, government energy agencies and institutions from Denmark, the Netherlands, Sweden, Switzerland and Germany have been co-operating to publish criteria for energy efficient home electronics and office equipment. In 2007, it was decided to terminate the groups' activities, transferring them to the IEA Implementing Agreement on Efficient Electrical End-use Equipment (4E).

National labelling programmes

There are a number of endorsement labels for products in national markets, which have been in existence for several years, including:

- Austrian Eco Label;
- UK Energy Efficiency Recommended Logo;
- Dutch Milieukeur Label;
- German Blue Angel eco-label (Umweltzeichen);
- Nordic Swan Ecolabel;
- Spanish Aenor-Metio Ambiente Label (Harrington, 2001).

Minimum energy performance standards (MEPS)

The adoption of the Directive 2005/32/EC in July 2005 on the Ecodesign of Energy-using Products (EuP) establishes the framework for requirements governing the environmental performance of

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products. Previously each MEPS requirement had to be introduced through individual primary legislation, as had been done for household electric refrigerators, freezers and combinations (96/57/EC) and ballasts for fluorescent lighting (2000/55/EC).

The Ecodesign Directive enables the European Commission, in consultation with stakeholders including industry and member states, to establish the most effective implementing measures without further recourse to Parliament. While mandatory or voluntary consumer information programmes (such as labelling) and industry agreements are included, there is emphasis placed on the establishment of minimum energy performance standards.

Existing Directives on minimum energy efficiency requirements shall be considered as implementing this framework. It is also envisaged that there be synergies between the Ecodesign implementing measures and the energy efficiency and the Eco-label.

Although improved energy efficiency is only one of the criteria to be considered under the framework, it specifically identifies "measures with a high potential for reducing greenhouse gas emissions at low cost" as a priority, in view of the urgent need to meet commitments in the framework of the Kyoto Protocol.

The Directive potentially applies to a wide range of non-transport energy using products, with sales in excess of 200 000 units per annum within the EU. The following products have been identified for consideration, including one horizontal issue - standby power:

- public street-lighting;
- battery chargers, power supplies;
- commercial refrigerators and freezers, including chillers, display cabinets and vending machines;
- residential room conditioning appliances (air conditioners and ventilation);
- room air conditioning;
- electric motors 1-150 kW, water pumps (commercial buildings, drinking water, food, agriculture), circulators in buildings, ventilation fans (non-residential);
- electric motors, pumps, fans;
- domestic lighting, phase 1;
- domestic refrigeration, freezers;
- domestic dishwashers and clothes washers;
- boilers and combi-boilers (gas/oil/electric);
- solid fuel small combustion installations;
- water heaters (gas/oil/electric);
- personal computers (desktops & laptops) and computer monitors;
- consumer electronics: televisions

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- office lighting;
- imaging equipment: copiers, faxes, printers, scanners, multifunctional devices;
- standby and off-mode losses;
- simple TV set-top boxes;
- vacuum cleaners;
- complex TV set-top boxes;
- domestic lighting, phase II;
- laundry driers.

A summary of the major national policies for residential electrical equipment is shown in Table 16.

Table 16 • Summary of major national policy measures for residential electrical appliances

	Comparison label	Endorsement label	MEPS	Industry agreement
Refrigerators	M (1995)		M (1999)	
Freezers	M (1995)		M (1999)	
Clothes washers	M (1996)			
Clothes washers/dryers	M (1998)			
Clothes dryers	M (1996)			
Dishwashers	M (1999)			
Air conditioners	M (2003)			
Space heaters				
Water heaters				
Ovens	M (2003)			
Lamps	M (2001)			
Lamp ballasts			M (2005)	
Televisions				
VCRs				
Audio equipment				
Set-top boxes				V (2002, 2003, 2004, 2005, 2006, 2008)
External power supplies				V (2000, 2004)
Uninterruptible power supplies				V (2008)
Broadband equipment				V (2004)
Office equipment		V (2003, 2006)		V (2001, 2004)

Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary.

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Standby power

The most recent assessment of standby power in the EU-25 estimated a total consumption of 76 TWh per annum (or 40 W per household) in 2005, which includes all mains connected household devices, equivalent to 10.1 % of household electricity. The total residential energy consumption in standby mode, including hard-wired appliances, is estimated to be 109 TWh, 14.5 % of the total electricity consumption of European households, or 57 W per household (Fraunhofer, 2007).

Voluntary agreements

There has been a long history of voluntary agreements for residential electrical appliances in Europe. One of the first was initiated in 1997 through the European Association of Consumer Electronics Manufacturers (EACEM), which negotiated agreement with individual consumer electronics manufacturers to reduce the stand-by losses of TVs and VCRs. A second agreement was negotiated with EACEM for reducing the stand-by losses of audio equipment was concluded in 2000 and a further arrangement for TVs and DVDs was concluded in 2003.

Other major voluntary agreements covering the EU area are identified below.

European Codes of Conduct

The aim of the European Codes of Conduct is to reduce standby power through voluntary agreements between the Commission and members of industry. They developed from the report on Policy Instruments to Reduce Stand-by Losses of Consumer Electronic Equipment COM(1999)120 in 1999, which led to the introduction of two Codes of Conduct, for External Power Supplies and for Digital TV Services. These have been periodically updated and improved to keep pace with technological developments.

Even though the Codes have no associated label, and therefore provide only limited marketing value, these have attracted considerable participation by industry. They have also, through the development of energy performance criteria, provided the technical basis for the criteria adopted by energy efficiency programmes in other regions. Likewise they have provided considerable input into the development of criteria for the Ecodesign Directive for external power supplies and set-top boxes.

Subsequently further products have been added, which includes Broadband Equipment (2004), Data Centres (2007) and Uninterruptible Power Supplies (2008).

EICTA self-commitment on televisions and DVD players

In 2003, 14 members of the European Information & Communications Technology Industry Association (EICTA) signed an undertaking to improve the energy performance of the following household consumer electronic products sold in the European Union:

- CRT based televisions:
  - To achieve a sales weighted average of 3 watts standby passive in 2005;

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- Set a maximum power consumption in standby passive to 1 W by 2007;
- Improve the sales-weighted energy efficiency index by a target of i.e.10%, etc. (2010).

- Non-CRT based televisions:
  - To achieve a sales weighted average of 3 watt stand-by passive in 2005;
  - Set a maximum power consumption in stand-by passive to 1 W by 2007;
  - Co-operate with the EU Commission and member states.

- Digital Versatile Discs (DVD):
  - To achieve a sales weighted average of 1 watt stand-by passive in 2005;
  - Co-operate with the EU Commission and member states.

An interim report in 2005 (EICTA, 2005), found that sales weighted passive standby levels had actually risen in the first year of the commitment and that the range of standby power levels in available products was large (see Table 17). The changing market away from CRT towards flat screen TVs, the introduction of Digital TVS, and particularly the competition from overseas manufacturers, were factors identified as leading to this growth in standby power.

Table 17 • Survey of standby power levels from EICTA 2005 survey

	2003	2004	Range
CRT TV	1.75 W	1.87 W	0.3 – 10.0 W
Non CRT TV	1.54 W	2.66 W	0.5 – 5.0 W
DVD	1.27 W	1.30 W	0.1 – 6.0 W

Source: EICTA, 2005.

In fact, participants have now terminated this commitment as a result of:

- Insufficient awareness reflected in purchasing decisions by consumers;
- A lack of returns on investment for participating companies.

As a result EICTA has now declared its support for regulatory approaches to ensure basic requirements for consumer electronic products and is working with the Commission on the relevant Ecodesign studies (EICTA, 2006, 2007).

European Committee of Domestic Equipment Manufacturers (CECED)

European Committee of Domestic Equipment Manufacturers (CECED) have launched, and revised, voluntary commitments for the following products since 1997:

- clothes washers (1997);
- home dishwashers (1999);

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- home electric storage water heaters (1999);
- refrigerators, freezers and their combinations (2002, updated 2004) covering the years 2002-2010;
- second voluntary agreement on clothes washers (2002) covering the years 2002-2008.

Typically these agreements build on the relevant EU Labelling Directives, specifying a target for additional savings through increasing sales of higher efficiency products, while reducing sales of the least efficient products. For example, the first commitment for domestic clothes washers set an overall target of reducing the specific energy consumption of domestic clothes washers by 20% over the period 1994 - 2000. Based on data provided by participants, this aim was achieved at the end of 1999 (CECED, 2002). Overall, the investments made by participants in these commitments have been estimated by CECED at EUR 10 billion over the past decade (CECED, 2007a).

However, in 2007 CECED announced they would not continue with these voluntary agreements, in part because CECED members could no longer influence a large proportion of some markets as a result of growing competition. Instead CECED called for "legislative measures to ensure future energy performance standards" and for Governments to step up activities to ensure that existing and future regulations were enforced (CECED, 2007a, 2007b).

Procurement

On 10 July 2007, the European Council adopted a new Regulation requiring EU institutions and central Member State government authorities to use energy efficiency criteria no less demanding than those defined in the Energy Star programme when purchasing office equipment (Meller, 2007).

This is the first time that the Council and the European Parliament agree on making certain energy efficiency criteria mandatory for public procurement.

Building regulations

The Directive on the Energy Performance of Buildings (EPBD) (2002/91/EC) in force since January 2003 aims to provide for an ambitious step-ahead to increase the energy performance of public, commercial and private buildings in all member states.

The Directive is set to promote the improvement of energy performance of buildings with five requirements to be implemented by the member states:

- A general framework for guiding the calculation of the integrated performance of buildings (Article 3);
- The establishment, and regular review of, minimum energy performance standards in new and existing buildings (Article 5);
- Energy efficiency requirements for the refurbishment of large buildings (> 1 000m^2) (Article 6);

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- The requirement for energy certification of buildings when buildings are constructed, sold or rented (Article 7); and
- Inspection and assessment of heating and cooling installations (Article 9).

The EPBD is currently being extended under Article 11 of the Directive to cover smaller buildings, to develop minimum performance standards applicable to new and renovated buildings and to promote passive energy buildings (EC, 2008c).

Implementation of the Directive has turned out to be a considerable practical challenge for most member states. At the time of the 4 January 2006 deadline for transposition into national law, only two countries had more or less implemented the legislation and by December 2007 this figure had grown to only five (RIC, 2007). By April 2008, the Commission had initiated 17 infringement cases against member states that have failed completely or partially to notify national implementing measures or properly to implement the EPBD. Of these, two countries have been referred to the Court of Justice (EC, 2008c).

Fiscal policies: taxation

In addition, there is discussion amongst European policy-makers about the Value-Added Tax (VAT), and how it influences energy efficiency. Current EU rules on VAT, elaborated in the 2006 VAT Directive (2006/112/EC), specify that member states must subject supplies of goods and services to a rate of at least 15%, with the exception of a broad range of areas deemed essential, including energy, where countries are free to apply reduced rates of no less than 5%. Energy efficiency products and services are currently not eligible for the lower rate. There is now a debate for greater flexibility on VAT rates to encourage energy efficiency, and the EC is expecting to bring forward new legislative proposals on VAT rates in the summer of 2008 (EC, 2006).

Other initiatives

Topten

Topten was launched in 2000 in Switzerland by the Swiss Agency for Efficient Energy Use (S.A.F.E.) to enable consumers to find the most energy efficient and environmentally friendly equipment, products and services available in the market. Topten Switzerland presents 120 lists of products, in 40 categories and 8 fields: domestic appliances (12 categories), office equipment (6), consumer electronics (3), building technology (6), lighting (3), mobility (6), green electricity (2) and leisure (2).

Subsequently several other national versions have been initiated as follows:

- Topten France was launched in 2004 supported by WWF France, the consumer organisation CLCV, Sowatt and the Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME). Products initially covered include cold appliances and cars;
- Topprodukte.at was launched by the Austrian Energy Agency in 2005 launched, with the support of the Lebensministerium, WWF Austria, the province of Lower Austria and

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some web-companies. Topprodukte.at is online with more than 1200 products in over 40 categories in the fields of domestic appliances, office equipment, lighting and cars;

- Office-Topten was launched in 2006 by Dena, the German Energy Agency, presenting information on the most energy efficient PCs, notebooks, monitors, printers, copiers, scanner and multifunction-devices;
- Also in 2006, Euro-Topten was launched in the framework of the Intelligent Energy – Europe programme (IEE) (Bush et al., 2006).

Evaluation and enforcement activity

Evaluation

For refrigerators and freezers, clothes washers and dryers, the improvement in average efficiency since 1996 is estimated to be in the range 20 – 35%. This move to higher efficiency appliances contributed to annual energy savings over this period in the order of 24 TWh to 34 TWh, half of which is estimated to be due to labelling schemes (EE, 2007).

Compliance

Responsibility of compliance monitoring and enforcement of European Directives rests with member states, although in past Directives and other instruments the guidelines or obligations on verification and enforcement activities have been sketchy. As a result there are substantial differences between the level of efforts by individual countries in ensuring that products meet programme requirements and very little centralised co-ordination.

An independent review into compliance activities undertaken by member states in relation to energy performance labelling requirements demonstrated a high degree of variation in verification and enforcement activity. Through interviews with 11 governmental bodies in nine member states and six consumer organisations, the review covered several areas of compliance verification (ANEC, 2007).

Regarding labelling of appliances, a minority of countries reported market surveillance activities in shops and, where information was available, a significant number of products appeared either unlabelled or incorrectly labelled. Very few countries appeared to pursue compliance problems when these were brought to attention.

The review also found that in most countries an inadequate number of products are tested to check that the label is correct, and that no enforcement actions are taken or reported in seven out of the eleven member states (ANEC, 2007).

Other information provided by member states and industry has brought to light major discrepancies between the performance of products purchased by consumers and that indicated by energy labels. Table 18 compared the difference between the declared and test results for nine air-conditioners measured according to the labelling requirements, showing that even when the allowable tolerances of 15% are taken into account, most of the nine products were labelled incorrectly.

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Table 18 • Test results on sample of European air conditioners

Model	Declared capacity (kW)	Measured capacity (kW)	Declared energy consumption (kWh)	Measured energy consumption (kWh)	Declared energy class	Measured energy class
1	2.62 (cool)	1.87	335	458	C	F
2	2.62 (cool)	1.78	335	463	C	F
3	3.70 (cool)	3.61	575	609	A (cool)	C
	4.10 (heat)	3.73			B (heat)	D
4	2.60 (cool)	2.24	405	466	A (cool)	F
	2.80 (heat)	2.57			A (heat)	F
5	2.60 (cool)	2.19	405	450	A (cool)	E
	2.80 (heat)	2.57			A (heat)	F
6	3.508 (cool)	2.68	625	654	A	F
7	3.508 (cool)	2.72	625	660	A	F
8	2.41 (cool)	2.03	505	527	C	F
9	2.41 (cool)	2.00	505	528	C	F

Source: Falcioni, 2008.

Such findings clearly suggest that there is substantial scope to improve energy savings through better verification and enforcement processes, and that there are risks that consumer and industry confidence may be damaged if such improvements are not pursued. As a result the current review of the Energy Labelling Directive includes consideration of measures to strengthen compliance provisions, not only through the action by member states but also through reducing the tolerances allowed in performance measurement methodologies (EC, 2008a).

In addition to the above review, there are clear indications that compliance issues will be given a greater priority in the design and implementation of future energy efficiency policies in Europe.

For example, in October 2007, the Commission launched infringement procedures against 12 member states for failing to notify the EU of their national energy efficiency action plan by the agreed June 2007 deadline (Europa, 2007).

The EC has also launched court proceedings in February 2008 against Belgium and the UK for failure to meet requirements to implement the EPBD (Europa, 2008).

It is also noteworthy that the Ecodesign Directive is far more specific about the requirements placed on member states with respect to verification and enforcement activities. The Directive includes a list of specific activities to be undertaken by member states, including but not limited to:

- All products covered by EuP implementing measures must carry a CE conformity marking and a declaration of conformity issued which declares that the product complies with all relevant requirements;

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- Member states must take all appropriate measures to ensure that products sold and used comply with all implementing measures and bear the CE marking;
- Member states must designate the authorities responsible for market surveillance, and arrange for them to have and use the necessary powers to enforce the Directive;
- Member states shall define the surveillance tasks, powers and organisational arrangements and undertake appropriate checks on EuP compliance, on an adequate scale, and to oblige the manufacturer to recall non-compliant EuPs from the market. States must have the ability to require the provision of all necessary information and to take samples of products and subject them to compliance checks;
- Member states shall keep the Commission informed about the results of the market surveillance. The Commission will share this with other member states;
- Member states shall ensure that consumers and other interested parties are given an opportunity to submit observations on product compliance (EC, 2005).

International engagement

The EC plays an important role in international energy efficiency policy. Most recently, it has been instrumental in laying the ground work for the high-level International Partnership for Energy Efficiency Cooperation (IPEEC).

IPEEC was launched on 8 June 2008, with the support of the G8 countries, China, India, South Korea and the European Community. The Partnership offers to the participants a high level policy discussion, regular strategic cooperation and exchanges focussed exclusively on energy efficiency. It will support the ongoing work of the participating countries and relevant organisations to promote energy efficiency.

The objectives of the Partnership:

- Secure a clearer picture of international action on energy efficiency;
- Enable the development of a shared and strategic view covering these activities;
- Identify jointly the possible collaboration actions and maximising the impact and synergies of their individual national actions.

The Partnership will have a modular structure:

- High level energy officials will meet once a year, at the level of Vice-Minister and/or Director General;
- Each Participant will prepare their voluntary energy efficiency action plan, based on their national circumstances and building on existing work, i.e. no duplication with already existing action plans is foreseen;
- Each country will choose the area of activity according to its own interests and possibilities;

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- Experts from designated institutions will participate in concrete activities/ projects;
- The Partnership will draw on the expertise and work undertaken by international organisations and financial institutions, research organisations, the private sector, support public – private partnerships (EU, 2008).

The *Energy Policy for Europe Action Plan* 2007- 2009 also highlighted the need for the EU to continue its efforts in the field of common external energy policy. In support of the security of supply, competitiveness and sustainability goals of the EU energy policy, the external energy policy aims to promote a range of issues including strengthening international partnerships and building cooperation, based on the existing bilateral energy dialogues with a range of countries, focussing on the reduction of GHG, and energy efficiency.

Other international initiatives related to energy efficiency in which the EC is playing an important role include the discussions of the post-2012 climate regime under the UNFCCC, the Energy Community Treaty, the Baku Initiative, the Euro-Mediterranean Energy Partnership and its involvement in the Energy Charter.

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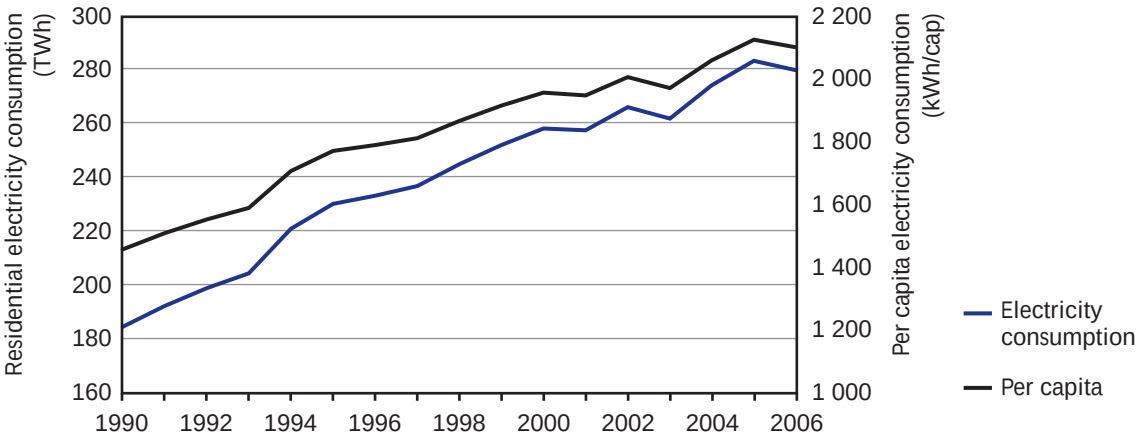
JAPAN

Residential electricity consumption has grown steadily by 2.6% per annum in the period from 1990 to 2006. Electricity consumption fell between 2005 and 2006, but because similar fluctuations have occurred previously, it is difficult to tell whether this is part of a trend. With little growth in the population, per capita electricity consumption has increased by 2.4% per annum over the same period (see Figure 38).

Figure 38 • Total and per capita residential electricity consumption in Japan, 1990-2006



Source: IEA Statistics.

Electricity was used to meet only 13% of all space heating energy demand in 2005, and 9% of energy for hot water, with the large majority used for refrigeration, lighting, televisions and sundry home appliances (see Figure 39). In 2005, cooling represented only 5% of household electricity consumption; however, with over 2.5 air conditioners per household in 2005, it is likely that space conditioning will account for a larger proportion of future household energy consumption (see Figure 40).

Japan has continued its focus on energy efficiency policy advancement and implementation over recent years, for example through the adoption of the new National Energy Strategy in 2006, and a revision to the Act on the Rational Use of Energy in 2005.

As part of the New National Energy Strategy the *Front Runner Plan* for energy conservation outlines specific measures for achieving its goal of improving energy consumption efficiency by at least 30% by 2030 compared with 2003. The plan is based on the recognition that, in addition to short-term energy conservation measures adopted with the first commitment period of the Kyoto Protocol, medium- and long-term measures are also important.

As holders of the presidency of the G8 in 2008, Japan played an important role in placing energy efficiency high on the list of topics discussed, and in ensuring that IEA policy recommendations featured prominently.

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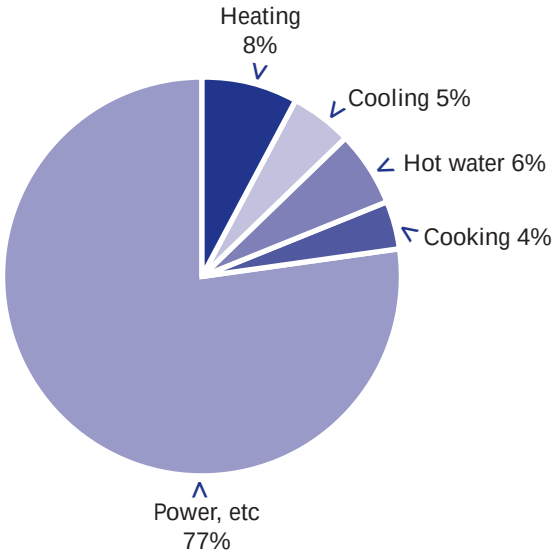
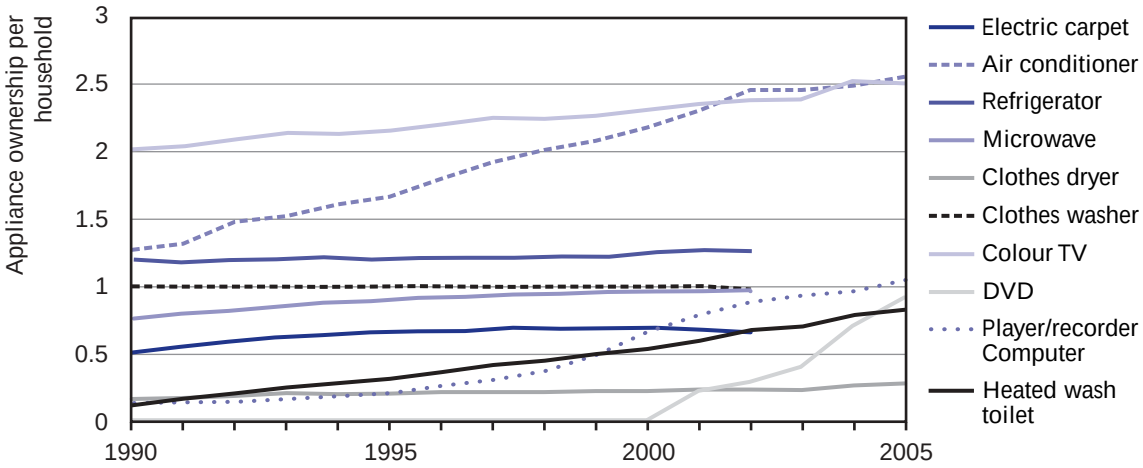
Figure 39 • Distribution of residential electricity consumption by end-use category, 2005



Source: ECCJ, 2007a.

Figure 40 • Household appliance ownership trends, 1990-2006



Source: ECCJ, 2007a.

Significant recent achievements in energy efficiency for residential electrical appliances include:

- A thorough assessment of electricity consumption by appliances in standby power mode, and the exploration of new policy options;
- The adoption of a new energy performance test method for refrigerators to ensure measurements reflect in-situ energy consumption;

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- The addition of two new product categories under the Top Runner programme: DVD recorders and routers;
- Updating the requirements for several existing appliance categories, such as air conditioners, refrigerators, televisions and computers;
- The introduction of a new comparative labelling programme for three appliance categories;
- Policy and technical support in energy efficiency activities outside Japan, particularly in Asian countries.

Institutional organisation, policies and financial issues

The 1979 Act on the Rational Use of Energy provides the legal basis for many of the energy efficiency programmes in the residential sector, including the Top Runner Programme. The Act has been revised in 1998, 2002 and most recently in 2005[6] in order to reflect changing policy objectives and technology improvements. The latest revision expands the scope of the regulation to include the transport sector and large residential buildings, and requires the energy supply and electrical product retail sectors to provide information that encourages consumers to conserve energy (OECD/IEA, 2008).

Overall responsibility for energy-sector matters resides with the Agency for Natural Resources and Energy (ANRE), a division of the Ministry of Economy, Trade and Industry (METI), which it fulfils in co-operation with other ministries that are responsible for the relevant sectors, such as the Ministry of Land, Infrastructure and Transport (MLIT) (OECD/IEA, 2008). Many energy conservations activities also require close links between METI and a number of government agencies, and independent institutes, which provide specialist advice, research capacity and administrative functions. Included amongst these are:

- Energy Conservation Center, Japan (ECCJ);
- The Institute of Energy Economics, Japan (IEEJ);
- The New Energy and Industrial Technology Development Organisation (NEDO);
- Jyukankyo Research Institute.

In additional, there are close links with Japanese industry, and many industry associations participate in advisory committees for energy efficiency programmes. The following associations are active in the residential appliances field:

- JEMA (Japan Electrical Manufacturers Association);
- JEITA (Japan Electronics & Information Technology Industries Association);
- JRAIA (Japan Refrigerator & Air Conditioning Industry Association;
- JLA (Japan Lighting Association);

6. Taking effect in April 2006.

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- JELMA (Japan Electric Lamp Manufacturers Association);
- JGKA (Japan Industrial Association of Gas and Kerosene).

Budget

There is a very substantial budget for energy conservation activities in Japan, totalling USD 1.49 billion (JPY 161.9 billion) in 2007, although this has fallen slightly (2%) compared to 2006. Table 19 shows the funding for the most relevant programmes in 2006 and 2007 (OECD/IEA, 2008).

Table 19 • Extract of Japan's energy efficiency budget

	2006 budget (JPY million)	2007 budget (JPY million)
Subsidy for support of project operators for rational energy use	24 150	26 926
Subsidy for promotion of introduction of high-efficiency energy systems for residences and buildings	13 420	12 176
Subsidy for promotion of introduction of high-efficiency water heaters	12 000	12 000
Subsidy for strategic technology development for rational energy use	6 200	8 000
Subsidy for promotion of introduction of energy-saving measures	371	372
Subsidy for information provision on introduction of energy-saving equipment	1 850	1 663

Source: OECD/IEA, 2008. Japan's fiscal year runs from 1 April to 31 March. For example, FY2006 runs from 1 April 2006 to 31 March 2007.

ECCJ staff undertake many of the administrative and management functions for the residential sector appliances programmes in Japan, with responsibility for:

- Energy conservation audits services for buildings;
- Ranking catalogue for energy efficient appliances (dissemination of Top Runner Program);
- Promotion of energy labelling system;
- International Energy Star programme implementation;
- Energy efficiency product retailer assessment system;
- Dissemination of energy conservation indicator *E-Co Navigator*;
- Energy education at primary and middle schools;
- ESCO research and development (EECJ, 2008).

Budget and staff allocations for ECCJ have remained stable for 2005 and 2006, as shown in Table 20, although both have fallen since 2003.

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Table 20 • ECCJ budget and staff allocations, 2001, 2003, 2005 and 2006

	2001 FY	2003 FY	FY2005	FY 2006
Budget	JPY 9.22 billion (USD 77 million)	JPY 5.869 billion (USD 53 million)	JPY 4.527 billion (USD 39 million)	JPY 4.631 billion (USD 39 million)
Staff	190	153	122	128

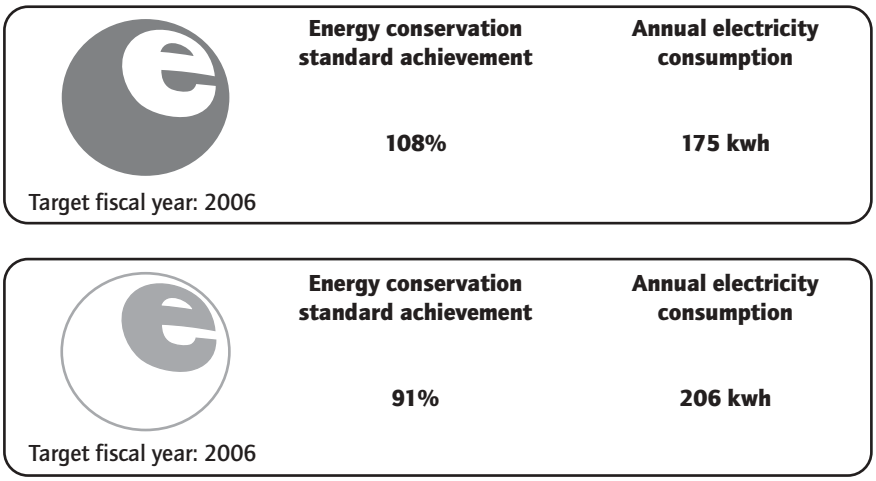
Source: ECCJ, 2001, 2003, 2004, 2006, 2007.

Energy performance labelling

Comparison label

Japan introduced a new comparison label, known as the *Uniform Energy-Saving Label* in October 2006, which is currently applied to air-conditioners,[7] refrigerators and televisions (CRT, LCD Plasma). The efficiency of the product is indicated by the number of stars displayed, with one star being the lowest ranking and five stars the most efficient. The average electricity consumption and costs are also displayed prominently.

Energy-saving label



In addition, the label indicates the performance of the product as a percentage of the Top Runner target. The number of stars however is not linked to the Top Runner target for each product category, and the allocation of stars is generally reviewed once more than 30% of models are eligible to display five stars (Yamada, 2008).

For the three products covered, it is mandatory for manufacturers to test products in accordance with the relevant JIS standard, and to make the energy performance information available to ECCJ. This information is then made available by ECCJ via the on-line database, *Information Service System on Energy Efficient Products*.

7. Excludes products with a cooling capacity of more than 4 kW.

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Uniform energy-saving label

Multi-stage rating system
Energy-saving performance is indicated in 5 stages, from 1 to 5 stars, from low to high performance of products offered on the market. – In order to clarify the compliance level with the Top Runner standard, arrows are placed under the stars, showing achievement and non-achievement.

Energy-saving labelling system
– Products which achieved the Top Runner standard, carry a green "e" mark, while others carry an orange "e" mark.
– Achievement level and energy consumption efficiency (annual electricity consumption) are also indicated.

Estimated annual electricity rates
– The estimated annual electricity rates are indicated to show the energy consumption efficiency (annual electricity consumption) clearly.

Unlike requirements for comparison labels systems in most other countries, in Japan there is no obligation on manufacturers to label products.[8] Instead, retailers are asked to use the labels as part of their marketing strategy. According to a survey in 2007/8 of 500 stores, approximately 60% applied labels to products (Yamada, 2008).

The more long-standing *Energy Saving Labelling Program* was launched in 2000 and applies to a broader range of 16 products running on oil, gas and electricity. The label itself does not carry as much information as the *Uniform Energy-Saving Label*; identifying the relevant Top Runner target date, the performance of the labelled product relative to this target, and the annual electricity consumption of the product.

The label carries an energy conservation logo, coloured orange for a product which does not meet the Top Runner target, and green when the product performance is better than the target (ECCJ, 2007b).

Neither manufacturers nor retailers are required to display this label, although the Japanese government requests that they do. Most of the leading home appliance brands include energy performance data (as would be displayed on the label), in catalogues and brochures, which are regularly updated. It should be noted that the use of such printed materials by consumers appears to be more widespread than is the case in most OECD countries.

As of July 2008, the *Energy Saving Label* can be applied to 16 products, including the following electrical appliances (the introductory date is shown in brackets):

- air conditioners (2000);
- electric refrigerators (2000);
- electric freezers (2000);
- fluorescent lights (2000);
- electric toilet seats (2003);
- televisions (CRT: 2000; LCD, Plasma 2006);

8. *However, it is understood that the Tokyo Metropolitan Government has mandated that retailers in Tokyo must label all products within a category where more than five similar products are displayed.*

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- computers (2004);
- magnetic disk units (2004);
- space heaters (2003);
- electric rice cookers (2007);
- microwave ovens (2007);
- DVD recorders (2007).

Endorsement label

Japan has been an international partner of Energy Star since 1995, although participation is limited to office equipment, i.e. computers, monitors and imaging equipment (printers, faxes, scanners, copiers, multi-function devices and digital duplicators). Consumers are able to access a database of products which meet the current Energy Star criteria from the ECCJ website.

Top Runner programme

The Top Runner programme, initiated in 1998 under the Rational Use of Energy Act, is the most significant policy measure in Japan for improving the efficiency of electrical appliances, although its coverage also extends to categories of non-residential equipment and vehicles.

The Top Runner programme works by setting energy efficiency performance targets for categories of products whether they are domestically manufactured or imported. These target levels are expressed as an average sales-weighted performance figure, which is generally based on the level of the most energy-efficient products on the market at the time when targets are set.

Manufacturers of a product category covered by the programme are deemed to have met the future energy efficiency performance standard if the sales-weighted average energy efficiency performance of their products meets or exceeds the target level in the target year. There are exemptions within most categories for suppliers that only sell small quantities of products per year.

Although the Top Runner programme shares the objective of raising the average efficiency of appliances sold with regulatory measures used in other countries, there are differences. For example, under Top Runner no appliances are excluded from the market unless the supplier chooses to withdraw a product voluntarily.

The process of establishing Top Runner targets for appliances is authorised and overseen by the Agency for Natural Resources and Energy (ANRE) within METI. Products are assessed and considered for inclusion if they:

- are used in large quantities in Japan;
- are responsible for substantial quantities of energy consumption;
- demonstrate potential for improved energy performance.

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Having deemed that a product category meets these criteria, ANRE requests the Energy Efficiency Standards Subcommittee to make a more thorough examination and put forward proposals. A specific working group (the Evaluation Standard Subcommittee) is established comprising relevant industry participants, academic experts and consumers to consider appropriate Top Runner target values and target dates. In doing so, information on the current efficiency of products, the technical potential for improvement, market trends and the availability test methodologies are assessed and included within an interim report. This report is made publicly available and used to solicit comments. A final report is then prepared for the Energy Efficiency Standards Subcommittee, including the detailed proposals for Top Runner requirements.

The Top Runner programme has a clearly articulated set of ten principles which guide the process of setting Top Runner requirements for any product. For example, in determining the target year, issues to be considered include the technical development and investment cycles for the particular product category, as well as technical trends. Generally this means that the target dates vary between four to eight years from the date when target performance levels are set (METI, 2008).

The current list of product categories covered by Top Runner is shown in Table 21, together with the date when each category was included, or revised. As in most major economies, the requirements for refrigerators, freezers and air conditioners have been revised and updated in recent years to take account of the energy efficiency improvements which have occurred in the appliance stock.

The criteria for several other product categories have also been updated, or new categories added to the programme, in order to maintain relevance. Rice cookers and microwave ovens, both of which account for an increasing quantity of electricity consumption, have been added to the programme in 2006. The Top Runner programme was the first national programme to introduce performance requirements for computers and televisions, both of which have been revised recently.

In the past few years, Japan has also added the important new categories of DVD recorders and routers to the list of electrical equipment covered by Top Runner.

The switch-over to full digital TV terrestrial transmission will occur in Japan in 2011, and as in other economies, this is stimulating a change in the market for televisions and related equipment (see Figure 41). As a result, the 2005 review of the television and VCR criteria resulted in an expansion of the scope to include TVs with integral tuners and DVD recorders. As the market has developed in the years leading up to the switch to digital TV, many DVD recorders in Japan now include a digital tuner (more than 65% of models shipped in 2006) and therefore the energy performance criteria for Top Runner were further amended in 2007 to cover these products (EESS, 2007).

The most recent addition to the programme is the category of routers and switches, which are used in relation to network access, including the internet, in both the residential and commercial sectors. Since most of these products remain switched on continuously, their energy consumption can be significant. Although these products are already widely used, sales are predicted to grow by approximately 5% per annum (ANRE, 2008).

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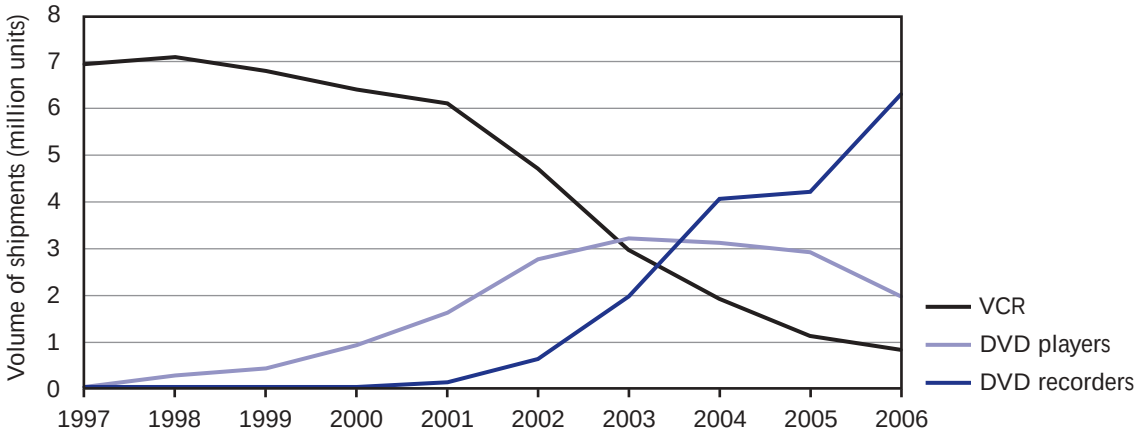
Figure 41 • Shipments of VCRs, DVD players and recorders in Japan



Source: EESS, 2007.

Table 21 • Implementation and revision dates of Top Runner residential electrical appliance categories

Product category	Implementation date
Air conditioners	1997, 2006
Electric refrigerators	1998, 2006
Electric freezers	1998,2006
Electric rice cookers	2006
Microwave ovens	2006
Fluorescent light fittings	1998
Electric toilet seats	2002, 2007
Televisions: cathode-ray tube	1997
Televisions: all types	2005
Video cassette recorders, (DVD recorders)	1997,2005
DVD recorder	2007
Computers	1999, 2003
Magnetic disk drives	1999, 2003
Copying machines	1999
Routers	2008

Source: METI, 2008; ECCJ, 2007b.

Standby power

Japan has placed considerable priority on the reduction of electricity consumption by appliances in standby mode, employing a range of policy measures. It also undertakes a periodic assessment process to track trends in standby power consumption on a national and product level (discussed

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further below). Significantly, the 2005 survey on standby power consumption in Japan is the first national study that indicates a reduction in standby power at the household level.

Standby power consumption is integrated within Top Runner energy performance criteria for relevant products, as required by one of the basic principles for the programme (Number 7) (METI, 2008). Where appropriate, standby power measurements are included in the algorithm used for calculating the energy consumption value specified by the target (*e.g.* kWh per annum). In most cases, this means that the energy performance of a product is calculated by comparing products undertaking an identical duty cycle, using data on average time spent in each mode.

While no limits for standby power consumption are included in the Top Runner approach, it does allow the contribution of standby power to be viewed in proportion to energy consumption in other modes for each product category. Suppliers can therefore decide which are the most suitable means to make energy efficiency improvements in order to meet the overall performance requirements of Top Runner.

The following seven product categories include standby requirements in the overall energy performance targets:

- televisions;
- electric toilet seats;
- microwave ovens;
- electric rice cookers;
- copiers;
- VCRs;
- DVD Recorders.

The second important element of the standby power programme comprises voluntary agreements by industry. In 2001 JRAIA, JEITA, and JEMA agreed to reduce the standby consumption of home appliances with either a remote-control or a clock/timer to 1 watt or less. For home appliances not included above, the aim was to reduce standby power as close to zero watts as possible. The average values measured for a sample of products in 2004, the agreed target date, are shown in Table 22.

A further voluntary agreement was entered into by the Japan Industrial Association of Gas and Kerosene (JGKA) in May 2005 covering gas and oil fired appliances with an electrical standby component. Under this agreement, efforts will be made to cut standby power requirements to 1 watt or less for fan heaters, and 2 watts or less for water heating units by 2009.

The final policy measure impacting on standby power is the Energy Star voluntary endorsement programme for office equipment, which include standby power specifications.

A summary of the major policy measures directed at residential electrical appliances is provided in Table 23.

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Table 22 • Standby power measurements by industry against self-declaration target, 2004

Product	Number of achieving models	Average standby power (W)
Air conditioners for home use	191	0.81
TV set	230	0.40
DVD player	23	0.43
Stereo system player	56	0.56
CD radio-cassette player	19	0.75
Electric rice cooker	114	0.74
Laundry machine	105	0.02
Electric clothes dryer	14	0.01
Microwave oven	46	0.05

Source: Okhuni, 2006b.

Table 23 • Summary of major national policy measures for residential electrical appliances

	Uniform energy label	Energy-saving label	Top runner	Voluntary agreement
Refrigerators	V (2006)	V (2000)	M (1998)	
Freezers	V (2006)	V (2000)	M (1998)	
Clothes washers				V
Clothes washers/dryers				V
Clothes dryers				V
Dishwashers				
Air conditioners	V (2006)	V (2000)	M (1997, 2006)	V
Space heaters		V (2003)		V
Water heaters				V
Ovens				V
Microwave ovens		V (2007)	M (2006)	V
Rice cookers		V (2007)	M (2006)	V
Light fixtures			M (1998)	

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Table 23 • Summary of major national policy measures for residential electrical appliances *(continued)*

	Uniform energy label	Energy-saving label	Top runner	Voluntary agreement
Televisions	V (2006)	V (2000, 2006)	M (CRT: 1997; 2005)	
VCRs			M (1997, 2005)	V
DVD recorders		V (2007)	M (2007)	V
Copiers		V*	M (1999)	
Computers		V (2004) V*	M (1999, 2003)	
Magnetic disc drives		V (2004)	M (1999, 2003)	
Routers			M (2008)	
Office equipment		V*		V
Electric toilet seats		V (2003)	M (2002, 2007)	

Source: ECCJ, 2001, 2003, 2004, 2006, 2007b. Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary; V* = Energy Star.

Other initiatives

Energy efficient product Retailer Assessment system

Home appliances retailers who achieve a high level of performance in staff knowledge, in-house training and information provision to customers are eligible for an annual commendation and the right to display a special sign indicating their award.

The number of awards made to large stores increased to 88 in 2005 from 43 in 2004. Also in 2005, the award was provided to 18 small stores (ECCJ, 2007b).

Financial subsidies for water heaters

In order to support the penetration of efficient water heaters, the Japanese government provides subsidies for the installation of advanced heat pump technology. In 2004, more than 5 billion yen (approx. U.S. $44.6 million) was budgeted for the provision of financial support with the aim that 5.2 million heat pump water heaters will be installed by 2010.[9]

The development of heat pump water heaters using CO2 as a refrigerant was initially developed by the Central Research Institute of Electric Power Industry (CRIEPI), which began work in 1995. This has culminated with the development of a commercial product, called *Eco Cute* which has a COP of 3.4 (including the power input to the air fan and water pump), able to produce hot water at 90 oC at an ambient air temperature of -15 oC. The product currently sells for approximately USD 6 000 and attracts a subsidy of USD 420 per unit (Hashimoto, 2006; Maruyama, 2006).

9. It is understood that this budget increased to JPY 13 million in 2007 (IEA, 2008).

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Evaluation and enforcement activity

Top Runner programme

During the process of developing the proposed specifications for a product category under the Top Runner programme, the Evaluation Standard Subcommittee prepares an ex-ante assessment of the energy saving potential on an average sales-weighted unit basis. This is the percentage reduction in energy consumption per product expected in the target year if the target threshold is achieved.

The 2008 IEA Country Report on Japan notes that ECCJ attempts to track compliance progress during the period between when the target is established and the target year, by publishing a biannual list of all products on the market and their energy efficiency performance (OECD/IEA 2008). The number of products that meet the target requirements can be observed, as can the proportion of compliant products increasing over time. However, without knowing the sales volumes of the products it is not possible to determine the sales weighted average.

However, following the target date, an assessment of whether the target has been achieved is made using sales and performance data provided by appliance suppliers. Table 24 shows the level of expected energy reductions for each of the product categories in the target year.[10] For programmes which have reached their target year and been assessed, the actual reduction calculated from performance and sales data is shown in the final year.

Table 24 • Expected energy reductions from Top Runner programme

Product category	Base year	Target year	Expected energy savings	Ex-post achievements
Air conditioners (1)	1997	2004	66.1%	67.8%
Electric refrigerators (1)	1998	2004	30.5%	55.2%
Electric freezers (1)	1998	2004	22.9%	29.6%
Fluorescent lights	1997	2005	16.6%	35.6%
Televisions: CRT	1997	2003	16.4%	25.7%
Video cassette recorders	1997	2003	58.7%	73.6%
Computers (1)	1997	2005	83%	99.1%
Magnetic disk units (1)	1997	2005	78%	98.2%
Air conditioners (2)				
coolers/heaters	1997	2007	63%	
coolers only	1997	2007	14%	
Non-ducted <4.0kW	2005	2010	22.4%	
Electric refrigerators (2)	2005	2010	21.0%	

10. Note, where new criteria have been set for product categories, the estimate for the initial programme is indicated by (1), and the subsequent round by (2).

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Table 24 • Expected energy reductions from Top Runner programme *(continued)*

Product category	Base year	Target year	Expected energy savings	Ex-post achievements
Electric freezers (2)	2005	2010	12.7%	
Electric rice cookers	2003	2008	11.1%	
Microwave ovens	2004	2008	8.5%	
Electric toilet seats	2000	2006	10%	
Televisions: LCD, plasma	2004	2008	15.3%	
DVD recorder	2004	2008	22.4%	
Computers (2)	2001	2007	69%	
Magnetic disk units (2)	2001	2007	71%	
Copying machines	1997	2006	30%	
Routers	2008	2010	16.35	
L2 Switches	2008	2011	37.7%	

Source: ECCJ, 2007b; EESS, 2008.

It is understood that some random checking of products is undertaken to verify submitted performance data, however no details of the quantity or results of these activities are available.

The importance of undertaking thorough evaluations is highlighted by the example of Japanese refrigerators, which were one of the first products in the Top Runner programme. When the target was set in 1998, the average electricity consumption of shipped products was 647.3 kWh per annum according to the test methodology, JIS 9801. In the target year of 2004, the average consumption was assessed to have fallen by 55.2% to 290.3 kWh, far exceeding the target.

However, concerned that measured electricity consumption did not appear to be falling as quickly as these results would suggest, consumer groups surmised that the test method did not provide a good reflection of the energy consumption of modern refrigerators as they were being used in Japanese households. A number of tests by the Japanese Consumer's Association and the National Consumer Affairs Centre of Japan between 2001 and 2004 confirmed this view. This was further verified by the Jyukankyo Institute which monitored major appliance usage in 96 households, finding that the average consumption of refrigerators and freezers was 65% larger than the value indicated by the JIS test.

As a result, manufacturers and governments have worked extremely quickly to implement revisions to JIS C 9801 in January 2006. During the process tests have been conducted to ensure that the revised method does accurately reflect actual usage on a consistent basis.

A comparison of values obtained under the previous and new JIS test method has been undertaken by JEMA, and results illustrated in Figure 42. One of the issues this highlights is that the discrepancies are larger for products with a capacity above 400 litres, which is particularly significant since the market for larger refrigerators has been growing rapidly in Japan.

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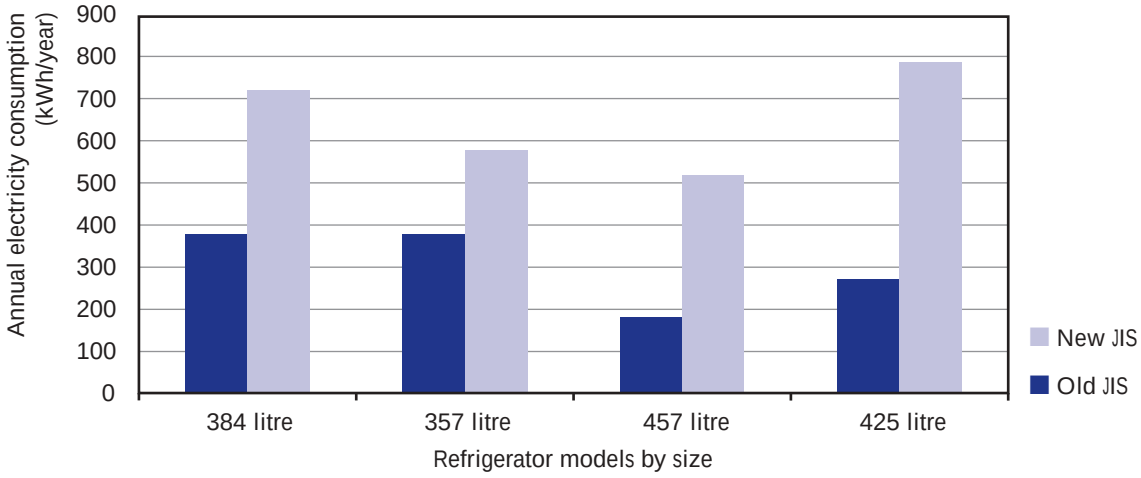
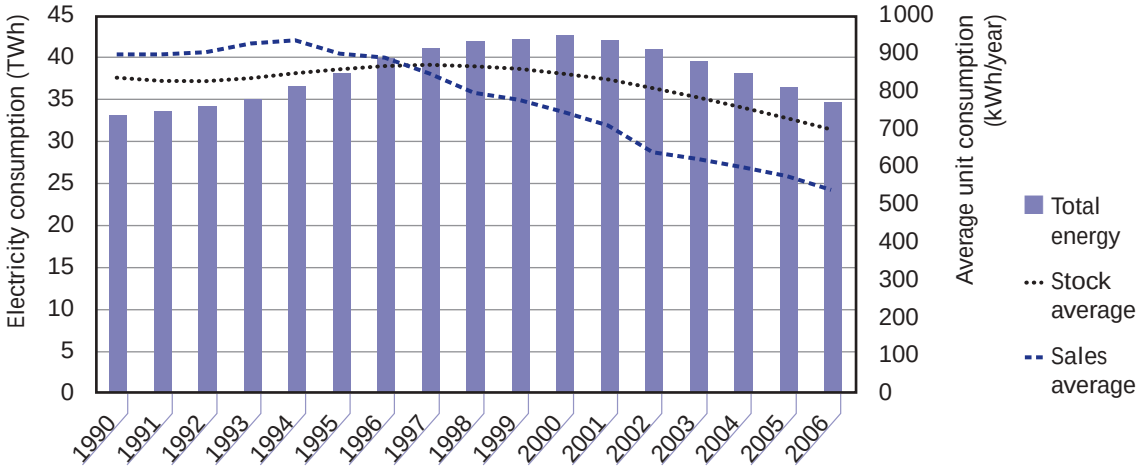
Figure 42 • Comparison of energy consumption values based on original and new version of JIS 9801



Source: Saito *et al.*, 2008.

JEMA have therefore re-examined the previous sales and performance data, using values according to the new method, to better understand the amount of energy that has been saved over recent years. The results indicate that the average consumption of new products fell by approximately 25% between 1998 and 2004, and overall consumption by 9% over the same period, as shown in Figure 43 (JEMA, 2007). While the level of these savings is not as high as had previously been thought, they are equivalent to savings made by mandatory programmes in other economies and represent a considerable achievement.

Figure 43 • Trends in electricity consumed by refrigerators in Japan, 1990-2006



Source: JEMA, 2007.

This example is noteworthy because it demonstrates both the value of programme evaluation and the prompt and comprehensive action taken by the Japanese government. By undertaking

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an appropriate number of checks and then making changes to the test procedure, the government has not only avoided a potentially serious loss of credibility amongst consumers and other stakeholders, but has been able to make a realistic appraisal of programme achievements.

Further, it has raised an important issue for the many countries which rely upon the results of laboratory performance tests for a range of appliance types to underpin their energy efficiency programmes. In the light of this experience, governments need to ensure that these test results reflect actual usage as far as possible.

Standby power

In order to track the progress of policies to reduce standby power in Japan, a series of surveys have been undertaken in 1999, 2003 and 2005. These follow consistent methodology in order to provide comparable results, and comprise three elements:

- The measurement of appliances in a sample of residences to determine the average power consumed by each type of appliance in low-power modes;
- A householder questionnaire designed to establish the number of appliances per household and the hours spent by each in low-power modes;
- A manufacturer questionnaire designed to provide information on the standby power consumption of new appliances sold in the market.

The sample size for each of these elements has increased progressively, as shown in Table 25.

Table 25 • Sample sizes for elements of standby power survey, 1999, 2002 and 2005

Survey year	1999	2002	2005
In-situ appliance measurements: number of appliances (number of houses)	955 (51)	1 760 (86)	2 825 (100)
Household questionnaire: number of responses	n.a.	n.a.	1 519
Manufacturer questionnaire: number of appliances (number of companies)	n.a.	n.a.	4 363 (85)

Source: ANRE, 2006; Ohkuni, 2006a.

Analysis of this data has indicated that the electricity consumed by household appliances in Japan has changed over time. In 1999 the average consumption per Japanese household was 398 kWh/year, and rose to 437 kWh/yr in 2002. However in 2005, standby power consumption fell to 308 kWh/year, or 7.3% of the average total household electricity consumption, based on the results of the survey. From Figure 44, which shows the change in average consumption for appliance categories resulting from the three surveys, standby power has decreased in 2005 relative to 2002 in all categories except water heaters (Ohkuni, 2008).

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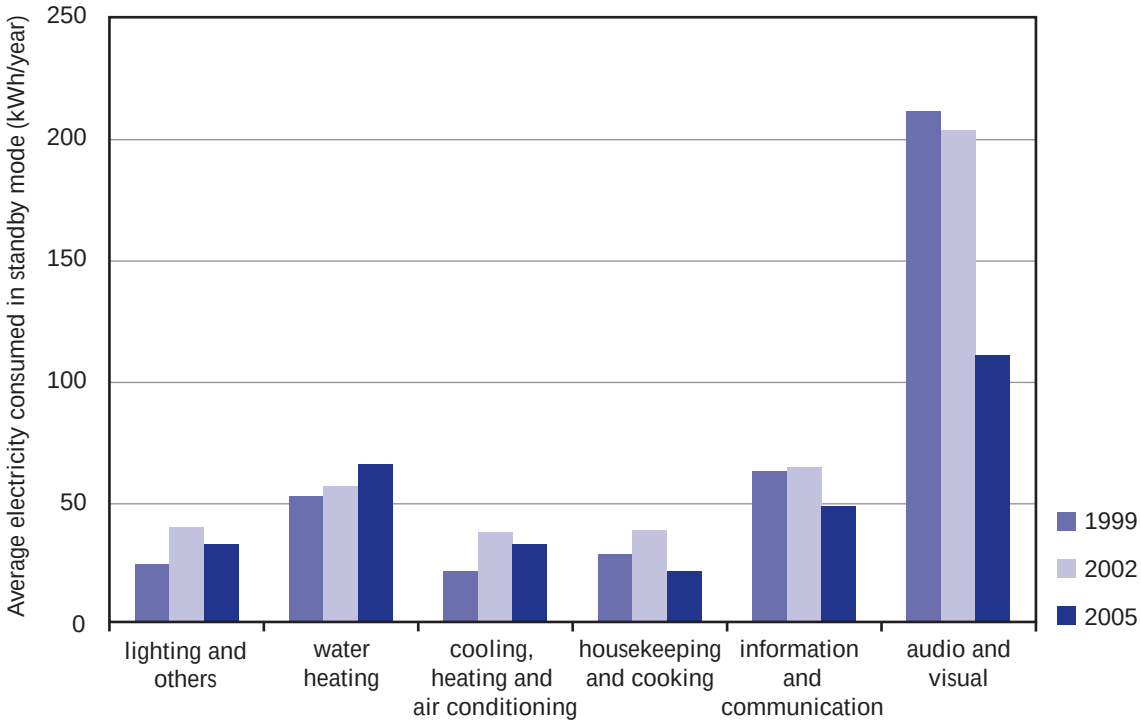
Figure 44 • Average electricity consumed per household by major appliance categories in standby mode, 1999, 2002 and 2005



Source: Ohkuni, 2006a.

The results suggest that while the penetration of most appliances has grown from 2002 to 2005, the reduction in overall power consumption is due to both a reduction in the power used by many appliances in standby mode, together with a downturn in the time that appliances spent in standby mode (Ohkuni, 2006b). The survey data also shows that some appliances are spending longer periods in active mode, as shown in Table 26 for televisions and DVD recorders.

Table 26 • Change in surveyed ownership and usage patterns for televisions and DVD players/recorders, 2002-2005

Appliances	Ownership per household		Active (using) time	
	2002	2005	2002	2005
TV sets	2.04	2.09	3hr 26min	4hr 32min
DVD/HD player/recorder	0.19	0.45	21min	1hr 20min

Source: Ohkuni, 2006b.

The survey has raised some important questions, which can be further investigated in the next study to be undertaken during 2008. One issue is whether a downturn in standby power can be partly attributed to fewer appliances entering a low-power mode, for example as a result of

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the growth in networked appliances. In this case, the fall in standby power consumption could be accompanied by an increase in total energy consumption.

A further issue which is being considered in Japan is the extent to which campaigns to encourage consumers to unplug appliances not in use are feasible and likely to be effective.

Other activities

A survey of consumer understanding of the information presented in the energy-saving and uniform energy labels is due to be undertaken in 2008, however no information is available to date on the findings of this study.

Enforcement

Under the Rational Use of Energy Act, METI has the power to disclose the names of companies which fail to meet the targets set by the programme, and can issue recommendations for actions to be taken by individual companies in order to improve their products. METI can also fine companies for non-compliance if required. However, to date METI has not undertaken any legal enforcement actions (OECD/IEA, 2008).

International engagement

Japan engages in very many international fora and activities with a special emphasis on Asian countries, where it has been very active in encouraging the transfer of policy and technical knowledge in the field of energy efficiency. In particular it helps to develop expertise in energy efficiency through the overseas placement of staff, offering traineeships and similar activities. With the adoption of the *National Energy Strategy* in 2006, the level of engagement with Asian countries is likely to increase.

National Energy Strategy 2006

International collaboration and cooperation is a major plank of the National Energy Strategy adopted in 2006. The *Asia Energy and Environment Cooperation Strategy* recognises the dependency on imported oil in many Asian countries, and the forecasted increase in demand as a result of improved standards of living in the region. The programme provides particular focus on the household and transportation sectors in the countries of China, India, Thailand, Indonesia, and Vietnam.

Included in the list of activities are:

- the promotion of energy efficiency standards and labelling for appliances and equipment;
- establishing appropriate legal systems for supporting energy efficiency objectives;
- the transferral of energy-saving technology (EECJ, 2007b).

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Asia Pacific Partnership (APP)

Government and industry members participate in many of the projects underway in the Buildings and Appliances Task Force (BATF), led by Korea and co-chaired by the United States. The aims of BATF are to:

- Use cooperative mechanisms to support the further uptake of energy efficient appliances, recognising that extensive cooperative action is already occurring between Partner countries.
- Promote best practice and demonstrate technologies and building design principles to increase energy efficiency in building materials and in new and existing buildings.
- Support the integration of appropriate mechanisms to increase the uptake of energy efficient buildings and appliances into broader national efforts that support sustainable development, increase energy security and reduce environmental impacts.
- Systematically identify and respond to the range of barriers that limit the implementation of end-use energy efficiency practices and technologies.

Asia-Pacific Economic Co-operation (APEC)

Japan is a full participant in the Expert Group on Energy Efficiency & Conservation, which undertakes co-operative action under the Energy Working Group of APEC.

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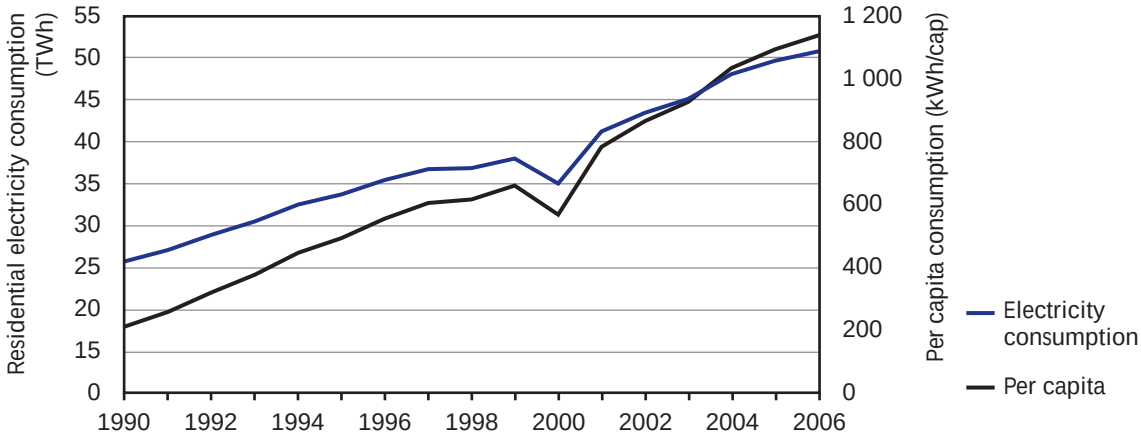
SOUTH KOREA

Total residential electricity consumption grew by 7% per annum between 1990 and 2006, while the population increased by only 1% per annum over this period. Per capita electricity consumption therefore grew at 6% per annum from 1990 to 2006.

Figure 45 • Total residential and per capita electricity consumption, South Korea, 1995-2006



Source: IEA Statistics.

The Korean Ministry of Knowledge Economy (MKE) and the Korea Energy Management Corporation (KEMCO) currently operate three programmes to promote energy efficient appliances and equipment: The Energy Efficiency Labels and Standards Program since 1992; the High Efficiency Appliance Certification Program which began in 1996, and; the e-Standby Program which commenced in 1999.

The Standards and Labelling programme targets household appliances, such as refrigerators, clothes washers lighting products and products for industry, such as 3 phase induction motors, while the e-Standby programmes targets office equipment and home electronics - those product categories that have capacity for significant reductions in standby power consumption. The voluntary certification programme for high efficiency appliances relates mainly to products for industry and buildings.

The federal government administer several other policies to induce market transformation and promote energy efficient household and other appliances, including financial incentives for consumers, priority purchase from the public procurement service, mandatory use of high performing products for new buildings and subsidies for manufacturers and installation parties (MKE & KEMCO, 2007).

Although the energy efficiency programme in Korea commenced later than in some other economies, it has advanced extremely quickly and continues to expand impressively. This is in part due to the excellent links that have been established with similar programmes in other economies, and Korea's willingness to build on this source of experience and support. In

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doing so, Korea has also tailored programmes to suit its own requirements and culture. Korea's approach to tackling standby power has shown that it can also be at the forefront of policy development, and the implementation of the Standby Strategy demonstrates a thorough and appropriate response.

Notable developments in appliances energy efficiency since 2002 include:

- expansion of the MEPS and labelling programme to include new product categories;
- more stringent MEPS levels for some consumer products;
- the introduction of an improved consumer comparison label for household products;
- the introduction of a 'Warning label' to alert consumers to products with a high consumption of standby power;
- increased engagement and leadership in the world-wide community.

Institutional organisation, policies and financial issues

Products are identified by KEMCO inclusion within one of the energy efficiency programmes following an examination made by a committee comprising policy-makers from governmental (MKE and KEMCO), technical experts from universities, research establishments and testing laboratories, and related NGOs. In addition to the technical potential, these committees examine overseas energy efficiency policies. Having determined the need for policy intervention, the committees devise a long-term strategy to achieve market transformation.

From the beginning of this process to the introduction of new regulations typically takes between 2 and 3 years. The list of products which are targeted for future attention is shown in Table 27.

Table 27 • Long-term roadmap for energy labels and MEPS

Categories	2008	2009	2010	2011	2012
Energy efficiency labels & standards program	• External power supplies • Heat pumps	Commercial refrigerators	HID lamps	Vending machines	• Televisions • Multi-type air con.
High-efficiency appliance certification program	• LED Lamps in substitution for halogen lamps • LED lamps in substitution for incandescent lamps • Multi-type air con. • Thermo-hygrostats	• Vacuum hot-water boilers • LED lamps in substitution for fluorescent lamps • LED lamps in substitution for street lights	• Refrigerating showcases • Screw chillers	• Commercial washers • Air compressors	
e-Standby Program	Home gateway	• Water purifiers • Projectors	• Humidifiers • Fan heaters	• Hand dryer • Mailing machines	Routers

Source: Kim, 2008.

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Budget

KEMCO employs between 450 and 500 staff in all, however only 15 are devoted to end-use energy efficiency programmes. The KEMCO budget has been growing since 2002, as shown in Table 28; however it should be noted that although there is the facility for private sector contributions, this is seldom realised.

Table 28 • KEMCO staff and budget allocation, USD, 2002-2007

Year	2002	2003	2004	2005	2006	2007
Personnel	451	458	508	450	464	475
Total operational budget	32.0 m	34.7 m	36.6 m	43.0 m	54.5 m	60.9 m
Government contributions	21.1 m	23.6 m	24.9 m	25.9 m	36.2 m	31.7 m
Rational use of energy loan fund*	376.6 m	315.5 m	293.4 m	293.4 m	479.0 m	510.3 m

** Since 1980, the Rational Use of Energy Loan Fund supports long-term, low interest rate loans for energy efficiency and conservation investments, mainly in the industrial/commercial sectors.*
Source: KEMCO, 2006; Kim, 2008.

Of this, the budget for the management of the appliance energy efficiency programmes is also quite small, although it has grown nearly fourfold between 2003 and 2007 (see Table 29).

Table 29 • Annual budget for appliance energy efficiency programmes, USD millions, 2003-2007

Year	2003	2004	2005	2006	2007
Budget	7.3	6.8	21.2	27.7	28.6

Source: Kim, 2008. The above figures do not include promotional expenditure.

Energy performance labelling

Comparison label

The Korean comparison label rates products on a scale of 1 to 5, where 1 is the most energy efficient and 5 the least efficient. Within this scale, typically the most efficient models (graded as 1) consume between 30% and 40% less energy than the least efficient model (graded as 5).

Energy efficient labels, standards and targets are closely linked to each other. Two energy efficiency set points are allocated to products in the programme. The less stringent value correlates to the label rating 5 and this also defines the MEPS level. The more stringent value is the 'target' value which corresponds to the requirements for a rating of 1. Energy label ratings are automatically updated as MEPS levels are made more stringent. The target value of an individual product often becomes the new MEPS level.

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The Energy Efficiency Standards and Labels Program includes MEPS and targets 21 household products. The following products have been added to the programme since 2002:

- dishwashers;
- electrical coolers and heaters for drinking-water storage;
- kim-chi refrigerators;
- freezers;
- rice cookers;
- vacuum cleaners;
- electric fans;
- horizontal drum clothes washers;
- dish driers;
- air cleaners;
- 3 phase induction motors;
- adapters-chargers;
- electric driven heat pumps.

A new circular 5-grade label was introduced 1 January 2008 to cover all products under the standards and labelling programme (KEMCO, 2006b).[11] The new label addresses issues of inconsistency and has been designed to provide a greater visual appeal to consumer, enabling them to better distinguish between the performances of different products.

Endorsement label

The major endorsement label used in Korea is *Energy Boy* used to identify products with low standby power consumption. This will be complemented from 28 August 2008 with the introduction of a 'Warning label' for products which do not meet the relevant standby criteria. In addition, Korea has a certification programme for high efficiency products, although the majority of these are used in the commercial and industrial sectors.

e-Standby programme

The e-Standby Power programme was launched in 1999 and 22 products are now covered by the programme, mainly home electronics and office equipment, and are listed in Table 30 (MKE & KEMCO, 2007).

11. Note that an additional modified label was introduced to cover domestic gas boilers, 3-phase electric motors and cargo vehicles specifically.

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The label, also known as the *Energy Boy* label, may be fixed on products which meet the relevant criteria, which typically save 30-40% more energy than average products. Based on a voluntary agreement, manufacturers may participate in the programme by adopting an advanced self-certification system. Voluntary reporting of product performance requires participating companies to submit an application along with a performance test report and product identification to KEMCO

In December 2007, the *Rational Energy Utilisation Act* was amended to make the reporting of standby power levels mandatory, and where appliances fail to meet the expected targets, the law makes it mandatory to display a new warning label. These mandatory policy tools will be applied to televisions from 28 August 2008, and computers, monitors, printers, multi function devices, set top boxes and microwave oven from 1 July 2009. After this pilot project, this mandatory change will be applied to the rest of the target products.

As an added incentive, products that qualify for the 'Energy Boy' label receive a priority in public procurement processes, and mandatory use by public organisations.

Standby Korea 2010

Released in July 2005, Standby Korea 2010 is a strategy to limit standby power to below 1 watt by 2010; as such, Korea is the 3rd country, after the Uunited States (2001) and Australia (2002) to announce their commitment to reduce standby power to 1 watt (MKE & KEMCO, 2005). This document was prepared and released at the International Standby Power Conference held in Seoul in 2005, sponsored by MKE, KEMCO and the IEA, which highlighted the importance of Korea's leading role with standby policy implementation.

The Standby Strategy describes three distinct phases to achieve this ultimate goal:

- Stage 1 (2005-2007) saw the implementation of Standby Korea 2010 on a voluntary basis. During this phase 1 watt standby requirements were progressively introduced as criteria for the products identified in Table 30. Depending on the product, this requirement became the requirement for the Energy Boy labelling or 1st grade mandatory labelling. It is worth noting that specifications for set-top boxes are more stringent at 0.5-0.75 W.

- Stage 2 (2008-2009) is a preparatory phase leading into the introduction of the mandatory 1-Watt policy in 2010. In this period, the Rationalization of Energy Utilization Act will be amended in preparation for mandatory measures and will require the mandatory reporting of standby power for target products and the mandatory application of a warning label for products that fall below the standby specification.
- From 2010, the "Mandatory 1W Policy" will be implemented as the final stage and apply to all target products (MKE & KEMCO, 2007). For adapters and chargers, MEPS will be introduced in 2009, calling for standby power of <0.5 W.

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Products targeted under this strategy include most consumer electronics, office equipment and whitegoods including clothes washers, horizontal drum clothes washers, dishwashers, rice-cookers, electric fans, air cleaners and adapters/chargers (KEMCO, 2006a).

Korea is the first country to introduce a 'warning label' for products which do not meet the specified criteria. In effect, this acts as a dis-endorsement label providing consumers with an easy means of identifying products with higher standby power consumption.

Table 30 • Implementation of Standly Power ≤1W Standards

Category	Date of enforcement	Target products
Energy Boy label	2006	TV's, adapters, chargers, mobile phone battery charges, copiers, cord/cordless phones, energy saving and controlling devices
	1 Jan 2007	Monitors, printers, scanners, radios
	1 Jul 2007	VCR's, home audio products, DVD's, microwave ovens, set-top boxes
	1 Jan 2008	Modems, bidets, door phones
	1 Jan 2009	Computers, multifunction devices etc.
Energy efficiency 1st grade	1 Jan 2007	Clothes washers, dishwashers
	1 Jan 2008	Electric rice cookers, air-cleaners
	1 Jan 2009	Drum clothes washers, electric fans

Source: Adapted from MKE& KEMCO, 2007.

It is estimated that the successful implementation of the 1-Watt standby power policy will deliver an accumulated electrical energy reduction of 170 kWh per household and 2 550 GWh (281 million USD) nationally by 2010 and 2,800 kWh per household and 42 000 GWh (4.62 billion USD) nationally by 2020 (MKE & KEMCO, 2007).

Minimum energy performance standards (MEPS)

KEMCO includes new products subject to their degree of use and capacity for energy savings, and 13 appliances have been added to the MEPS programme since 2002. Three-phase induction motors and air-cleaners are target products for 2008, and adapters/chargers, electric driven heat pumps for 2009.

As well as the addition of new products, more stringent labelling or MEPS levels have been introduced as follows:

- 2006 : clothes washers, dishwashers;

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- 2007 : Refrigerators, air conditioners, rice cookers;
- 2008 : horizontal drum clothes washers, kim-chi refrigerators, electrical coolers and heaters for drinking-water storage, electric fans, vacuum cleaners, incandescent lamps, fluorescent lamps, fluorescent lamps ballasts, compact fluorescent lamps

Korea is looking at policy options to phase out of inefficient incandescent lighting in favour of more efficient technologies such as CFLs. Public campaigns on the use of CFLs and the financial rebate programme are examples of efforts made to transform the market. The market share of CFLs did rise from 11% in 1999 to 39% in 2006; however incandescent lamps still exceed CFLs in sales. The Korean government recognises that current voluntary policies are not sufficient to overcome barriers to market transformation and will consider alternative options (MKE & KEMCO, 2007).

A summary of the major policy measures directed at residential electrical appliances is provided in Table 31.

Table 31 • Summary of major national policy measures for residential electrical appliances

	Comparative label	Endorsement label	MEPS
Refrigerators	M (1992, 1995, 2000, 2002, 2007)		M (1992, 2002)
Freezers	M (2004)		M (2004)
Kim-chi refrigerators	M (2004, 2008)		M (2004, 2008)
Clothes washers	M (2001, 2006)		M (2001)
Horizontal drum clothes washers	M (2006, 2008)		M (2006, 2008)
Dishwashers	M (2002, 2006)		M (2002)
Dish dryers	M (2007)		M (2007)
Air conditioners	M (1993, 1995, 1996, 2000, 2002, 2007)		M (1993)
Rice cookers	M (2004, 2007)		M (2004)
Vacuum cleaners	M (2004, 2008)		M (2004)
Electric fans	M (2006, 2008)		M (2006, 2008)
Air cleaners	M (2008)		M (2008)
Incandescent lamps	M (1992, 2002, 2008)		M (1992, 2002, 2008)
Fluorescent lamps	M (1992, 1999, 2002, 2003, 2008)		M (1992, 2002, 2008)
Lamps ballasts	M (1994, 1999, 2002, 2005, 2008)		M (1994, 2002, 2008)
CFLs	M (1999, 2002, 2005, 2008)		M (1999, 2002, 2008)

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Table 31 • Summary of major national policy measures for residential electrical appliances *(continued)*

	Comparative label	Endorsement label	MEPS
Office equipment		V (1999, 2001, 2004, 2006, 2008)	
Energy-saving and controlling devices		V (2001, 2004, 2007)	
External power supplies		V (2004, 2006)	
Televisions		V (1999, 2002, 2005, 2006), M(2008)	
Consumer electronics		V (1999, 2002, 2006)	
Bottle-water coolers	M (2002, 2008)		M (2002)

Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary.

High Efficiency Appliance-Certification Program

The federal High Efficiency Appliance Certification Program aims to single out products that perform above certain standards. The programme covers products for industry and buildings and includes over 41 product categories including: pumps, fans & blowers, induction motors, transformers, windows, fluorescent lamps and ballasts, sensor lighting equipment and LED lighting products. The programme was launched in 1996 and currently continues to operate as a voluntary certification programme.

KEMCO certifies high-efficiency appliances for industry and buildings, where the energy efficiency and quality test results are above the standards set by the government. Financial rebates are provided for high-efficiency lighting equipment and there are various promotion policies for market development including rebates, public procurement and mandatory use in public and specified buildings (Lee, 2007).

Public procurement

Public preferential procurement of high efficiency equipment and appliances was introduced in 2005 and requires that public institutions place priority on the purchase of energy efficient products with label rating 1, high-efficiency certified products and Energy Saving Products with 'Energy Boy' label when making new purchases or replacing existing equipment.

In accordance with new mandatory provisions contained in the Instruction for Rationalization *of Energy Utilization* of Public Institutions, every public institution is also required to purchase high-efficiency certified products and products with the Energy Boy label, giving priority to appliance with standby power usage below 1 watt (MKE & KEMCO, 2007).

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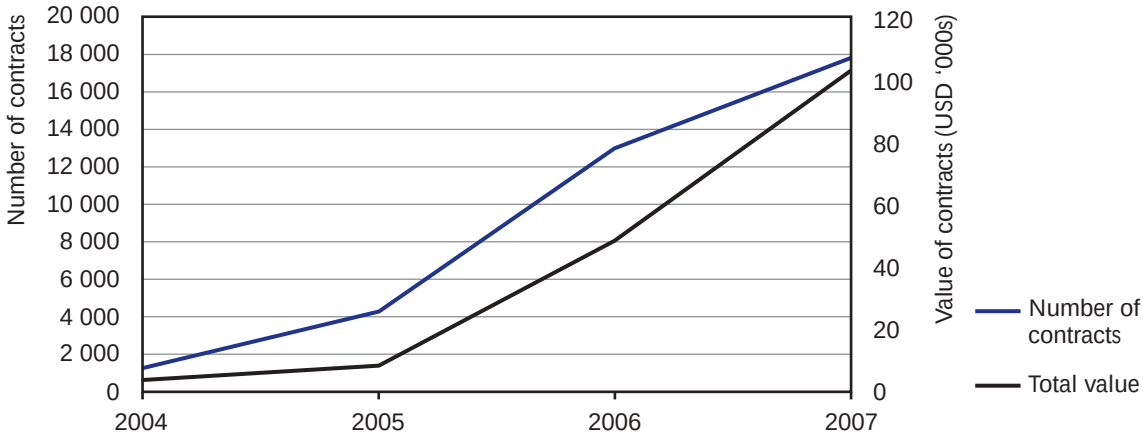
A special category of highly energy efficient products has been added to Korea's ON-line E-Procurement System (KONEPS). KONEPS was launched in 2002 by the central procurement agency, Public Procurement Services (PPS), and is an online procurement system for all public organisations which facilitates all processes from registration, bidding, contracting, through to payment. Figure 46 shows the number and value of contracts involving energy efficient products sourced through this system, demonstrating considerable growth (Lee, 2007).

Figure 46 • Uptake of energy efficiency products through public procurement system, 2004-2007



Source: Lee, 2007.

From 2001, all new housing complexes (50+ households) and educational facilities (with floor-space >3000 m²) are required to install high efficiency lighting equipment – either types which are high efficiency certified or which meet the 1st grade on the mandatory label. The installation of other energy efficiency products and equipment is not mandatory but is recommended (MKE & KEMCO, 2007).

Fiscal incentives

The Korean federal government currently offers a number of financial incentives to increase the uptake of high performing products. Between 1 January 2005 and 31 December 2008, a 10% tax break from income or corporate tax is available to domestic residents who invest in high efficiency products covered by the High Efficiency Product Certification Program.

Financial support is also offered to users who install and operate high-efficiency certified appliances or high standby power products. The government's Rational Energy Utilization Fund offers loans of up to USD 20 million with a 3-4% floating interest rate for installation and up to USD 1 million for operation.

Small and medium sized manufacturers are eligible for financial assistance for appliance testing (MKE & KEMCO, 2007).

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Information and education

The Korean government is active in promoting energy efficiency and high performance appliances via information and education and engages the community at a number of levels to gain support. The many activities are spread over several ministries and include:

- 2 energy conservation museums;
- *Energy Conservation Month* including national awards for companies who excel in contributing to reducing energy, and design competitions for marketing material;
- Korea's Energy Conservation Exhibition (ENCONEX), organised annually since 1975;
- Consumer education websites, such as Energy Sarangbang;
- 32 demonstration low energy schools;
- Training courses for energy managers and energy auditors.

Building regulations

Korea has three policy tools for the building sector – 'Mandatory Standards for Building Insulation and Energy Efficient Designs', 'Energy Efficient Labeling for Buildings', and 'The Green Building Certification Program'.

South Korea formally adopted its first building energy standard in 2001 supported by established compliance and enforcement mechanisms and systematic revision.

The voluntary *Energy Efficient Labeling Program for Buildings* targets new or renovated units for classification into grades 1 to 3, depending on the expected energy saving ratio. A Certificate of Building Energy Efficiency and a low interest rate loan for construction is provided to buildings that exceed a certain performance standard.

The Green Building Rating System has been effective since 1999 and evaluates six elements affecting the environment throughout the life-cycle of building construction, including production of materials, design, construction, maintenance and dismantling (ABC, 2007).

Evaluation and enforcement activity

Evaluation

To measure the performance of the Energy Efficiency Label and Standards Program, KEMCO has established key performance indexes for some 15 products (17 000 models), registered as efficiency management target products from 1996-2006. Results from an analysis using these indicators show that through the three major appliance efficiency programs, Korea has achieved significant improvements in product energy performance. The energy efficiency improvements in refrigerators, air conditioners, and clothes washers are considered especially successful cases (see Figure 47) (MKE & KEMCO, 2007).

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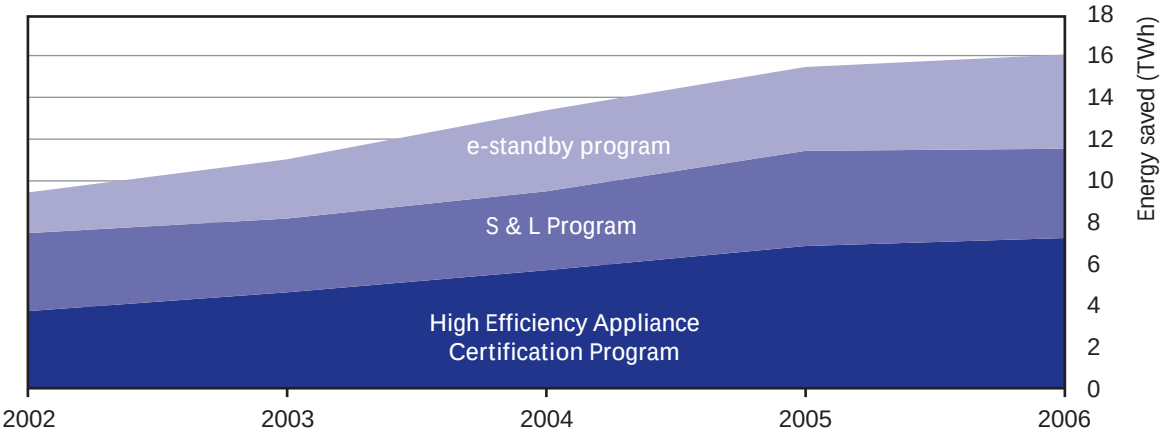
Figure 47 • Estimated energy savings from three energy efficiency programmes, Korea, 2002-2006



Source: MKE & KEMCO, 2007.

Regular market research is undertaken to track the impact of policy measures, including surveys of market share and stocks of appliances, polls to understand consumer preferences and levels of satisfaction. This information is then analysed to evaluate the effect of the policy measure.

The average energy consumption of refrigerators has decreased over 60% in 11 years, from 1.750 kWh/L to 0.707 kWh/L. The energy efficiency ratio for air conditioners has increased from 2.974 to 3.417 in the same time period. Korea's air conditioners were found to have the highest energy efficiency of the 5 APEC countries (Korea, Australia, China, Thailand, Malaysia), according to a survey commissioned by the Australian Greenhouse Office in 2004. The power consumption of clothes washers has also decreased significantly – by 16% in just 3 years (2004-2006). Prior to including drum clothes washers in the standards and labelling programme, there were no products that met the 1st grade requirements for this product (below 65 Wh/kg). This figure jumped to 68% in 2007 (MKE & KEMCO, 2007).

In 2004, MEPS was increased (66 lm/watt to 80 lm/watt) for 40W fluorescent lamps. This more stringent MEPS level successfully transformed the lighting equipment market as the market share of 32W fluorescent lamps increased from around 20% in 2003 to 70% in 2007 (32 W lamps have 20% more energy efficiency potential).

Monitoring

Energy efficiency labelling tests are conducted on request at designated national testing institutes (or self certified testing institutes) to determine the energy efficiency performance of products, including imported goods. Test performance must be reported to KEMCO by the relevant manufacturer or importer and then the energy efficiency rating is posted by KEMCO on the Internet.[12] It is the responsibility of manufacturers and importers to correctly label each relevant product according to its energy efficient rating (MKE & KEMCO, 2007).

12. At http://www.kemco.or.kr

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KEMCO undertake marketplace inspections to ascertain whether all products subject to the regulations are correctly labelled, and that labels accurately reflect the product energy efficiency. Product testing is conducted on an annual basis, and more frequently as required in response to market research, and information from consumers or civic groups.

When manufacturers fail to meet MEPS, MKE can prevent the product from sale on the market and issue a fine of up to KRW 20 million (USD 18 800) under the *Law on Rationalized Use of Energy* (MKE, 2006). A fine of up to USD 5 000 can be given for non-compliance with labelling requirements.

Random product sampling is also undertaken to test qualified products under the High Efficiency Certification Program and e-Standby Program. If qualified products fail to meet requirements (after re-tests if necessary) the public is notified that the product's certification or registration has been cancelled.

International engagement

Asia-Pacific Partnership (APP)

Korea's international cooperation on energy efficiency is most active in the appliances sector, with energy standards and labelling accounting for 70-80% of international cooperation (MKE & KEMCO, 2007). Korea is an active member of the Asia-Pacific Partnership on Clean Development and Climate (APP), which was launched in 2006 by Korea, Australia, the United States, Japan, China, Canada, and India. Notably, Korea chairs the Buildings and Appliances Task Force (BATF) which as a first step, aims to harmonise the test procedures of all participating nations in the period 2007-2011.

APEC

Korea is also a participating member on the APEC Expert Group on Energy Efficiency & Conservation (EGEE&C) under the broader Energy Working Group. APEC comprises representatives from 21 member countries and is an international economic cooperation community. The APEC EGEE&C meet twice yearly to benchmark energy efficiency improvement policies. Korea maintains close relations with Germany, China and Japan especially to exchange information and develop collaborative programs such as joint seminars, training or research projects. In April of 2005, KEMCO and Germany's national energy agency Deutsche Energie-Agentur GmbH (DENA), signed a MOU for agreed cooperation on energy efficiency, climate change and renewable energy.

Memorandum of understanding with the United States

On 29th November 2006, South Korea and the United States entered into their first MOU on energy efficiency and climate change cooperation. Under this MOU, America and Korea agreed to share information on issues such as standardisation techniques for evaluating energy savings performance and establishment of energy efficiency standards. The two countries will explore options to exchange researchers/experts and implement collaborative research projects,

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organise joint seminars and lectures to promote greater mutual understanding between the two energy authorities.

UNDP/GEF BRESL project

The Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labelling Project (BRESL) aims to improve the energy efficiency of five Asian developing countries including China, Vietnam, Malaysia, Thailand and Bangladesh. Korea plans to play a key role in sharing experiences gained from its energy efficiency standards and labelling programme.

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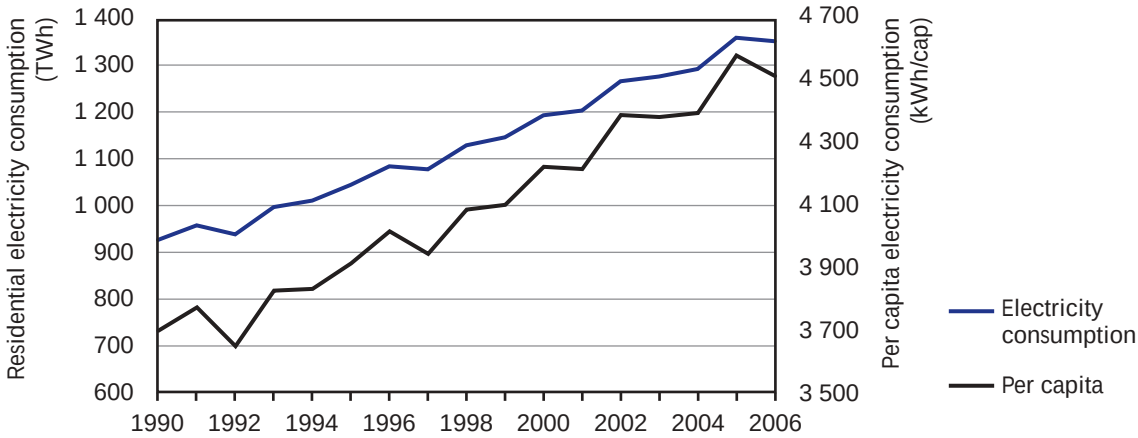
UNITED STATES

Residential electricity consumption grew by 2.6% per annum between 1990 and 2006. Population growth accounted for an increase of approximately 1% during the period, while the average electricity consumption per person grew by 1.4% per annum (see Figure 48).

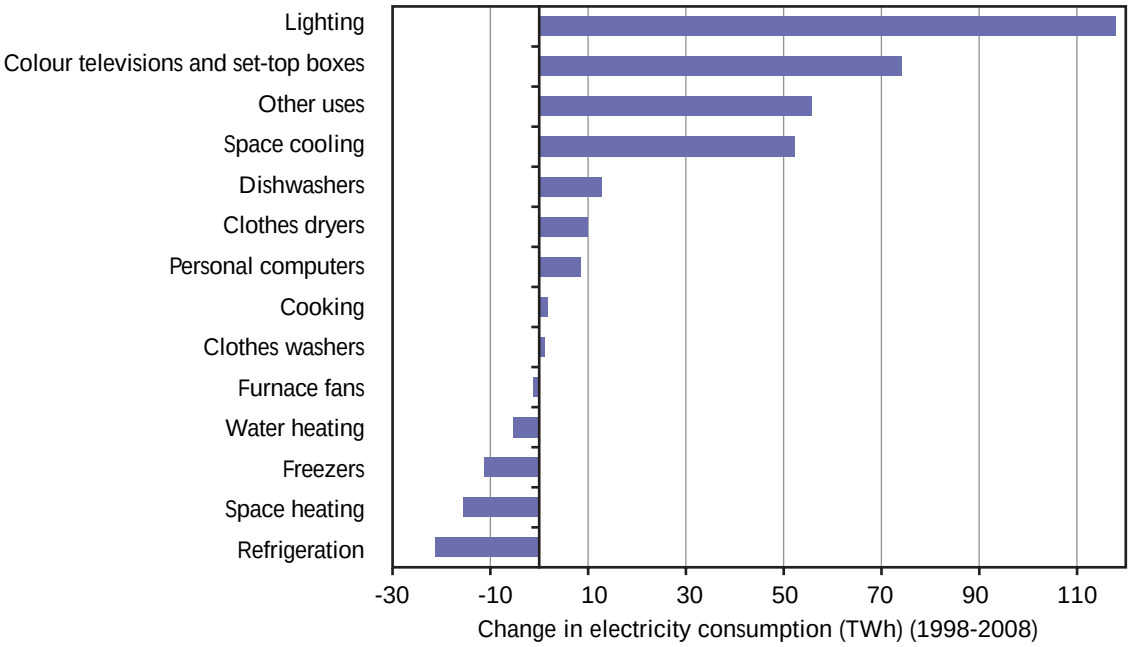
Figure 48 • Total residential and per capita electricity consumption, United States, 1995-2006



Source: IEA Statistics.

The profile of residential electricity consumption in the United States has changed over recent years, as indicated in Figure 49; with lighting, space cooling and consumer electronics growing more rapidly than many of the traditional home appliance categories.

Figure 49 • Change in United States residential electricity consumption, 1998-2005



Source: EIA, 2008.

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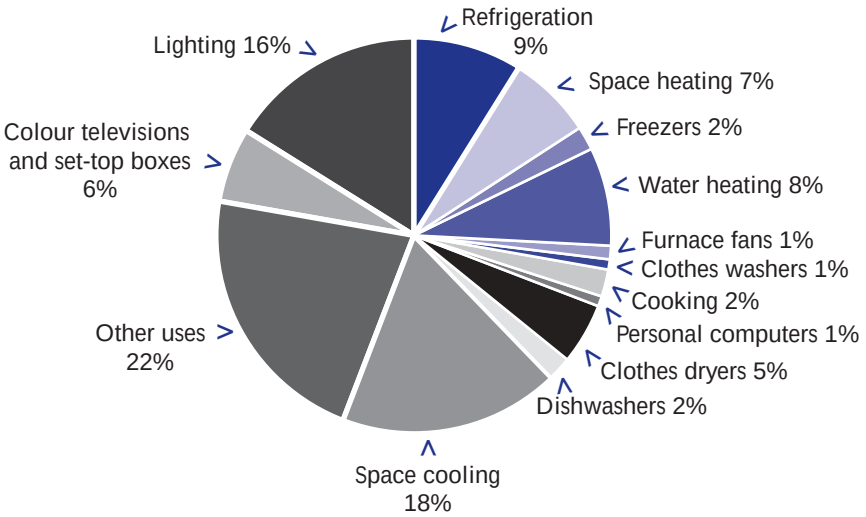
As a result, in the distribution of electricity consumption by end-use category in 2005, lighting, space cooling, televisions/set-top boxes and miscellaneous others account for 62% of total electricity consumption (see Figure 50).

Figure 50 • Distribution of residential electricity consumption by end-use, United States, 2005



Source: EIA, 2008.

The United States makes extensive use of comparison labels, endorsement labels and energy efficiency standards to improve the energy performance of residential equipment and appliances. Since 2002, notable developments have included:

- The introduction of 2 new major pieces of energy legislation - the Energy Policy Act 2005 (EPAct) and the Energy Independence and Security Act 2007 (EISAct);
- Release of an aggressive 5-year schedule (2006-2011) by the U.S. Department of Energy (DOE) to address a backlog of 18 products due for appliance standards rulemaking and the statutory requirements under the new EPAct;
- New Improved EnerGuide comparative label for major household appliances;
- New and revised MEPS for several product categories;
- Expansion of the ENERGY STAR programme to include new products and more stringent performance specifications for others; and the broadening of specifications to capture active mode consumption for some products.

Institutional organisation, policies and financial issues

Energy Policy Act of 2005 (EPAct)

The new Energy Policy Act was signed into law in August 2005 and is the first major piece of energy legislation since 1992. The EPACT 2005 establishes regulatory requirements which cover

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many products previously regulated and expands the Department of Energy's (DOE) authority to new products areas. Another major energy efficiency provision under this Act is manufacturer and consumer tax incentives for advances in energy saving technologies and practices (more than USD 2 billion over 2 years) (Nadel, 2005).

National Action Plan on Energy Efficiency 2025

In 2006, the National Action Plan on Energy Efficiency 2025 was released, providing recommendations to help states and other utilities address barriers that limit investment in energy efficiency. The report was facilitated by U.S. Environment Protection Agency (EPA) and the DOE and developed by a leadership group of more than 60 organisations, comprising electric and gas utilities, state agencies and other organizations. The National Action Plan made the following five key recommendations for aligning policies at the state level:

- Recognise energy efficiency as a high-priority energy resource;
- Make a strong, long-term commitment to implement cost-effective energy efficiency as a resource;
- Broadly communicate the benefits of and opportunities for energy efficiency;
- Provide sufficient, timely, and stable programme funding to deliver energy efficiency where cost-effective;
- Modify policies to align utility incentives with the delivery of cost-effective energy efficiency, and modify rate making practices to promote energy efficiency investments (EPA, 2007c).

In November of 2007, it was reported that close to 120 organisations had taken action in that year to remove barriers by establishing and supporting new energy efficiency programmes, exploring policies to align utility incentives with cost-effective energy efficiency, collaborating with state and local governments, and meeting energy saving goals (EPA, 2007b).

The Energy Independence and Security Act of 2007 (EISAct)

In December 2007, two years after Congress passed the EPAct 2005, new federal energy legislation was passed which included the following major provisions for appliance energy efficiency:

- New energy performance standards based on consensus agreements between industry and the American Council for Equipment Energy Efficiency (ACEEE) for eight products;
- Revised standards affecting regional efficiency for heating and cooling products;
- Revised procedures for new or amended standards;
- Energy efficiency labelling for consumer electronics (ACEEE, 2007).

The details of these undertakings are discussed below.

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Budget

The overall funding for DOE Energy Efficiency Programs has declined steadily between 2002 and 2008, although some subsectors such as building technologies have seen increased budgets. A relatively large cut in 2005 budget relative to 2004 has been blamed by some analysts for impeding efforts by the DOE to address a backlog of products subject to energy efficiency regulation (ASE, 2005a; UCS, 2005). However, funding for equipment energy performance standards has increased recently to facilitate implementation of provisions under the EPAct and EISAct (ASE, 2007b).

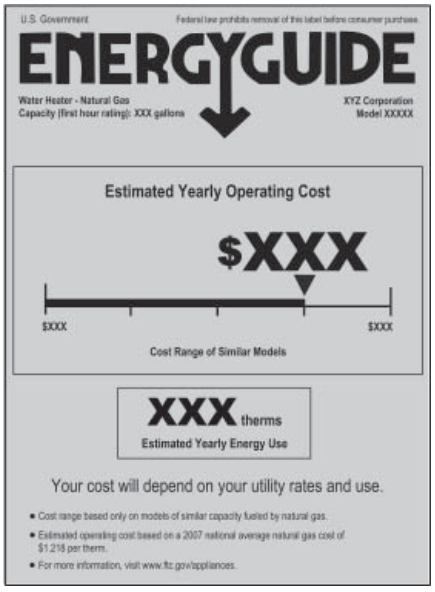
Table 32 • US federal government expenditure on major energy efficiency programmes (USD million)

Financial year	2002	2003	2004	2005	2006	2007	2008
DOE Energy efficiency programs	**682**	**659**	**650**	**626**	**631**	**622**	**514.9**
Equipment standards and analysis	*8.4*	*n.a.*	*n.a.*	*n.a.*	*10.2*	*n.a.*	*22.0*
Building technologies	*82.3*	*78.1*	*75.4*	*83.2*	*83.4*	*104.3*	*109.0*
Federal energy management	*20.3*	*20.7*	*21.4*	*19.9*	*19*	*19.5*	*19.8*
State energy program	*45.0*	*44.7*	*44.0*	*44.2*	*35.6*	*49.5*	*44.1*
Low-income weatherisation assistance	*23.0*	*223.5*	*227.2*	*228.2*	*242.6*	*204.6*	*227.2*
Energy Star (total)	**53.5**	**48.7**	**54.0**	**54.1**	**55.7**	**n/a**	**50.7**
EPA	*50.5*	*44.5*	*50.3*	*49.9*	*49.8*	*45.9*	*48.2*
DOE	*3.0*	*4.2*	*3.7*	*4.2*	*5.9*	*–*	*6.7*

Source: ASE, 2007b; CRS, 2006.

Energy performance labelling

Comparison Label: EnerGuide Label



The US EnerGuide comparative energy label has been in force since 1978 and covers major household appliances (See Table 34 for a list of products covered by the EnerGuide label). Labels must be displayed at the point of sale by all appliances of the designated product type and indicates the efficiency of each appliance compared to the maximum and minimum efficiency levels found on the market at that time. The energy labelling programme is legislated through the National Energy Policy and Conservation Act (NEPCA 1978) and is administered by the Federal Trade Commission (FTC).

Following direction in the 2005 Energy Policy Act and a two-year process to assess the effectiveness of the appliance labelling programme, a new design was released in 2007.

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The EnerGuide now displays estimated yearly operating costs in addition to annual energy consumption data for refrigerators, refrigerator/freezers, freezers, clothes washers, dishwashers, room air conditioners and water heaters. This change makes the new label a more comprehensible tool, enabling consumers to compare products and assess trade-offs between energy and other costs (FTC, 2007a, 2007b).

Under the Energy Independence and Security Act of 2007, the FTC have been directed to develop new energy consumption labelling programmes for consumer electronics, including television, personal computers, cable and satellite set-top boxes, stand-alone digital video recorder boxes, and computer monitors (ACEEE, 2007).

To further assist consumers when purchasing household appliances, the DOE has developed the Major Appliance Shopping Guide which contains information such as how appliances are rated for energy efficiency, what the ratings mean and, what to look for specifically when purchasing products.[13]

Endorsement Label: Energy Star

The US Energy Star programme, administered by the US Environment Protection Agency (EPA) and the DOE, began in 1992 and combines a voluntary endorsement label with information and promotion campaigns to improve energy efficiency. The programme is continuously expanding to include a wider range of products as well as updating the criteria for selected products where technology has advanced.

United States Energy Star vigorously engages with partners in the United States. and overseas and is the best-known and most comprehensive energy efficiency endorsement label in the world.

There are more than 12,000 businesses and organisations across the United States associated with Energy Star, and international partners in most of the major economies (EPA, 2008b).

Agreements to promote certain Energy Star qualified products have been established with government agencies in order to unify voluntary energy efficiency labelling programmes in major global markets. Activities by international partners include:

- The Australian Greenhouse Office is currently implementing Energy Star for office equipment and consumer electronics products;
- Natural Resources Canada (NRCan) is implementing Energy Star in Canada for a broad range of products including office equipment, consumer electronics, heating and cooling equipment, home appliances, lighting and signage, distribution transformers, commercial solid door refrigerators and freezers, and windows;
- The European Commission (EC) is implementing Energy Star in the European Union (EU). The United States and the countries of the European Community recently renewed their agreement to use the Energy Star label on energy-efficient office equipment which was first

13. Available from: http://www1.eere.energy.gov/consumer/tips/printable_versions/shopping_guide.html

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signed 2000. Specifically, the agreement covers the use of Energy Star labelling on office equipment including computers, monitors, printers, copiers, fax machines, and scanners; with other products possibly added in the future;

- The European Free Trade Association (EFTA) is implementing Energy Star in Norway, Iceland, and Liechtenstein;
- The Energy Conservation Centre Japan (ECCJ) is implementing Energy Star for office equipment on behalf of the Ministry of Economy, Trade, and Industry;
- The Energy Efficiency and Conservation Authority (EECA) is implementing Energy Star for office equipment, consumer electronics products, heat pumps/air conditioners and dishwashers in New Zealand;
- The Environment and Development Foundation (EDF) is implementing Energy Star for office equipment on behalf of the Environmental Protection Administration of Chinese Taipei;
- The EPA and the China Standard Certification Center (CSC) have agreed to begin voluntary work toward harmonising energy efficiency standards for a variety of products in China, including consumer electronics and office equipment (EPA, 2007a).

Since 2000, the coverage of the Energy Star label has increased from 40 residential and commercial product categories to over 50. Energy Star Retail Partners have increased from 25 to over 900 and consumer awareness of the Energy Star label jumped from 40% to over 65% in 2006 and up to 76% in 2007 (EPA, 2006; EPA 2008a).

Since 2002, the Energy Star programme has expanded to include an additional five products from the residential electricity end-use sector including:[14]

- air cleaners (2004);
- power adapters (2005);
- battery chargers (2006);
- decorative lighting strings(2007;
- set-top boxes (2008).

In addition, existing appliance specifications have been revised for an additional nine product categories including:

- audio/DVDs (2002);
- ventilation fans (2003);
- computer monitors (2005);
- clothes washers (2005);
- telephony (2006);

14. The bracketed dates denote the year new specifications were introduced.

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- dehumidifiers (2006);
- imaging equipment (copiers, fax machines, printers, and scanners) (2006);
- computers (2006);
- digital TV adaptors (2007);
- ceiling fans (2007);
- televisions (2008).

The specifications developed for power adaptors, computers and imaging equipment mark an important departure from the previous practice of specifying performance thresholds for products only in low power modes. These new product specifications address active mode consumption in addition to energy consumed in low power modes, and have required the development of new test methodologies (EPA, 2006).

Revisions are still in progress for CFLs, external power supplies, set-top boxes, imaging equipment, clothes washers, residential light fixtures, ventilation fans and programmable thermostats (EPA, 2008c).[15]

Table 33 below provides a full list of residential products eligible for the Energy Star label up to December 2007, and the estimated average energy savings achievable above the standard product in each category.

Table 33 • Energy Star qualified products

Product category	Average energy savings above standard product**	Product category	Average energy savings above standard product**
OFFICE		**CONSUMER ELECTRONICS**	
Monitors	20-60%	TVs	25%
Computers	5-55%	VCRs	30%
Fax machines	20%	TVs/DVDs/VCRs	90%
Copiers	20%	DVD products	60%
Multifunction devices	20%	Audio equipment	60%
Scanners	50%	Telephony	55%
Printers	10%	External power supplies	35%
		Battery charging systems	35%
RESIDENTIAL APPLIANCES		**HEATING AND COOLING**	
Room air conditioners*	10%	Furnaces	15%
Dehumidifiers	15%	Central air conditioners	15%
Room air cleaners	45%	Air source heat pumps	10%

15. This list correct at June 2008.

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Table 33 • Energy Star qualified products (continued)

Product category	Average energy savings above standard product**	Product category	Average energy savings above standard product**
Exhaust fans	70%	Geothermal heat pumps	30%
Ceiling fans	45%	Boilers	5%
Dishwashers*	40%	Programmable thermostats	15%
Refrigerators*	15%	**LIGHTING**	
Clothes washers*	25%	CFLs	75%
		Light fixtures	75%

Source: EPA, 2006.

*DOE managed products.
** Actual savings will vary by climate region and home characteristics.

Energy Star campaigns

Energy Star products are strongly supported nation-wide by educational programmes/campaigns that encourage greater uptake of qualified equipment and appliances by residential consumers, businesses and government. In 2006, the annual Energy Star *Change a Light, Change the World Campaign*, which was launched in 2000, was expanded to target organisations and businesses in addition to residential consumers. The campaign invites individual consumers to take a pledge to replace a traditional light bulb with an Energy Star qualified compact fluorescent light bulb. Businesses were invited to set a pledge goal and encourage employees, members and other networks to take the Energy Star *Change a Light* pledge. More than 600 organisations across every state hosted events to support the campaign in 2006 (EPA, 2006).

In 2006, the EPA also launched *ENERGY STAR@Home* which is an interactive online educational tool to assist consumers in understanding how energy is used in the home. A special feature of the tool is that it is updated seasonally to provide weather specific information. An additional feature was added in 2007 which facilitates online information sharing for homeowners.

The *Home Performance with ENERGY STAR* Initiative, launched in 2001, is part of a joint EPA and DOE effort to promote whole-house, energy efficiency retrofits, supported by a quality assurance programme. Retrofits are conducted through a network of qualified contractors who evaluate all of a home's thermal and mechanical efficiency components. In 2006 more than 12 000 *Home Performance with ENERGY STAR* retrofits were recorded, bringing the total number of retrofits completed under this programme close to 28 000. Partners participating in the programme during 2006 included the Long Island Power Authority, Austin Energy, Efficiency Vermont, National Grid, New York State Energy Research and Development Authority (NYSERDA), Wisconsin Focus on Energy and the states of New Jersey and Maine (EPA, 2006).

As a result of the *ENERGY STAR Qualified New Homes* programme, which was launched in 2000, almost 840 000 Energy Star qualified homes have been built, covering all 50 states and the District of Columbia. This initiative is reported to be saving homeowners more than

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USD 200 million annually. Homes that earn the Energy Star label are estimated to be at least 15% more energy efficient than homes built to the 2004 International Residential Code (IRC) and include additional features that make them 20-30% more efficient than standard homes. Qualifying homes must be independently verified to meet the EPA's strict guidelines (EPA, 2008b).

Minimum energy performance standards (MEPS)

New federal energy legislation

MEPS have been in existence nationally in the United States since the National Appliance Energy Conservation Act (NAECA) was introduced in 1987, and then extended by the Energy Policy Act in 1992. More recently two new bills have renewed and expanded the programme: the Energy Policy Act 2005 (EPAct) and Energy Independence and Security Act 2007.

Major provisions relating to electrical residential equipment in the EPAct 2005 include:

- Manufacturer tax incentives for very efficient refrigerators, clothes washers and dishwashers; and consumer tax credits for very efficient residential air conditioners, heat pumps, furnaces and water heaters;
- MEPS for 16 residential and commercial appliances[16] and furnace fans (Table 34 below shows the relevant national legislation and timescale for revision and implementation for each product. Information on products covered by state legislation is also included);
- Energy labelling for electronic devices;
- An appliances rebate programme, providing up to USD 50 million to match rebate programmes run by state-based energy departments;
- Extension of daylight saving by one month to reduce residential electricity use;
- Expansion of energy efficiency resource standards for electric and gas utilities;
- A requirement for Energy Star to provide at least nine months notice to industry in advance of new or revised specifications.

Only two years later, the Energy Independence and Security Act 2007 introduced new and revised MEPS provisions for an additional 10 products,[17] some of which apply to the residential electricity sector (see details in Table 34). In response to concerns that delays in the introduction of new and revised MEPS has caused a backlog, the bill included a number of measures to streamline the process. These include the ability of the DOE to implement revised requirements where there is consensus amongst stakeholders, and the removal of some elements of the consultation process (see section below).

16. Note that energy efficiency standards are also applied to water-using residential devices in the US, most notably shower heads.

17. Or, as in the case of dishwashers and clothes washers, extend the scope of standards to include water efficiency.

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Table 34 • MEPS for residential electrical equipment in the United States

Product covered	Coverage legislated	Last standard issued*	Effective date	Updated DOE MEPS due**	Potential effective date	States MEPS***
Battery charges	EISAct 2007	None	None	2011, 2015	2014	
Ceiling fans and light kits	EPACT 2005	2005	2007	2010	2012	
Central a/c and heat pumps	NAECA 1987	2001	2006	2011	2016	
Clothes dryers	NAECA 1987	1991	1994	2011		
Clothes washers	EISAct 2007	2001	2004	2012		CA
CFLs	EPACT 2005	2005	2006			
Cooking products: electric	NAECA 1987	1998	1998	2009	2012	
General service lamps	EISAct 2007			2017, 2022		
Dehumidifiers	EISAct 2007	2005	2007	2009	2012	
Dishwashers	EISAct 2007	1991	1994	2015		
External power supplies	EISAct 2007	None	None	2011, 2015	2014	AZ, CA, CT, MA, MD, NY, OR, RI, VT, WA
Fluorescent and incandescent lamps	EPACT 1992	1997	1997	2009		CA, MA, NY, OR, RI, VT, WA
Fluorescent lamp ballasts	NAECA 1987	None	None	2011		
Furnaces and boilers	EISAct 2007	2007	2008	2014		MA, RI, VT (furnaces only)
Furnace fans	EPACT 2005			Optional		MA, RI, VT
Pool heaters	NAECA 1987	1987	1990	2010	2013	
Refrigerators and freezers	EISAct 2007	1997	2001	2011		
Room a/c	NAECA 1987	1997	2000	2011	2014	
Torchiere light fixtures	EPACT 2005	2005	2006			AZ, CA, CT, MD, NJ, NY, OR, RI, WA
Unit heaters	EPACT 2005	2005	2008			CA, CT. MA, MD, NJ, NY, OR, RI, WA
Water heaters	NAECA 1987	2001	2004	2010	2013	
Direct heating equipment	NAECA 1987	1987	1990	2010	2013	
Hot tubs	N/A					CA,CT,OR
Pool pumps	N/A					CA, CT
Compact audio products	N/A					CA, NY
DVD players & recorders	N/A					CA, NY, OR

* Derived from the Appliance Standards Awareness Project webpage http://www.standardsasap.org/federal.htm (accessed September and December 2007). Also updated in accordance with product updates at http://www.eere.energy.gov/buildings/appliance_standards/residential_products.html (accessed December 2007).
** These are the final action dates derived from DOE's updated 'Multi-year Schedule' published in the Department's August 2007 Implementation Report: Energy Conservation Standards Activities, submitted to Congress Pursuant to Section 141 of the Energy Policy Act of 2005.
*** Derived from Appliance Standards Awareness Project webpage http://www.standardsasap.org/state.htm (accessed December 2007).

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The bill also includes requirements to undertake reviews of existing MEPS every six years and establishes deadlines for the completion of requirements (rulemaking) for eight products.

Other notable provisions under this bill include:

- DOE are permitted to set up regional standards, in addition to the national standard, for heating and cooling products to better accommodate the climatic ranges across the United States;
- All future standards for electrical products must incorporate energy use in standby and off modes.

The American Council on Equipment Energy Efficiency (ACEEE) estimates that new standards provision will save 177 TWh per year in 2030 and reduce peak electricity demand by 33 000 MW. The provision with the largest impact is likely to be the new standards for lamps, which will require them to use about 25-30% less energy than common incandescent light bulbs by 2012-2014 and at least 60% less by 2020 (ACEEE, 2007).

Table 34 over shows, for each product, the relevant national legislation and timescale for revision and implementation. Information on products covered by state legislation is also included.

Procedures for adopting new or revised MEPS

The development of new or revised MEPS in the U.S. is a thorough and complex process which involves many stages. NAECA and EPAct authorise the U.S. DOE to issue MEPS for household and commercial energy using equipment which shall be designed to achieve the maximum improvement in energy efficiency which the Secretary of the DOE determines is technologically feasible and economically justified. Generally MEPS must have a payback time of three years or less for an average consumer to gain approval.

The standards process involves four analytical phases and begins with the publication of a planning document and an announcement of intent by the DOE. Together with a call for comments and the scheduling of a public meeting for stakeholders, these form the *Notice of Availability*.

A rigorous investigation of incremental investments and energy savings, including identification of the least life-cycle cost configuration, is then undertaken, usually by contractors such as the Lawrence Berkeley National Laboratory. This also considers impacts on manufacturers and consumers. These results are disseminated in a *Technical Source Document* for comment and discussion, and sometimes further public meetings, and an *Advance Notice of Proposed Rulemaking* (ANOPR) is placed in the Federal Register.

The Department reviews all of the comments gathered from this process and addresses them in the third phase of analysis, which results in the publication of a *Notice of Proposed Rulemaking (NOPR)* in the Federal Register.

These various analytical phases of the standards making process are published in the *Final Rule: Procedures for Consideration of New or Revised Energy Conservation Standards for Consumer Products, 61 FR 36974* (also referred to as the *Process Rule*). This complex procedure ultimately leads to the publication of the Final Rule in the Federal Register which contains agreed MEPS levels and effective dates, typically a few years after the publication date.

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The Energy Independence and Security Act 2007 introduced a new process to streamline the procedures for reaching agreement on new or revised MEPS. The Act removes the requirement for two analytical phases of the standards making process; specifically the *Advance Notice of Proposed Rulemaking (ANOPR)* and the *Notice of Proposed Rulemaking* (*NOPR*). These have been replaced by a workshop to review the initial analysis to gain public input and comment on technical documents. There is also provision for an additional analytical phase if needed (LBNL, 2005; DOE, 2006a).

Progress since 2002

For the first half of this decade progress with the implementation of MEPS was extremely slow, for reasons acknowledged by the DOE in the January 2006 report to Congress: *Energy Conservation Standards Activities* (DOE, 2006a). With the introduction of EPAct 2005 and settlement of two legal proceedings bought by the State of New York and the Natural Resources Defence Council (NRDC), the DOE made considerable efforts to manage the programme effectively and expedite the agreed schedule (DOE, 2007c). This schedule and six-monthly updates of progress can be viewed online.[18]

Since 2002, new and revised MEPS have been issued for:

- residential clothes washers (2004);
- water heaters (2004);
- residential furnaces and boilers (2007);
- air conditioners and heat pumps (2007);
- ceiling fan light fittings (2007).

Additionally, new test procedures have been adopted for the following products:

- clothes washers;
- residential air conditioners ;
- heat pumps;
- ceiling fans;
- ceiling fan light kits;
- dehumidifiers;
- CFLs (medium-based);
- battery charges;
- external power supplies;
- torchieres.

A summary of the major policy measures directed at residential electrical appliances is provided in Table 35.

18. See http://www1.eere.energy.gov/buildings/appliance_standards/schedule_setting.html

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Table 35 • Summary of major national policy measures for residential electrical appliances

	Comparison label	Endorsement label	MEPS
Refrigerators	M	V (2001, 2005)	M (2001)
Freezers	M	V (2001, 2005)	M (2001)
Clothes washers	M	V (1997, 2005)	M (2004)
Washer/dryers		V	M (2004)
Clothes dryers			M (1994)
Dishwashers	M	V (1997, 2001, 2006)	M (1994)
Air conditioners:			
– Room	M	V (2003)	M (2000)
– Central	M	V (1995, 2002, 2005)	M (2007)
– Single packaged	M	V	M (2007)
– Split system	M		M (2007)
Heat pumps	M	V (1995, 2002, 2005)	M (2001, 2007)
Ceiling fans		V (2005, 2007)	M (2007)
Ventilation fans		V (2003)	
Dehumidifiers		V (2002, 2005)	
Air cleaners		V (2004)	
Space heaters	M	V	M (1990)
Furnaces	M	V	M (2008)
Water heaters	M	V	M (2004)
Ranges/ovens			
Pool heaters			M (1990)
Light fixtures		V (1997, 2002, 2005)	
Light strings		V (2007)	
Lamps	M	V (2003)	M (1997, 2006)
Ballasts	M	V	M
Copiers		V (1995, 2006)	
Fax machines		V (1993, 1994, 2006)	
Computers		V (1992, 2006)	
Monitors		V (2005)	
Printers		V (1993, 1994, 2006)	
Scanners		V (1997, 2006)	
Multi-function devices		V (1995, 1997, 2006)	
Televisions		V (2001, 2008)	
Set-top boxes		V (2007, 2008)	
VCRs & DVDs		V (2002)	
Radios		V	
Telephony		V (2002, 2006)	
External power supplies		V (2005)	
Battery chargers		V (2006)	

Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary.

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MEPS at the state level

Where no federal MEPS exist for a particular product, states are able to set their own requirements, however once a federal standard takes effect for that product, any state standards are automatically superseded. In recent years, the number of state MEPS has increased to fill perceived 'gaps' in the coverage of the federal programme. Of the 50 U.S. states, 12 currently regulate equipment and appliances for energy efficiency, including:

- Arizona (AZ)
- California (CA)
- Connecticut (CT)
- Maryland (MD)
- Massachusetts (MA)
- Nevada (NV)[19]
- New Jersey (NJ)
- New York (NY)
- Oregon (OR)
- Rhode Island (RI)
- Vermont (VT)
- Washington (WA) (ASE, 2008).

State standards laws enacted in 2001 (California), in 2004 (California, Connecticut and Arizona) and in 2005 (New Jersey, Arizona, Washington, Oregon, Rhode Island, New York and Massachusetts) prompted broad support for strong federal standards resulting in Congress enacting new standards as part of EPAct 2005. Table 34 lists state energy performance standards for residential product only.

Fiscal incentives

Manufacturer and consumer tax incentives for energy efficient technologies were one of the major energy efficiency provisions under EPAct 2005. (Nadel *et al.* 2006) For the years 2006 and 2007 a federal tax credit (known as the *nonbusiness energy property credit*) of up to USD 300 was available to consumers purchasing eligible high efficiency heating, cooling and water heating equipment, with a maximum credit of USD 500 per home (TIAP, 2007).

A separate *residential energy efficient property credit* was established in 2006 and will run to the end of 2008. A tax credit of up to 30% of the capital and installation costs is available for eligible solar electric and water heaters and fuel cell equipment.

19. Standards for general purpose lights sold in Nevada come into effect for the first time in 2012.

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During 2006 and 2007, manufacturers of dishwashers, clothes washers and refrigerators were eligible for tax credits of up USD 175 per unit[20] for qualifying models produced in 2006 and 2007. Eligibility under this scheme required an increase in production of qualifying products over a 3-year rolling baseline. Each manufacturer was limited to a total of USD 75 million of credits under this provision (TIAP, 2006).

From 1 January through to the end of December 2008, a tax credit of USD 2 000 is available to home builders who build homes projected to save at least 50% of the heating and cooling energy comparable to those that meet the 2003 International Energy Conservation Code (IECC) (TIAP, 2006).

Manufacturers can also receive a tax credit of USD 1 000 for manufactured homes that use 30% less energy than the IIEC or that met the then-current Energy Star criteria for manufactured homes (Nadel, 2005). These tax credits apply to homes acquired between 1 January 2006 and 31 December 2007.

In 2007, over 900 federal, state and utility financial incentives for energy efficiency were available including loans, bonds, grants, rebates and taxes (DESIRE, 2007a). Further information on state and utility programmes relating to equipment and appliances is provided below.

Consortium for Energy Efficiency (CEE)

Founded in 1991, the U.S. Consortium on Energy Efficiency (CEE) is a non-profit, public benefit corporation, supported by the U.S. EPA and DOE, to promote the use of energy efficient products, technologies and services. CEE membership includes electric, gas and water utilities, research and development organisations, and state energy offices and regional energy programmes.

CEE's activities in the residential sector include a variety of specification development and qualifying product identification, in order to promote bulk purchasing; government procurement; manufacturer incentives (Golden Carrot), particularly in the following areas of electrical appliances:

- super-efficient refrigerators, room air conditioners, clothes washers and dishwashers;
- compact fluorescent lamps (CFLs) and fixtures;
- central air conditioners and heat pumps;
- televisions, set-top boxes, computers, internal and external power supplies, and standby power.

The most recent of the residential activities is the Consumer Electronics Initiative which was launched in June 2007, under which CEE will work with Energy Star to develop a consistent definition of and criteria for energy efficiency in the consumer electronics product area, and to identify products that meet these criteria (CEE, 2007).

There have been several developments since 2002 in relation to other CEE residential initiatives, including:

20. Available for refrigerators that save 25% or more energy relative to the 2001 standard.

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- In 2002 CEE partnered with the American Lighting Association and the DOE to deliver *Lighting for Tomorrow*, a national lighting fixture design competition providing incentives for the development of innovative, decorative, and energy efficient (meeting Energy Star criteria) lighting fixtures. Four winners were announced in May 2004, three of which were subsequently introduced to the marketplace;
- Phases 2 and 3 of the competition were introduced in January 2005 and January 2006 for indoor and outdoor lighting fixtures, and innovative technologies. In 2006, CFL fixture families were promoted to retailers and builders through a Yearbook. Another competition was launched in 2007 and 10 000 copies of the 2006 yearbook were distributed nationwide;
- In 2004, under the Residential HVAC Initiative, the CEE launched a directory of energy efficient residential and small commercial HVAC systems. The federal tax incentive for central air conditioners requires that products achieve the highest efficiency tier established by the CEE. The directory allows consumers to search for central air-conditioning systems that meet these required specifications (CEE, 2007).

Federal procurement

As directed by EPAct 2005 and a number of Executive Orders, U.S. federal agencies are required to purchase only products which meet criteria established by Energy Star, or the Federal Energy Management Program (FEMP). It is also a requirement that federal agencies select products that meet FEMP minimum requirements for standby power consumption (DOE, 2007d).

FEMP publishes online *Purchasing Specifications for Energy Efficient Products*, which provide information about efficiency criteria, tips for correct installation and use of products, life-cycle energy cost savings, product supply sources, and resources to assist with further product research. FEMP also works with Energy Star to develop specifications for federal purchasing of low standby power products and has created a database of devices that meet the standby power requirements.[21]

FEMP and Energy Star also provide two software tools, the lifetime energy *Cost Calculator* and the *Building Life-cycle Cost* tool to assist procurement managers to estimate the energy savings from energy efficient products (DOE, 2007d).

Building regulations

Building energy codes and standards are supported by the DOE through its Building Energy Codes Program (BECP) and by providing funding to states through the State Energy Program (SEP).[22] The BECP provides direct financial and technical assistance to the states to implement and enforce state and local building energy codes; helps tailor the national model energy codes to meet the needs of individual jurisdictions; develops code compliance software and training

21. *Available at: http://www1.eere.energy.gov/femp/procurement/eep_standby_power.html*
22. *Established in 1996, the SEP provides grants to the states to design and carry out their own renewable energy and energy efficiency programmes.*

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materials; provides compliance training and undertakes evaluations of state programs. This information is then made publicly available to other jurisdictions (DOE, 2007b).

On 21 December 2007, mandatory federal energy codes were introduced for new federal buildings constructed on or after 3 January 2007. Federal commercial and multi-family high-rise buildings and new federal low-rise residential buildings are required to achieve greater energy efficiency of at least 30% compared to existing building codes. U.S. energy codes for buildings typically specify requirements for thermal resistance in the building shell and windows, minimum air leakage and minimum energy efficiency for heating/cooling equipment and lighting. These new standards consider the entire buildings performance rather than individual building components and systems (DOE, 2007a).

For buildings outside the scope of this new federal legislation, the DOE approves a series of model codes, which are not mandatory, such as those developed by the International Code Council and ASHRAE. These may adopted at the state and local government level.

Today, over 40 U.S. states, and the District of Columbia, use either a version of the Model Energy Code (MEC) or the IECC model energy code, or their own energy codes that are equal to or more stringent than the models. Eleven of the 40 states are using the most stringent version of the International Energy Conservation Code (IECC) model energy code (IECC 2006), which was approved by DOE. Several large municipalities within three of the nine states that do not have energy building codes have adopted the 2003 IECC.

Recent developments in building energy codes in select U.S. states include:

- Oregon is updating its residential code to be 15% more stringent than the IECC 2006;
- Idaho adopted the IECC 2006, effective 1 January 2008. There is also a new legislative requirement that means this code will be updated every 3 years;
- Montana adopted the IECC 2006, with amendments, effective 1 January 2008 (EPA, 2008d; DOE, 2007b).

Snapshot of state government programmes

There are scores of state energy efficiency programmes operating around the United States. In 2007 alone, there were more than 900 financial incentives available including loans, grants, rebates and tax deductions. Included below is a snapshot of a variety of policy tools that have been implemented at the state level since 2002, to provide an indication of the scope of activity.

Personal tax credit - Oregon

Home-owners and renters in Oregon who purchase high efficiency appliances, heating and cooling systems, duct systems, closed-loop geothermal space of water systems are able to claim an energy tax credit. Incentives are also offered for renewables and alternative fuels for vehicles. In December 2007, the incentive was extended to include certified, residential clean burning wood stoves.

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The Oregon Department of Energy keeps a list of qualifying products. The tax credit is 25% of the net cost of the appliance or the amount listed for qualifying models, whichever figure is less. Eligible consumers can receive a maximum USD 1 000 per calendar year under this scheme (ODE, 2007).

Sales tax exemption: Connecticut

CFLs and a number of residential weatherisation products are exempt from the state sales and use tax. Weatherisation products include programmable thermostats, water heaters, furnaces and boilers that meet the Energy Star standard, oil furnaces and boilers that are at least 84% efficient, and ground-source heat pumps that meet the federal MEPS (SOC, 2007).

Property tax exemption: New York

A number of energy efficient technologies are exempt from New York's real estate property tax to the extent that the addition would increase the value of the dwelling. The exemption applies to water heaters, furnaces, boilers, heat pumps, air conditioners, programmable thermostats and other technologies. Single-family to four-family dwellings are eligible. Conservation state or federal tax credit or deduction is also exempt from New York's property tax (NYS, 1997).

Utility rebate programme: California

The City of Lompoc Utilities (CLU) in California offers rebates to customers who upgrade the energy efficiency of their appliances. Energy Star clothes washers and dishwashers are eligible for rebates of USD 120 and USD 50 respectively which are paid as monthly credits on consumer utility bills. A rebate of USD 100 is paid in full to customers who replace electric clothes dryers or water heaters with models that use gas. LED holiday lights earn USD 4 for strands up to 70 feet or USD 8 for longer strands.

The CLU also has a fridge buy-back scheme which offers USD 35 to customers (or USD 120 for refrigerators manufactured before 1992) and free pick-up and disposal of refrigerators (LOMPOC, 2007).

Grant programme: Delaware

Delaware's *Energy An$wers for Home Appliances* programme provides grants to residents who replace inefficient products with eligible high-efficient ones. Clothes washers/dryers, refrigerators/freezers, water heaters, air-conditioners and programmable thermostats are all eligible products. Residents may select any combination of up to five products to receive USD 500. Grants offered on an individual basis are USD 100 for high-efficiency refrigerators, USD 50 for freezers, USD 100 for front-loading clothes washers, USD 25 for a/c window units, USD 25 for electric water heaters and USD 350 for central a/c. In 2006, USD 8 million in funds was appropriated to fund the programme (DNREC, 2007).

State loan Programme: Idaho

The State Department of Water Resources administers low-interest loans of up to USD 15 000 for residential energy efficiency retrofit projects in Idaho. There is a 5-year repayment term

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with an interest rate of 4%. Two loan options are available to residential consumers: the standard *Residential Loan Program or the Home Performance with Energy Star Program*. Eligible improvements under both programmes cover electric and gas heating upgrades, and improvements to water heaters. The *Home Performance with Energy Star Program* also provides funds for improvements to air-conditioning (ASE, 2007a).

California

California serves as a model for other U.S. states seeking to reduce energy consumption. Beginning in the 1970's, California enacted energy efficiency building code policies, financial and other incentives to lower the use of electricity state-wide. California adopted the first appliance standards law in 1974. Today, California uses less energy per capita than any other state in America and has managed to hold this energy consumption constant while energy use per person for the United States has been increasing (Mufsen, 2007).

In 2005, the California Energy Commission (CEC) adopted the state's 2006 *Appliance Efficiency Regulations*, replacing all previous versions of these laws. These regulations create minimum energy performance standards for 21 categories of appliances, more than any other state. The CEC also plans to introduce MEPS for all general purpose lights by December 2008, designed to reduce the average statewide energy consumption of indoor lighting by 50% compared to 2007 levels for the residential sector, and by 25% of 2007 levels for the commercial sector by 2018 (CEC, 2007; DESIRE, 2007b).

Over 70 energy efficiency rebates, grants and loans are offered by utilities in the state of California. The state government administers a loan programme for energy efficiency projects in schools, local governments and public hospitals. The programme has a USD 40 million endowment, with a maximum loan of USD 3 million per application. The residential sector is eligible for a tax deduction on loans (from publicly-owner utilities) used to purchase energy efficient products or equipment.

In 2005, California released an Energy Action Plan, endorsed by the Governor, California Public Utilities Commission (CPUC), and California Energy Commission (CEC), which establishes energy efficiency as the state's top priority procurement resource. A new administrative structure calls for utilities to invest in energy efficiency whenever it is cheaper than power plants, which may double the level of energy savings that California's largest utilities achieve over the next decade, according to some estimates. Also in 2005, the CPUC authorised utility energy efficiency plans and USD 2 billion in funding for 2006-2008 to support projects (ASE, 2005b).

Evaluation and enforcement activity

Evaluation

The DOE is responsible for undertaking analysis and reporting on the impacts and saving potential of U.S. energy efficiency performance standards for a range of products, including residential products. This analysis is typically undertaken by the Environmental Energy Technologies Division, within the Lawrence Berkeley National Laboratory (LBNL).

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The most recent evaluation of federal residential energy efficiency standards in 2005 provides programme impacts for federal standards that came into effect between 1988 and 2001, or took effect by the end of 2007. The study is an updated version of an earlier report submitted in 2002. The updated study considers initial standards and updates for the following nine residential products: refrigerators; central air conditioners and heat pumps; clothes washers; clothes dryers; dishwashers; water heaters, and gas furnaces.

The report estimates that the MEPs for these products will reduce residential energy consumption and CO_2 emissions in 2020 by 8% compared to the levels in the absence of standards. This equates to a cumulative total of 34 quads by 2020 (approx 35 871 PJ) and 54 quads by 2030 (approx 56 973 PJ). The estimated cumulative NPV of consumer benefit is USD 93 billion by 2020 and grows to USD 125 billion by 2030 (Meyers *et al.*, 2005). These estimates do not differ substantially to the original evaluation report.

The Energy Star Program is evaluated on an annual basis and key achievements are reported in the EPA Annual Report. Reductions in greenhouse gas emissions and energy bills resulting from the Energy Star programme in 2006 were reported to be 10% higher than in 2005 and more than double the savings in 2000. These savings are attributed primarily to reduced demand for electricity which was 170 billion kWh – almost 5% of the total U.S. demand for electricity (EPA, 2007d).

Annual surveys of consumer awareness of the Energy Star label have been undertaken since 2000 by the CEE and its members. As reported earlier in this publication, survey results indicate that consumer awareness of the Energy Star label has increased from 40% in 2000 to over 70% in 2007.

Compliance and enforcement: federal government level

The DOE has primary responsibility for verification and enforcement of the U.S. MEPS programme, and substantial legislative powers including:

- The right to access manufacturers' records;
- The power to oblige a manufacturer to supply products for third-party verification testing at the manufacturer's expense;
- The ability to levy penalties of up to USD 100 for each violation or instance of non-compliance. Note that a "violation" is defined as each unit sold for each day of non-compliance (Witkowski, 2008).

The manufacturer or supplier is required to submit a certification report to DOE prior to launching products in the marketplace, containing energy-performance data and a completed compliance conformity declaration. Suppliers are also required to file a report each time a model is discontinued.

Many manufacturers and suppliers in the United States undertake their own product tests and submit certificates to the DOE via a relevant industry association. Several trade associations conduct their own verification testing using an independent organisation, and the results are forwarded to the DOE (Egan, 2008). However, there is no publicly available information on

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the number of tests undertaken by DOE, trade associations or third parties, or the results of verification testing or, if instances of non-compliance have been found, what actions have resulted.

For the EnergyGuide label, energy-performance testing is conducted by the supplier and the test data is provided to the Federal Trade Commission (FTC). In cases where well-established trade associations have initiated their own credible product-certification scheme, the DOE will allow the trade association to compile and report test results in a product directory of its members, which is then sent to DOE. For example, the Air-conditioning and Refrigeration Institute (ARI) programme is a trade association led certification scheme that is recognised by DOE.

Energy Star undertakes a range of evaluation processes, including the monitoring of awareness, market share of uptake of labelled products and to ensure that labelled products meet Energy Star specifications. Under the verification programme, third-party laboratories are contracted to source products, perform the required tests and reports on the results. Generally products selected for testing include those with the largest market share, providing good geographical coverage and available through different channels (retail, Internet, etc).

Where products are shown to be non-compliant, the EPA negotiates an appropriate course of action with the manufacturer. To date, verification tests have been conducted on the following products:

- televisions;
- DVDs;
- monitors;
- telephony (*e.g.*, cordless phones);
- scanners;
- multifunction devices and upgradeable digital copiers;
- printers and fax machines;
- dehumidifiers;
- computers.

For luminaires, lamps and ballasts, Energy Star operates a quality assurance programme (QA-4) which is funded by programme participants. In this scheme, suppliers nominated the third-party laboratory to undertake tests and agree to de-list non-compliant products.

During 2007, the results of verification testing included 100% pass rate by 15 computer monitor; 9% failure rate by 11 air cleaners, and 20% failure rate by 10 light fixtures (Egan, 2008).

Compliance and enforcement: state government level

Typically, manufacturers are required to provide certification details to individual jurisdictional authorities to demonstrate that products have been tested in accordance with energy efficiency regulations under the relevant state legislation. Some states such as California specify that product

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testing and certification must be undertaken by approved third-party testing laboratories. A database of approved products is usually maintained which may be made available to the federal government for verifying compliance. The federal government does not maintain a database of U.S. compliant products.

Legislative provisions vary with respect to enforcement activities amongst states but may include, for example: third-party or self-certification; product testing by state authorities to check for non-compliance; periodic inspection of retailers and distributors, and; the issuing of fines for non-compliance. Some states, such as Maryland, have adopted all of these measures and also have the mandate to publicly list non-compliant products to deter repeat offenders (MEA, 2005). California is currently is the process of establishing a compliance and enforcement programme in 2008.

International engagement

Asia-Pacific Partnership (APP)

In July 2005, the United States joined with Australia, China, India, Japan, and South Korea to establish the Asia-Pacific Partnership on clean development, energy security and climate change. The United States co-chair the Building and Appliances Taskforce. For the fiscal year 2007 budget, the United States had agreed to provide USD 47 million to support the work of the partnership.

Energy efficiency promotion: India and China

In 2006, the US and India reiterated their commitment to work together to build the capacity to plan and implement energy efficiency to help advance Indian's energy security and address rapid energy growth. The Power and Energy Efficiency Working Group, launched in 2005, facilitates US-Indian dialogue of energy efficiency by promoting exchange of information, technology choices and regulatory policies (CGUS, 2006).

The US-China Energy Policy Dialogue between DOE and China's National Development and Reform Commission was developed in 2004 as a forum to discuss areas for energy cooperation between the two countries. In September 2006, a five-year agreement to extend cooperative dialogue between energy security and environmental protection was agreed by both parties (DOE, 2006c).

In March of 2007, the EPA and the China Standard Certification Center (CSC) agreed to work towards harmonising information on their respective energy efficiency labels for consumer electronics and office equipment. Future endeavours will also see more unified energy standards in both programmes and building China's capacity to manage an internationally-recognised product labelling programme. Past cooperation on certification development between the EPA and CSC has led to the addition of 10 product categories to China's certification and labelling programme since 2001, including computers, monitors, televisions, office copiers, fax machines and external power supplies.

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Energy Star international partnerships

The U.S. EPA engages with government agencies in Australia, Canada, the European Union, Japan, New Zealand and Chinese-Taipei to promote select Energy Star products. These partnerships aim to achieve consistency across voluntary energy efficiency labelling programmes to avoid a patchwork of varying country-specific requirements for Energy Star partners. Energy Star International stakeholder meetings were held in 2002 and 2005 to discuss a range of implementation and coordination issues.

North American Energy Working Group

In June 2005, the governments of Canada, Mexico and the United States launched the Security and Prosperity Partnership (SPP) to strengthen regulatory cooperation; streamline regulation and regulatory process, and; encourage the compatibility of regulations where appropriate and feasible. The North American Energy Working Group (NAEWG), which was established in 2001, became part of this broader trilateral initiative. One focus of this partnership is to build on existing efforts by NAEWG to explore opportunities for greater cooperation on energy efficiency standards.

Since 2002, the NAEWG has successfully harmonised energy performance standards for refrigerators, air conditioners and large electric motors. In July 2007, energy ministers from the three jurisdictions endorsed a work programme which will see strengthened cooperation on standby power consumption and further harmonisation of energy standards. Products for consideration include gas and oil water heaters, clothes washers, dishwashers, fluorescent lamps, incandescent reflector lamps, single package central air conditioners and heat pumps (Cockburn, 2007).

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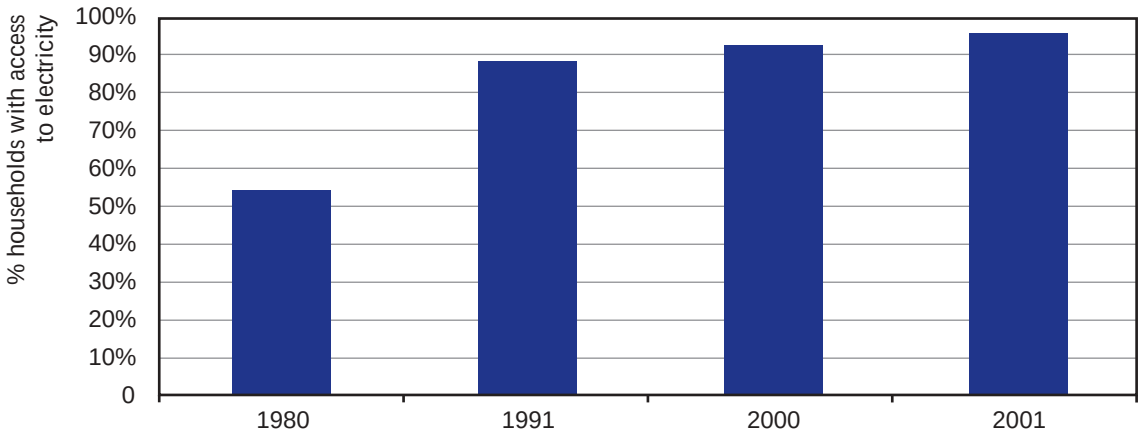
BRAZIL

Brazil has a growing residential demand for electricity which has risen by an average of 3.6% per annum from 1990 and 2005. Electricity consumption per capita has also increased 3.1% per annum from 1990 to 2000, partly due to the increasing access to electricity (see Figure 51) so that by 2001, 93% of households had connection to electricity.

Figure 51 • Households with access to electricity (%)



Source IAEA, 2003.

In 2001 Brazil experienced a shortage in electricity supply which prompted the government to impose rationing of electricity. For the residential sector, the aim was to reduce consumption by 20% compared to the previous year, translating to maximum threshold of 200 kWh per month for each household. Those using 201-500 kWh were threatened with a 50% surcharge, while households which consumed more than 500 kWh could face a 200% surcharge and ultimately disconnection. However, households which restricted their use to less than 200 kWh received a rebate. In addition, the government mounted an energy saving campaign which led to:

- the distribution of 5.6 million of compact fluorescent lamps;
- a 30% decrease in air conditioning sales;
- the replacement of electric showers with gas heaters;
- the rapid diffusion of solar panels; and
- information to end users, resulting in less usage of air conditioning and lighting (Souza *et al.*, 2007; De Almeida 2005).

The impact of these measures was considerable. During the 9 months of rationing, from June 2001 to February 2002, Brazil saved an estimated 26 TWh of electricity. Many of the technologies and practices from this period have endured, further stimulated by increases in residential electricity tariffs, so that per capita electricity consumption has remained lower than before the

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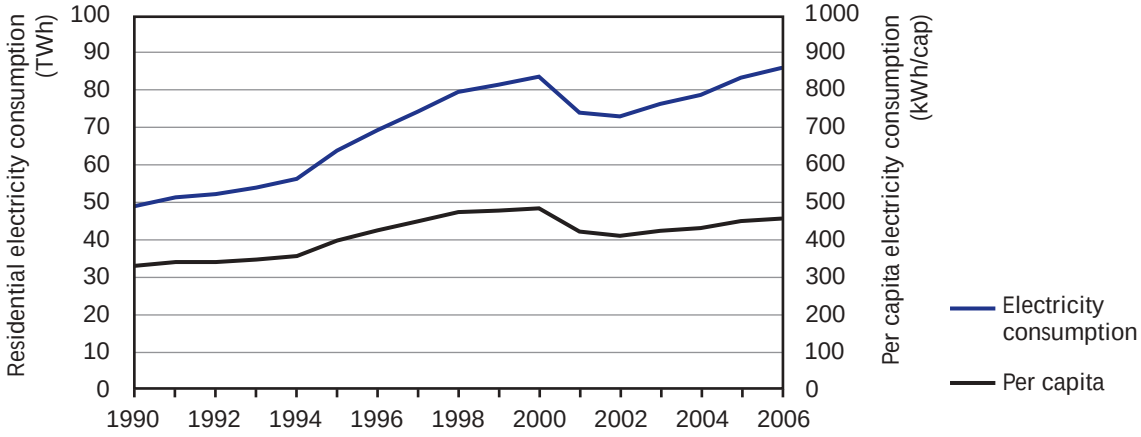
2001 crises, as shown in Figure 52. However in recent years total residential consumption has now surpassed the 2000 level.

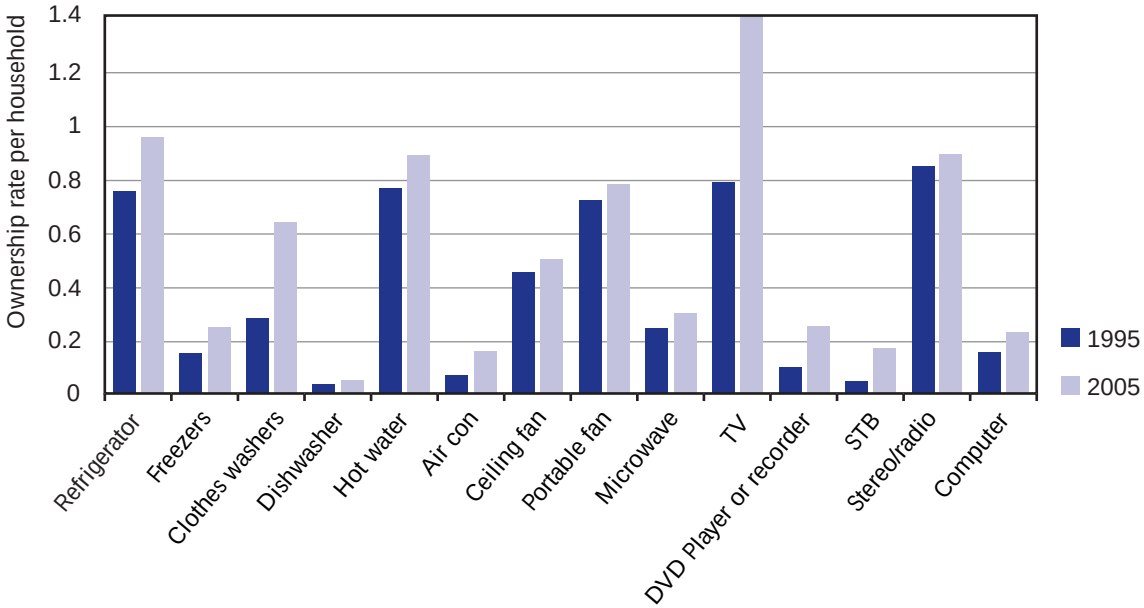
Figure 52 • Total and per capita residential electricity consumption, 1990-2005



Source: IEA statistics.

Increasing ownership levels for many common household appliances has contributed to the growth in electricity consumption, as shown in Figure 53. Most pronounced is the increasing penetration of televisions, clothes washers, refrigerators and entertainment equipment.

Figure 53 • Growth in ownership levels of household appliances, 1995-2005



Source: Electrobras, 2007.

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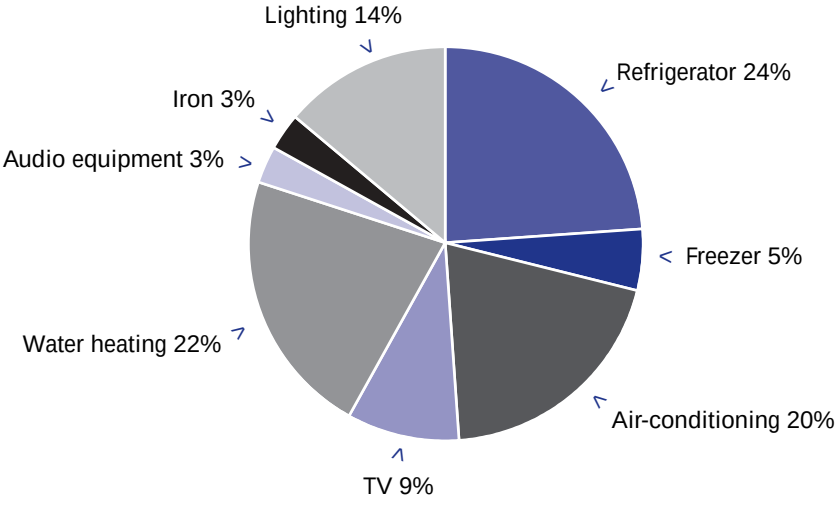
The estimated distribution of residential electricity consumption by end-use category shows that refrigeration, water heating, air conditioning and lighting are currently the largest users of electricity.

Figure 54 • Residential end-use electricity consumption, 2005



Source: Electrobras, 2007.

Electricity supply and distribution constraints, together with the aspirations for increasing access to electricity, have led to energy efficiency having a high profile within the Brazilian economy. This has not always been the case – indeed government acknowledgement of the barriers facing investment in energy efficiency in the 1980s led to the launch of the Brazilian Labelling Programme (PBE) in 1984, and a year later to the establishment of an efficiency programme (PROCEL) targeted at the electricity sector. Particular barriers identified at the time included:

- low electricity tariffs;
- insufficient resources;
- resistance by utilities;
- lack of a legal framework.

Additional issues which required attention at the programme level were also identified, such as:

- lack of information (categories of largest consumption and growth; energy savings potentials);
- lack of technology dissemination;
- few qualified professionals.

PBE launched its appliance energy labelling programme in 1984 with a voluntary label for refrigerators and freezers, and it has developed considerably since that date to cover electrical and gas products in all sectors. Currently there are 29 products covered by the comparative

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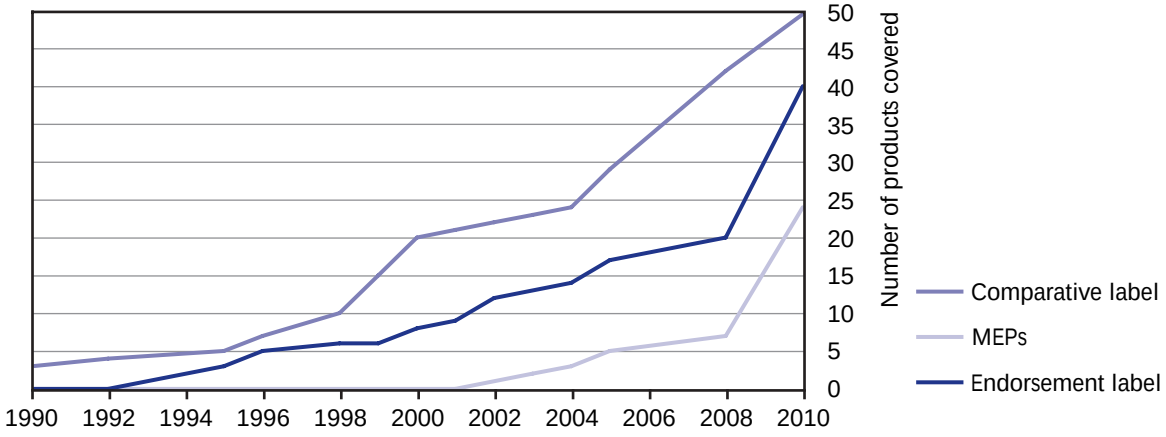
energy performance label, and 17 by the Brazil endorsement label, with plans to expand to 50 and 40 respectively by 2010 (see Figure 55).

Figure 55 • Progress with MEPS and labels for all products in Brazil



Source: Derived from Menandro *et al.*, 2007.

The standards and labelling programme is in a transition phase, moving from a largely voluntary approach initially to the introduction of more mandatory measures. The *National Policy for Energy Efficiency*, passed in 2001, established the legal basis for minimum energy performance standards, with the intention that most major energy using appliances would be covered in due course. Brazil has so far introduced MEPS for 5 products and will move to expand this to 24 by 2010.

In 1998 Utility involvement in energy efficiency received a major boost with the requirement that 1% of revenues must be spent on energy efficiency and R & D, thereby releasing considerable funds (equivalent to USD 156 million in 2003/4) for programme activities.

Energy efficiency initiatives in Brazil have developed steadily, as has the institutional and technical capacity to deliver effective programmes. Like many countries, increased consumer wealth is leading to growth in residential electricity consumption, as householders make increasing use of the appliances now available. The penetration of appliances in many end-use categories in Brazilian households is still considerably less than in many OECD countries, and therefore there is a likelihood that further increases will follow. This situation requires careful monitoring to ensure that policy measures remain effective (Leonelli, 2007; Guerreio, 2006).

Institutional organisation, policies and financial issues

The Brazilian Ministry of Mines and Energy (MME) has overall responsibility for energy efficiency, which is discharged through two agencies: Petrobras (The Directory of Energy and Gas) and Electrobras (The Directory of Special Projects).

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Petrobras manages the national programme for the efficient use of oil and gas, called CONPET, while Electrobras manages the equivalent programme for electricity, called PROCEL (Program to Combat the Waste of Electricity).

Other relevant agencies include

- ANEEL (Agência Nacional de Energia Elétrica), the federal regulatory body for the electricity sector;
- INMETRO, the national metering and standardisation organisation;
- EPE (Empresa de Pesquisa Energetica) state owned company established in 2005 to undertake planning studies;
- CEPEL (Centro de Pesquisas de Energia Electrica), a non-profit research institute for the power sector founded in 1974, provides technical support to Electrobras (Pinto, 2007).

PROCEL, launched in 1985, has a mandate to promote the efficient use of electricity through educational and demonstration projects, and the development of technical support for laws and regulations relating to energy efficiency measures.

In 1998, the federal regulator ANEEL placed a requirement on domestic electricity distributors to invest 1% of revenues on energy efficiency and R&D activities (called the 'wire-charge'). Funding is allocated on a project basis to a number of sectors by specialist committees (including for energy efficiency) established for the purpose (Guerreiro, 2006; Hollauer, 2008).

In October 2001, Law 10.295 on National Policy for the Conservation and Rational Use of Energy (Política Nacional de Conservação e Uso Racional de Energia) came into force. This stipulates that the government has authority to (i) lay down minimum mandatory energy efficiency standards for household appliances and equipment that consume energy and (ii) develop mechanisms to promote energy efficiency in buildings. Technical standards and secondary legislation are required for the provisions of these two measures to be implemented (CLASP, 2000).

Budget

Since 1998 electricity distributors have been required to invest 1% of revenues in energy efficiency and R&D activities; however the rules governing the allocation of funds have changed since this time. Generally around 50% of funds are targeted towards energy efficiency activities although the specific allocation for end-use measures has varied from year to year. The requirements have been further strengthened by the introduction of cost-benefit tests and the exclusion of marketing programmes. In recent times a further requirement that half of the energy efficiency budget must be spent on low income households has also been added.

Since projects may have a lifetime exceeding 12 months, Table 36 provides only an approximate picture of the funds targeted towards end-use efficiency initiatives. It nevertheless provides a reasonable indication of the scale of investments, which are considerably larger than the budget allocation for government activities.

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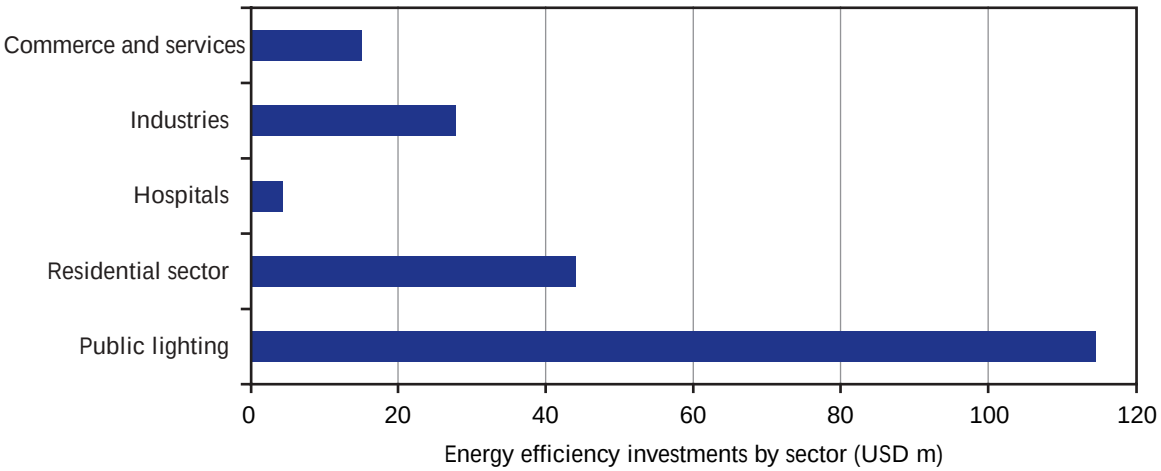
Table 36 • Investments in energy efficiency from wire charge

Year	1998/9	1999/0	2000/01	2001/2	2002/3	2003/4
Investments (USD million)	118	124	91	86	95	188
Allocation to end-use energy efficiency (%)	59%	59%	40%	50%	40%	40%
Allocation to energy efficiency (USD million)	69	73	36	43	38	75

Source: Guerreiro, 2006; World Bank, 2008.

Some criticism has been made that these funds have not been well directed; for example over 50% of funds have been spent on public lighting, although this represents only 3% of annual electricity consumption (see Figure 56). Since municipalities have a poor payment record for public lighting, targeting energy efficiency programmes at this sector may have been a means for utilities to minimise their lost income. Increasingly, projects are sub-contracted to ESCOs for design and implementation, which has led to the development of this industry. However, concerns have been raised about the long-term viability of ESCOs reliant upon this source of income, as well as other issues regarding the planning of initiatives, their co-ordination with public policy, the involvement of customers and the private sector, and the lack of thorough *ex post* cost-benefit analysis (World Bank, 2008).

Figure 56 • Allocation of investments from wire charge by sector



Source: Guerreiro, 2006.

As noted previously, the PROCEL budget is considerably smaller than the funds generated by the wire-charge, and has fallen in recent years. In 2007, PROCEL employed 85 staff (Menandro *et al.*, 2007).

Table 37 • PROCEL budget, 1996-2003

Year	1996	1997	1998	1999	2000	2001	2002	2003
Total budget* (USD million)	12	25	30	24	16	18	18	17

Source: Guerreiro, 2006.

* Not including costs of Electrobras staff.

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PROCEL: Voluntary agreements

Launched in 1986, the programme's first initiative established energy efficiency targets for domestically-manufactured refrigerators, which helped increase the market share of high-efficiency models, reducing overall energy consumption of refrigeration units by an average 10% in just over five years.

In 1993, PROCEL signed another agreement with members of Brazil's lighting industry calling for an average 10% efficiency improvement of domestically produced fluorescent lamp ballasts.

In 1994, PROCEL and INMETRO reached a new agreement with domestic refrigerator manufacturers to improve average efficiency by an additional 10%.

Another voluntary agreement in 1998 between PROCEL, INMETRO and Brazilian industry associations ABINEE and ELETROS (representing the Brazilian electrical and electronics industry sectors) led to the drafting of new test procedures for refrigerators, freezers and window air conditioning units. The agreement called for a 20% increase in average efficiency by 2002 and led to the introduction of a new energy label for these products (CLASP, 2000).

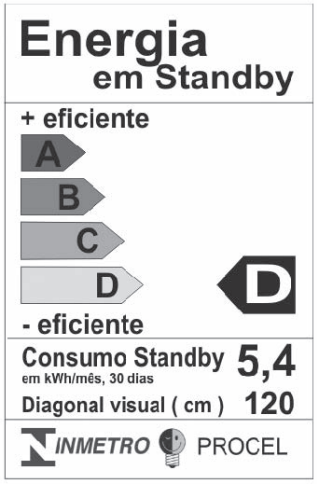
Energy performance labelling

Comparative label

The Brazilian comparative label is based on the European model, and is now used on a total of 29 gas and electric products covering the residential, commercial and industrial sectors.

The most recent additions include:

- electronic ballasts for fluorescent lamps;
- lighting fixtures;
- microwave ovens;
- heat pumps;
- computer monitors;
- televisions;
- set-top boxes;
- domestic fans.



In 2007 a new label was introduced, designed to show the standby power consumption of CRT televisions with a diagonal screen size between 10 to 34 inches, expected to save 240 GWh. Initially use of the label was voluntary, but it became mandatory in August 2008, and in due course it is intended that the label will be extended to cover on-mode electricity consumption and other electronic products (Novgorodcev, 2008; Caripress, 2008).

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The power levels corresponding to the rating labels reflect the performance of the range of products on the market, and already these have been revised as fewer televisions fall into the lowest category (see Table 38). The test method specified is harmonised with the U.S. Energy Star Program requirements.

Table 38 • Standby power levels for label rating

	2006	2007
A	1.0 watts	1.0 watts
B	3.43 watts	3.2 watts
C	5.86 watts	5.4 watts
D	8.2 watts	7.8 watts

Source: Novgorodcev, 2008.

Endorsement label

The endorsement label, known as the PROCEL Seal, is organised by a partnership of INMETRO, PROCEL and CEPEL. Currently there are a total of 17 products carrying the seal, which is issued annually on a voluntary basis to the most efficient products within specified categories. Where appropriate, the seal is used in association with the comparative label to show the best performing products.

PROCEL has undertaken market research on consumer awareness of seal in 2005. 44% of those interviewed recognised the label, although of these 77% was not aware of the meaning of the label or how much is possible to save by acquiring certificated products (Menandro et al., 2007). This indicates that there is still considerable scope for further consumer education leading to greater take-up of labelled products.

Minimum energy performance standards (MEPS)

Following the introduction of *Law 10.295* in 2001, the intention is that many of the products currently labelled will become subject to minimum energy performance standards. Electric motors were the first products to be regulated in 2003, and since that date MEPS have been introduced for refrigerators, freezers, air conditioners and CFLs. PROCEL is providing the technical support for the implementation of MEPS.

The process of establishing MEPS in Brazil involves many agencies and consultative mechanisms, involving the following stakeholders:

- Government regulatory agencies: responsible for decision making (e.g. MME, Ministry for Science and Technology, Ministry of Development, Industry and Foreign Trade);
- Technical committees: providing technical input (e.g. Procel, CEPEL, INMETRO, Academia);

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- Negotiation groups: finalising implementation issues (government agencies, Industry) (Poppe, 2007).

A summary of the major policy measures directed at residential electrical appliances is provided in Table 39.

Table 39 • Summary of major national policy measures for residential electrical appliances

	Comparative labelling	Endorsement label	MEPS
Refrigerators	M (1984)		M (2006)
Freezers	M (1984)		M (2006)
Clothes washers	M (2002)		
Air conditioners (windows)	M		M (2006)
Air conditioners (split)	M (2003)		M (2006)
Domestic fans	M		
Electric water heater (shower)	M		
Electric boilers	M		
Solar water heaters	M (1998)		
Electric cooktop	M		
Microwave ovens	M (2002)		
Incandescent lamps	M		
Circular fluorescent lamps	M		
CFLs		V	M (2006)
Electro-magnetic ballasts	M (2002)		
Electronic ballasts	M (2002)		
TV (standby mode)	M (2008)	V (2007)	
Computer monitors	V (2007)		
Bottled water coolers	M (2004)		

Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary.

Utility DSM

COELBA (distribution utility) distributed 17,000 refrigerators to low income residential customers who have difficulty paying bills (Pinto, 2007).

Capacity building

Considerable attention has been given to capacity requirements in order to support existing and future energy efficiency activities. For example, PROCEL has been investing in the development

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of technical capacity though the support of test laboratories. USD 6 million has been spent since 2003 in the support of 22 new laboratories throughout Brazil, in order to provide technical capacity for the Energy Efficiency Law (Menandro *et al.*, 2007).

PROCEL has also invested in understanding energy consumption patterns by increasing the scope of end-use assessments. In 1988 surveys were undertaken of the residential sector covering a few utility areas. This was extended in 1997/8 to cover the entire Southeast region. In 2004/5 a major national survey was undertaken with coverage of the Residential, Industrial, Commercial and Public sectors. The findings are published in a series of reports in 2007 (Electrobras, 2007).

The latest initiative by PROCEL is the *Brazilian Energy Efficiency Information Center*, launched in November 2006. All of these initiatives have been supported by funding from the Global Environment Fund (GEF) totalling nearly USD 12 million (see Table 40).

Table 40 • Allocation of GEF funding for capacity building in Brazil

Item	USD million
Marketing plan	1.4
Dissemination of information (sectoral educational programme)	1.65
Laboratory capacity	5.4
Management	0.71
Brazilian Energy Efficiency Information Center	1.32
Market evaluation	1.42
Total	**11.9**

Source: Menandro *et al.*, 2007.

Evaluation and enforcement activity

Programme evaluation

It is estimated that improvements in end-use efficiency between 1984 and 2004 has reduced total electricity consumption by 42.5 TWh or 11.8% of electricity demand. Of this, approximately 50% is directly attributed to the impact of public policy and the programmes run by utilities and government agencies (Leonelli, 2007).

Based on information available, the savings impact and cost effectiveness of programmes funded by the wire- charge is shown in Figure 57. As noted previously, the lack of comprehensive *ex post* evaluations and the difficulties of accounting for long-term initiatives make detailed analysis difficult and may explain the fluctuating value for the costs of energy saved. On average over the period, the cost of energy savings is approximately USD 0.11/kWh.

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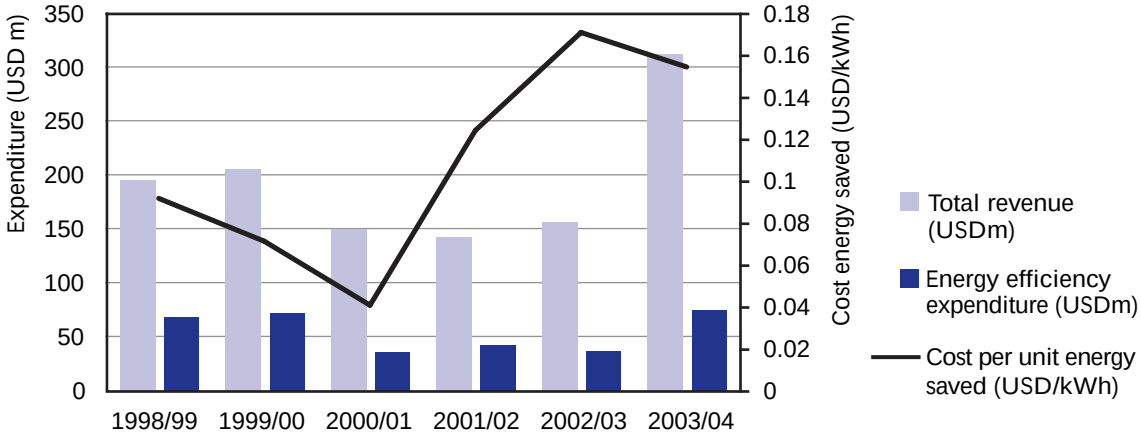
Figure 57 • Estimated savings and cost effectiveness of wire charge expenditure on energy efficiency



Source: Hollauer, 2008; Guerreiro, 2006; World Bank, 2008.

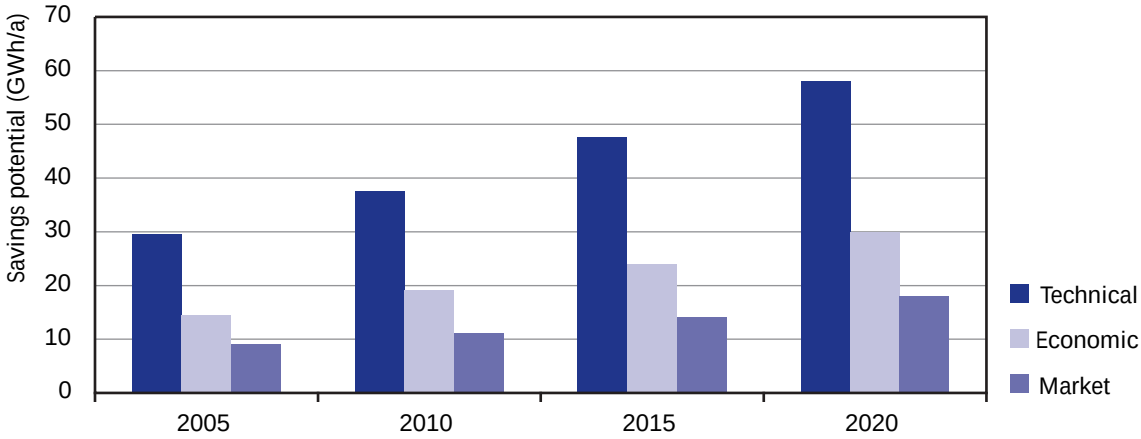
Energy efficiency potential

The further potential for energy efficiency has been assessed as part of the long-term planning process (Leonelli, 2007). This identifies a total of 59 TWh of energy savings to be achieved by 2030, 50% of which will come from implementation of public policy (the remainder from autonomous improvements and voluntary activities).

Further, analysis has indicated the potential uptake of energy efficiency under three scenarios (see Figure 58):

- Technical: the most effective combination of the most efficient alternatives of products available;
- Economic: considered when the cost-benefit is greater than one;
- Market: the business as usual scenario considering the available financial resources and barriers to consumers.

Figure 58 • Potential energy saving under three scenarios to 2020



Source: Zimmerman, 2006.

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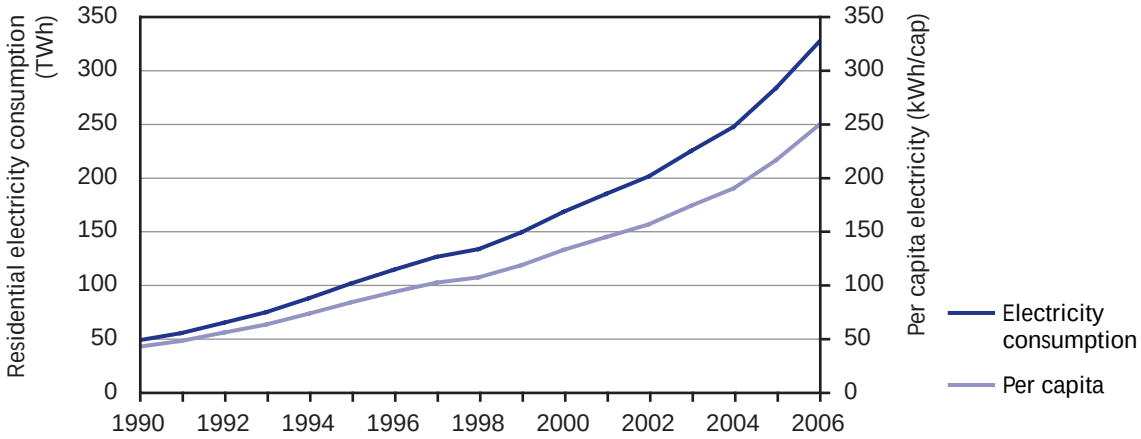
Residential electricity consumption grew by 12.5% per annum between 1990 and 2005, slightly faster than the per capita consumption, which grew at 11.5% over the same period.

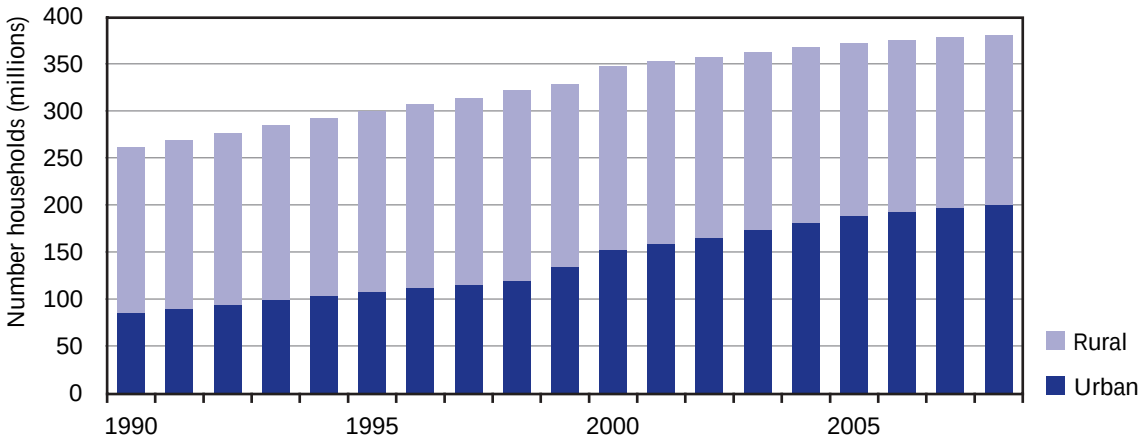
Figure 59 • Total residential and per capita electricity consumption, 1990-2005



Source: IEA statistics.

Structural changes have made a significant contribution to this growth, particularly a shift to greater urbanisation and access to electricity in rural areas of China. As shown in Figure 60, the trend towards greater urbanisation was particularly strong up to 2000, with the proportion of urban households increasing from 33% in 1990 to more than 50% by 2005.

Figure 60 • Number of Chinese households in urban and rural locations



Source: Various including Pan *et al.*, 2006; REN21, 2008.

This trend, together with grid extension and renewable energy programmes have increased access to electricity considerably, so that by 2002 approximately 98.5% households were electrified, leaving around 4.5 million households without access (see Figure 61 and Figure 62).

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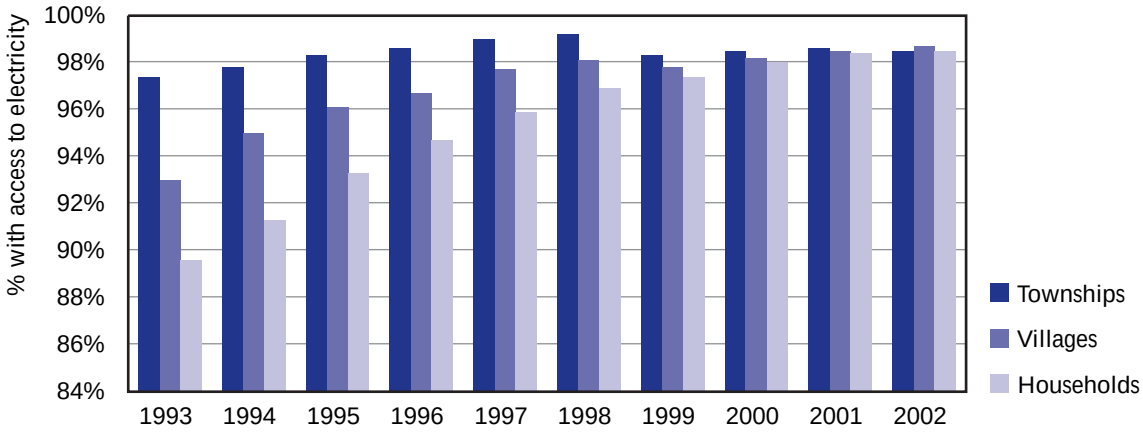
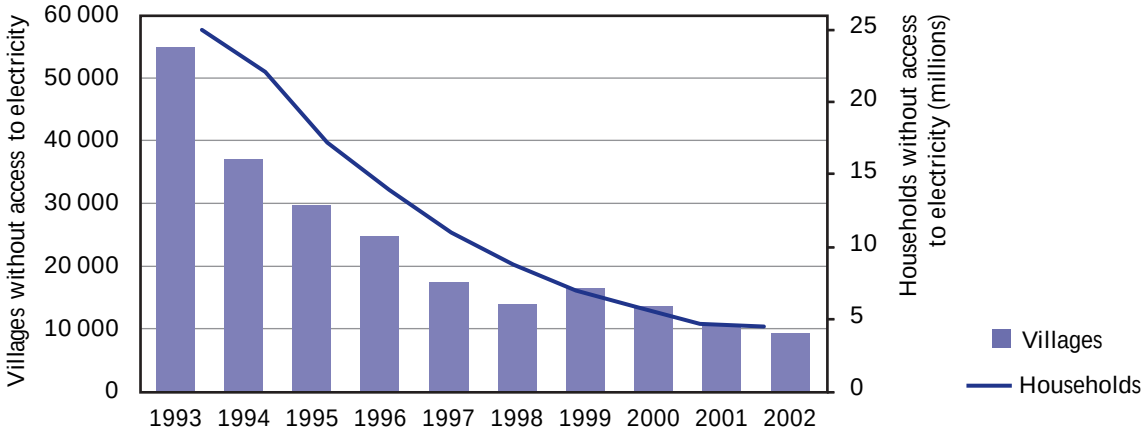
Up to 2005, the China Township Electrification Program brought electricity to about 1.3 million rural people in 1,000 townships (about 200,000 households) with solar PV, small hydro, and a small amount of wind power. By 2010 renewable energy will supply a further 10,000 villages and 3.5 million rural households. Full rural electrification is planned by 2015 (REN21, 2008).

Figure 61 • Progress with electrification in China, 1993-2002



Source: Pan *et al.*, 2006.

Figure 62 • Villages and households without access to electricity, 1993-2002



Source: Pan *et al.*, 2006.

Starting with the introduction of MEPS in 1990, China has continued to develop and extend its Standards and Appliance Labelling (S&L) programme with the technical assistance of many overseas experts, so that it is now one of most comprehensive national programmes. There are now MEPS for all major household appliances; voluntary endorsement labelling for over 40 products covering all sectors (residential, commercial, and industrial), and; mandatory comparative energy labelling for targeted household appliances, introduced in 2005 (CLASP, 2007a).

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Building on this foundation, in recent years there has been increasing emphasis placed on extending market transformation programmes (e.g. government procurement), a focus on international harmonisation efforts and to improving enforcement and monitoring of the programme.

Notable developments in recent years include:

- The launch of a medium and long-term *Energy Conservation Plan;*
- A National goal to reduce energy intensity of the economy by 20% by 2010;
- Revisions to China's Energy Conservation Law;
- Expansion of the MEPS programme to include new products and the updating of MEPS for several product categories;
- Introduction of a mandatory comparative label for household appliances;
- Requirements on government procurement to purchase only the most energy efficient products;
- International collaboration on harmonisation of energy specifications for external power supplies and other products;
- Improved focus on enforcement of MEPS and the Mandatory Information Label.

Institutional organisation, policies and financial issues

Medium and Long-term Plan for Energy Conservation (2005-2010 and 2010-2020)

China's Energy Conservation Law (ECL), enacted in 1997, set out provisions addressing the management of energy conservation, rational energy utilisation, technological developments and legal liabilities. To provide further guidance on implementation, the National Development and Reform Commission (NDRC), the body responsible for energy efficiency policy development, launched the *Medium and Long-Term Plan of Energy Conservation* in 2004 which covered the phases 2005-2010 and 2010-2020. Ten key projects were put forward including:

- Coal Burning Industrial Boiler Renovation;
- Regional Co-generation;
- Residual Heat and Pressure Utilisation;
- Petroleum Conservation and Substitution;
- Motor System Energy Conservation;
- Energy System Optimisation;
- Building Energy Conservation;

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- Green Lighting;
- Energy Conservation in Governmental Agencies;
- Creation of Energy Conservation Monitoring and Technical Service System.

MEPS, energy labelling, government procurement and the Top-1000 Enterprises Energy Efficiency Program are some elements of the detailed action plan developed by NDRC to implement this programme.

China's energy reduction target

In March 2006, as part of the 11th Five-Year Economic Program, the Chinese government announced an ambitious target to reduce China's energy intensity by 20% on the 2005 level by 2010 (CG, 2006). This target translates into a reduction of over 1.5 billion tonnes of CO_2 in 5 years from a growth baseline, which will still result in an overall growth in emissions. In comparison, the EU commitment under Kyoto is approximately 30 million tonnes between 1997 and 2012 (CSEP, 2008). Increasingly, attention is being placed on maximising energy savings from China's standards and labelling programme to meet this goal.

Conservation targets were not met in 2006 and 2007; however, the government has taken steps to bolster efforts to meet the goal, including revisions to China's *Energy Conservation Law* that took effect from 1 April 2008. The new revised law now explicitly states that a system of accountability for energy conservation targets and a system for energy evaluation will be implemented. The revised law also recognises the importance of energy conservation as a national policy priority, noting:

"Energy Conservation is a basic policy of China. The State implements an energy strategy of promoting conservation and development concurrently while giving top priority to conservation." (McElwee, 2008).

China National Climate Change Program (CNCCP)

In July 2007, China released its first *National Climate Change Program* which sets out a strategy to address climate change by way of measures envisaged and already adopted, many from the 11th 5-year plan. The goal of reducing economic energy intensity by 20% by 2010 is a key element of the document. In addition, the government aims to take measures to cease the operation of small, less efficient industrial facilities in sectors such as iron, steel and cement.

Responsibility for energy efficiency policies and measures

Responsibility for energy efficiency policy rests with the National Development and Reform Commission (NDRC). Though administratively separate, China National Institute of Standardization (CNIS) and China Standards Certification Centre (CSC) both provide technical support to NDRC (CLASP, 2007b).

The State Administration of Quality, Supervision, Inspection and Quarantine (AQSIQ) currently oversees China's standards system. The Standardization Administration of China (SAC) is

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responsible for the administrative functions of AQSIQ, including the review and approval of new energy standards. China's National Institute of Standardization (CNIS) undertakes the technical development work on energy standards.

Work on China's voluntary energy efficiency labelling programme was initially the responsibility of CSC (formerly the China Certification Centre for Energy Conservation Products, CECP), but authority for certification of energy-efficient products passed to the China Quality Certification Centre (CQC) in early 2008.

Budget

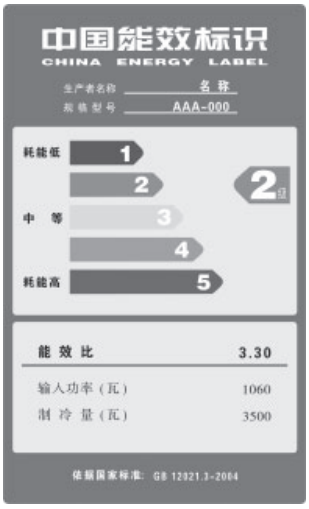
Total expenditure on energy efficiency and greenhouse gas emission reduction schemes rose by 78% to CNY 41.8 billion (USD 6.1 billion) in 2008 compared to CNY 23.5 billion (USD 3.4 billion) in 2007. CNY 27 billion (USD 3.9 billion) comes from Ministry of Finance special funds, and the remaining CNY 14.8 billion (USD 2.2 billion) is part of the NDRC budget.

Of the CNY 27 billion, 7.5 billion will be invested in ten energy-saving programmes, including technological transformation in factories, substitutes for oil and the introduction of energy-efficient light bulbs.

The Ministry will spend CNY 4 billion (USD 0.6 billion) in closing inefficient coal-fired power units and outmoded steel plants, while CNY 5 billion (USD 0.7 billion) will be used to tackle environmental issues in major rivers and lakes (XNA, 2008).

Energy performance labelling

Comparison label



A mandatory comparative labelling programme was introduced for the first time in 2005 for refrigerators and room air conditioners; and extended in March 2007 to include household electric clothes washers and unitary air-conditioners. The scope was further extended in June 2008 to instantaneous gas water heaters, water chilling packages, three-phase induction motors, high-pressure sodium lamps, and self-ballasted lamps. The label, based on market research undertaken in China, is similar to the European energy efficiency label but uses a grading system that rates energy performance from 1 (more efficient) to 5 (less efficient). For the products added in June 2008, the label has been simplified to 3 categories except for water chilling packages (Jin, 2006).

Models are labelled by manufacturers on the basis of a self-declaration, providing a copy of the supporting test report to CNIS.

China's Energy Label Centre (CELC), within China's National Institute for Standardisation (CNIS), is in charge of the work concerning the China mandatory comparative label research, recording, promotion, training as well as market monitoring. It is responsible for supervising the registration

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of energy information labels and also for setting the monitoring agenda, organising random check-testing and publishing results (see 'Monitoring and Enforcement' for more information). By October 2007, over 495 companies had registered 17 000 labelled products in the database (See Table 41).

Table 41 • Registered enterprises and products for energy information, October 2007

Product types	No. of companies	No. of product models
Refrigerators	139	5 630
Room air conditioners	82	7 852
Clothes washers	257	3 291
Unitary air conditioners	18	934

Source: Zhou, 2008.

Endorsement label

The China Standards Certification Center (CSC) was responsible for the national energy efficiency endorsement labelling programme; in February 2008, management passed to the China Quality Certification Center (CQC) under CNCA.

China's endorsement labelling programme was introduced in 1999 and applies to home appliances, lighting products, industry products, standby power products and building materials. The programme is analogous to the U.S. Energy Star programme with which it cooperates closely. Labelling 51 products, this voluntary programme currently draws participation by over 300 manufacturers. To partake in the programme, participants are required to submit to on-site annual audits of production facilities; undertake third-party testing in certified laboratories; and to harmonise with ISO 9000 standards (CLASP, 2007b).

Residential energy-using products subject to the endorsement labelling scheme include:

- refrigerators/freezers
- air conditioners
- electric water heaters
- residential microwave ovens
- rice cookers
- washing machine
- ballasts for fluorescent tubes
- double-capped fluorescent lamps
- CFLs
- colour TVs
- DVD/VCR
- printers
- copiers
- fax machines
- computers and displays
- set-top boxes

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For products that are subject to MEPS, voluntary labelling criteria are developed simultaneously with the same timeframe of implementation and revision. For those products that are covered by the voluntary labelling programme only, typically consumer electronics, the timeline for revisions is subject to market and technical developments (CLASP, 2007b).

Minimum energy performance standards (MEPS)

China first introduced minimum energy performance standards for eight residential appliances in 1989, but in recent years, this number has increased to a total of 34 products, including industrial, commercial, office, lighting and transportation equipment. Seventeen of these products are residential and are listed in Table 42 below. MEPS also apply to small and medium electric motors, commercial packaged AC, water chillers and gas water heaters. Note that office products are the most recent additions to the MEPS programme and that existing standards have been made more stringent for many products already covered by MEPS.

Since 2003, most energy performance standards have included more than one set of performance requirements. In addition to the initial mandatory requirements, standards may include the threshold for an endorsement label, and in some cases standards also include a "reach" level – indicating the likely level of a future performance requirement. Some standards specify the date at which these will come into force, thereby providing regulatory certainty to industry.

The following products are currently under consideration for inclusion in the MEPS programme:

- flat panel colour televisions;
- microwave ovens;
- set-top boxes.

A summary of the major policy measures directed at residential electrical appliances is provided in Table 42.

Table 42 • Summary of major national policy measures for residential electrical appliances

Product	Comparative label	Endorsement label	MEPS
Refrigerators/freezers	M (2005)		M (1990, 1999, 2003)
Clothes washers	M (2007)	V (2003)	M (1990, 2005)
Room air conditioners	M (2005)		M (1990, 2000, 2005)
Variable speed room air conditioners			M (2008)
Unitary air conditioners	M (2007)		M (2005)
Electric fans			M (1990)
Electric water heaters		V (2001)	M (2008)
Electric shower heads		V (2004)	

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Table 42 • Summary of major national policy measures for residential electrical appliances *(continued)*

Product	Comparative label	Endorsement label	MEPS
Microwave ovens		V (2001)	
Household induction cookers			M(2008)
Electric rice cookers		V (2001)	M (1990)
Linear fluorescent lamps		V (2003)	M (2003)
Single-capped fluorescent lamps			M (2004)
CFLs	M (2009)	V (2003)	M (2003)
Fluorescent lamp ballasts		V (2000)	M (2000)
Computers		V (2004)	
Printers		V (2003)	
Fax machines		V (2004)	
Monitors		V (2004)	M (2008)
Copiers		V (2004)	M (2008)
External power supplies		V (2005)	M (2007)
Televisions		V (2002, 2006)	M (1990, 2006)
DVD players		V (2004)	
Radio rcvr/rcdr			Now abolished
Set-Top boxes		V (2006)	
Electric irons			Now abolished

Source: Various including Li Tienan, 2006; Li Aizhen, 2008.
Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary.

Standby power

A survey of 200 households in Beijing and Guangzhou in 2001 found the average standby power consumption in urban households to be about 15 watts, representing 5-10% of the average Chinese household electricity consumption. Similarly a 2005 study of government buildings showed the large quantities of office equipments led to standby power consumption contributing 20% of the overall electricity consumption (Li Aizhen, 2008).

Since 1998, China's endorsement labelling programme has focussed on reducing the standby power consumption of a range of consumer electronic devices. There are now 10 products included in the standby power certification programme:

- TVs;
- DVD players;
- printers
- fax machines;
- copiers;

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- multifunction devices;
- computers;
- monitors,
- overhead projectors;
- external power supplies.

The MEPs programme establishes maximum standby power consumption limits for:

- colour TVs, issued in July 2005 and implemented in March 2006;
- external power supplies, issued in May 2007 and implemented in December 2007;
- MEPs for copiers and monitor are under development (Li Aizhen, 2008).

Additionally, the mandatory procurement requirements (described below) also cover many products in standby mode.

Other initiatives

Government procurement

The Ministry of Finance and the National Development and Reform Commission (NDRC) first issued a procurement policy for energy-saving products in China in December 2004, requiring government to give priority to products certified as energy-efficient. Beginning with central government offices only, this was extended to cover all levels of government, including central, provincial, and local, schools and hospitals, by the end of 2006.

A formal list of energy efficient products for public procurement was published in 2006, and included the following certified products: refrigerators, room air conditioners, double-capped fluorescents for general service lighting, self-ballasted fluorescents for general service lighting, televisions, computers, printers, and toilets.

Although not mandatory, the Ministry of Finance reserved the right to refuse to pay the purchase value if the energy requirements were not made a priority and procurement guidelines not followed (MoF, 2004).

In December of 2007, the Chinese government established a system of compulsory government procurement of energy-saving (including water-saving) products, which runs in tandem with the preferential system. Nine product categories have been included on the list:

- air conditioners;
- fluorescent lamps;
- televisions;
- electric water heaters;

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- computers;
- printers;
- computer monitors;
- urinals;
- toilet pans, and;
- water nozzles. (CCCIN, 2007).

At this time, the list of preferential products was also updated to include a total of 24 types of products: rice cookers, clothes washers, DVD players, projectors, gas heaters, power switches and shower units, among others.

Efficiency upgrade for appliance production and public lighting

Effective from 2006, China has mandated:

- The renovation of production and assembly lines of high-efficiency electronic appliances; and
- The promotion of higher efficiency lighting systems and three-primary-colour phosphorous in public facilities, hotels, shopping centres, office buildings and sporting venues.

The aim of this policy is to reduce energy consumption by 29 billion kWh by 2010 (PDO, 2004).

China Green Lights programme

Launched in 2001, the China Green Lights project was a joint initiative of the Chinese government and UNDP/GEF to improve the quality and efficiency of Chinese lighting products and to stimulate the demand for these products nationally and internationally. The overall objective was to save energy and protect the environment by reducing lighting energy use in China by 10% by 2010 (relative to a constant efficiency scenario). Specific objectives included upgrading Chinese lighting products; increasing consumer awareness of, and comfort with efficient lighting products and the establishment of a vibrant self-sustaining market in efficient lighting products and services.

China Green Lights ran until 2005, and cost USD 26.2 million of which USD 8.14 million was provided by the Global Environment Facility (GEF) and USD 18.07 million by co-finance. An evaluation of the project in November 2005 concluded that, by the end of 2003, a saving of 11.77 billion cumulative kWh had been achieved; there had been a 4.9% reduction in lighting electricity use and a reduction of more than three million tonnes of CO2 (UNDP, 2005).

Amongst other achievements, under China Green Lights:

- Product standards for six categories of lighting equipment: double capped fluorescent tubes and compact fluorescent lamps (2002); high pressure sodium lamps and their ballasts (2003); metal halide lands and their ballasts (2004) were produced;

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- The Ministry of Construction mandatory standards for seven types of buildings and for street lighting;
- Benchmark testing was undertaken and a series of international round-robin testing comparisons (with Australia and the United States) was organised to improve test consistency;
- Possession of a CCC (Compulsory Quality Certification Certificate) became compulsory for any company manufacturing lighting products in, or supplying lighting to, China in August 2003;
- 400 products (in eight lighting product types) from 46 firms had been certified by the China Energy Conservation Product (CECP) Certification Committee.

Phase-out of incandescent bulbs

Over the next 10 years, China, which makes 70% of the world's light bulbs, has agreed to phase out incandescent bulbs in favour of more energy-efficient ones through a programme backed by the Global Environment Facility (GEF). GEF will invest about USD 25 million for the Chinese programme, which could mitigate 500 million tonnes of carbon dioxide annually (EL, 2007). In April 2008, China announced a subsidy programme for at least 50 million energy-efficient bulbs. The subsidies will be indirect, with efficient bulbs sold to consumers at a substantial discount and companies reimbursed by the government for the shortfall. Individual consumers pay half of the price agreed by manufactures and the government, whereas businesses pay just 30% of that price (Reuters, 2008).

Energy conservation in buildings

Also effective from 2006, China aims to reduce residential and public buildings' energy consumption by 50% by 2010 and 65% by 2020. This federal plan formally mandates:

- Swift technical reform of heat-supply systems;
- Renewed efforts to promote building energy efficiency technology and related products; and
- Renovation of existing building in China's cold northern regions, focussing specifically on hotels (CG, 2006).

In 1986, China's Ministry of Construction issued an energy-saving code for "cold and severe cold" climates, beginning a two-decade effort to develop codes and standards for building sectors in disparate climates (see Table 43). In March 2006 the government announced a single set of building codes that are similar to U.S. standards. The Residential Buildings Code is China's first set of mandatory national standards for residential construction based on existing mandatory provisions and relevant standards, with technical specifications for the performance, functions and objectives of residential buildings. The government target is for developers in the largest cities to adhere to them by 2010, however it is estimated that only 15% of new homes conform to existing standards (NSM, 2007).

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Table 43 • Progress with residential building codes

Climate zone	Building type	Issued/updated
Cold/severe cold	Residential	1986/1995
Hot summer/cold winter	Residential	2001
Hot summer/warm winter	Residential	2003
All	Residential	2006

Source: Langer, 2008; HKTDC, 2008.

Evaluation and enforcement activity

Ex-ante evaluations of the energy efficiency S&L programme in China have been undertaken in 2003 and 2007. Table 45 shows the results of the first evaluation undertaken by CNIS into the impact of the MEPS and the endorsement label for 10 appliances in the electricity sector. This analysis includes savings made primarily in the residential sector, although some of the lighting and office products span both residential and commercial sectors.

Table 44 • Estimated impacts of China's MEPS and labelling programmes for electric appliances and lighting in 2020

Impacts	2020
Electricity	157 TWh
Electricity demand	34 GW
Net benefit (NPV)	USD 32 billion
Benefit-cost ratio	4.0

Source: CNIS, 2003.

In the later study undertaken by CLASP, the impacts relate to both MEPS and the voluntary endorsement label, also for 10 products although limited to the residential sector (CLASP 2007b). The differences in scope between the two studies go a long way in explaining the variations in estimated impacts of the programmes. However, it is likely that the use of different baseline information on product performance and stocks has been used, and that some market conditions will have changed in the four years between the dates of these two studies.

Table 45 • Estimated impacts of China's MEPS and labelling programmes for electric appliances and lighting in 2020

Impacts	2020
Electricity	106 TWh
Electricity demand	27 GW
Fuel savings	USD 10 billion

Source: CLASP, 2007b.

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Compliance activities

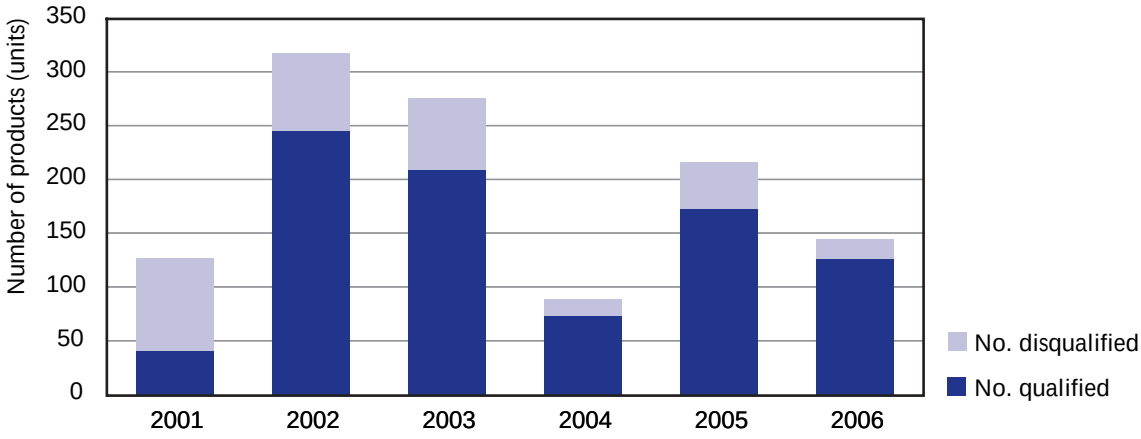
China's General Administration for Quality Supervision, Inspection and Quarantine (AQSIQ) and its provincial branches, China's National Institute for Standardisation (CNIS) and China's Standards Certification Centre (CSC) are the agencies involved in implementation and enforcement of appliance standards and labels. AQSIQ sets the agenda for standards compliance monitoring and inspection and organises national product quality testing. Enforcement responsibilities are delegated to local AQSIQ branches. China's Energy Label Centre (CELC) (within CNIS) supervises the registration of energy information labels and is responsible for setting the monitoring agenda for the new mandatory appliance label, organising random check-testing and publishing test results. CELC does not have enforcement power and refers issues of non-compliance to AQSIQ.

Products subject to MEPS have no reporting requirement, nor a national registry of product performance. National product quality supervision testing is at present the main mechanism to verify whether products comply with MEPS. Regular product quality testing happens every quarter and the special product quality testing is set according to the degree of concern over product quality.

AQSIQ has deemed that priority should be given to products concerning human health, personal and property safety, industry products essential to the national economy and the people's livelihood, and products that have been reported to have quality defects by consumers.

Nevertheless about 1 200 electrical products have been tested between 2001 and 2006, and the results are shown in Figure 63. The compliance rate is approximately 75% and appears to have improved over time, although it should be recognised that the sample sizes are small in comparison with the number of products produced and sold in China. The current AQSIQ budget for product testing in the fields of household appliances, home electronics, and lighting totals about USD 72 000 per annum (CLASP, 2007a).

Figure 63 • Results of product performance testing, 2001-2006



Source: CLASP, 2007a.

In 2006, CNIS conducted testing on 48 sample refrigerators and room air conditioners purchased from retail markets in Beijing, Heifei, and Guangzhou, and tested in three national test laboratories. A similar exercise was undertaken in 2007 for a total of 73 refrigerators, air conditioners and

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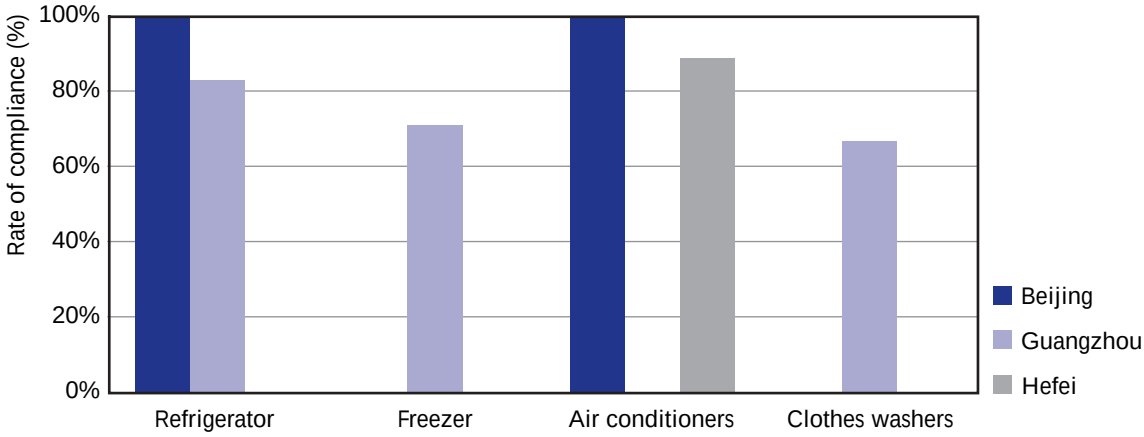
clothes washers. The 2007 testing showed significant improvements in compliance across product types compared with 2006; with the number of non-compliant product models decreasing from 11 out of 43 in 2006, to only 3 out of 73 models in 2007 (Zhou, 2008).

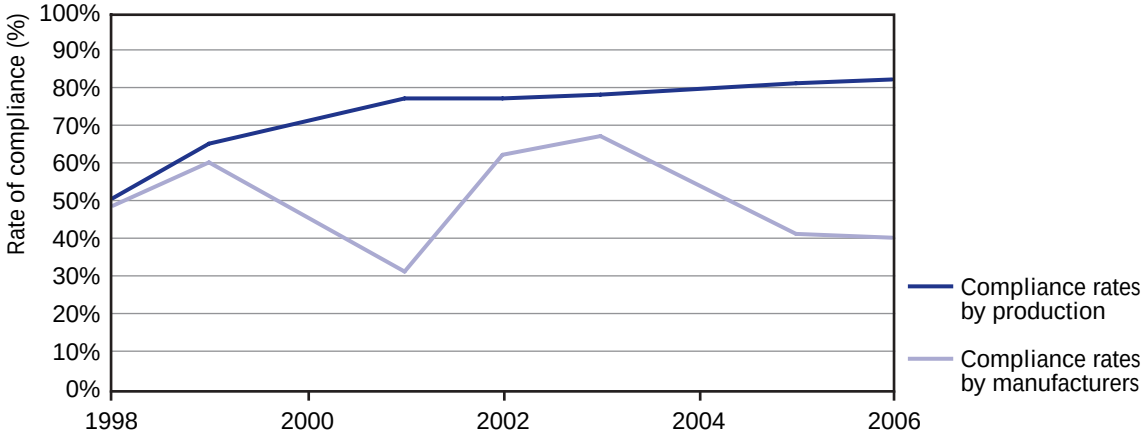
Figure 64 • Results of product performance testing by CNIS, 2006



Source: Zhou, 2008.

In addition to the verification activities identified above, the Chinese government has implemented a National Supervision and Inspection (NSI) programme for CFLs since 1998. This is a thorough examination designed to improve manufacturing quality and covers processes from the production line to the market. Figure 65 shows the results of testing for the period from 1998 to 2006, indicating that a growing proportion of CFLs bought to the market complied with energy (and other) performance requirements during this period (NLTC, 2008).

Figure 65 • Results of NSI testing on CFLs, 1998-2006



Source: NLTC, 2008.

Enforcement

AQSIQ has considerable sanctions available in the case of non-compliance with MEPS, including fines worth 20% to 50% of the value of the products sold and confiscation. However, it is

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unclear how often such actions are taken. Typically it is left to provincial officers to negotiate with manufacturers some remedial actions. It is understood that the threat of bad publicity is an effective sanction at the current time (CLASP, 2007b).

Nevertheless a thorough examination of the monitoring and verification framework used in China in 2007 identified further steps that China can take to develop a more robust system of enforcement and monitoring for the MEPS and labelling programmes. The report concludes that the existing legal basis for monitoring and enforcement of S&L in China is sufficient, and that the key gaps between China's current monitoring and enforcement system in comparison to international best practices are:

- There is no product registration and reporting requirement for MEPS;
- Though such a requirement is in place for the China Energy Information Label this covers only four products (expanded in June 2008);
- Monitoring and verification of products performance are inadequate in China, both for the MEPS and the Energy Information Label and in particular limited by sample sizes too small to qualify for vigorous monitoring as well as a lack of attention to energy efficiency versus other issues such as health and safety;
- There is insufficient funding to undertake verification testing for MEPS and the Energy Information Label; and
- The testing infrastructure in China is relatively weak in comparison with the need (CLASP, 2007b).

International engagement

The China CSC maintains relationships with the UN Development Program (UNDP), UN Environment Program (UNEP), UN Department of Economic and Social Affairs (UNDESA), UN Economic and Social Commission for Asia and the Pacific (UNESCAP), Asia Pacific Economic Corporation (APEC), International Finance Corporation (IFC), U.S. Environment Protection Agency (USEPA), the Australian Greenhouse Office (AGO), UK's Department for Environment, Food and Rural Affairs (DEFRA), New Zealand's Energy Efficiency and Conservation Authority (EECA), Korean Energy Management Corporation (KEMCO), Lawrence Berkeley National Laboratory (LBNL), and the Collaborative Labelling and Appliance Standards Program (CLASP) (Li Tienan, 2006). China is also a member of the Asia-Pacific partnership on Clean Development and Climate (APP), which offers many opportunities to support energy efficiency projects.

China engages in international harmonisation of energy efficiency standards and labels with the U.S. (Energy Star), Australia (AGO) and other counterparts. China is also participating in the development of international harmonised testing specifications and energy performance levels for external power supplies, CFLs, set-top boxes, among others.

CLASP

As previously mentioned, the nature of the support provided by CLASP has changed over the years as China's capacity for standards and labelling implementation has grown. Following

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early efforts to establish the foundations of a domestic Standards and Labelling programme for China, CLASP provided assistance to extend market transformation effects internationally. Today, the support provided by CLASP targets the application of China's S&L programmes into new market transformation programmes domestically (such as government procurement) as well as the expansion of China's outreach internationally in additional harmonisation efforts.

Market Transformation Programme with the UK

China's Market Transformation Program (MTP) is supported by UK government policy of sustainable products and jointly funded by the Foreign and Commonwealth government. Announced in 2006, the programme aims to foster the development of efficient products at a lower cost globally. The United Kingdom and China will look to harmonise and converge product performance specifications for traded products, including set-top boxes, CFLs, refrigerators, TV's, rice cookers, clothes washers, microwave ovens and room air conditioners. United Kingdom experts are working with Chinese institutions to assess current gaps, prioritise appropriate policy tools and develop a plan to progress product policy in china. The project is mandated by China's NDRC, working in partnership with CNIS, responsible for setting MEPS and initiating the development of test methodologies and China Standard Certification Centre (CECP), who develop, manage and enforce product certification (IEA, 2006).

China End-Use Energy Efficiency Project (EUEEP)

Launched in June 2005, China's End-Use Energy Efficiency Project is a joint project of the UNDP and GEF, aimed at improving the efficiency of China's major end-users: commercial and residential building, and heavy industry. The EUEEP also aims to improve the efficiency of household appliances such as refrigerators and clothes washers, as well as office automation equipment.

Collaboration on energy efficiency endorsement labelling with the USEPA

In March 2007, the US Environmental Protection Agency (US EPA) and the China's Standard Certification Centre (CSC) signed a Memorandum of Understanding (MOU) to collaborate on a project to assess and potentially harmonise elements of the United States EPA Energy Star endorsement labelling programme with China's existing endorsement labelling scheme for one or more product categories. Cooperation on this matter is envisaged to comprise of two main activities: harmonisation on performance standards and harmonisation of labelling process. Furthermore, the programme will look at the development of a mutual recognition programme, which would allow a product to carry both the CSC endorsement label and the Energy Star label (CECP, 2008).

Bilateral cooperation with Australia

An MOU was signed between China's CSC and the Australian Greenhouse Office in 2005 in regard to the harmonisation of energy performance criteria and testing procedures, as well as the certification of selected products, including appliances, lighting, standby and industrial equipment. The MOU establishes a framework for joint activities in relation to: policy development

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and analysis for end-use efficiency; projects of mutual interest; staff development and training; scientific and technological information and data on end-use efficiency; and the harmonisation and promotion of test methods and market assessments (CECP, 2008).

Asia and Pacific BRESL Project

The "Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labelling Project" (BRESL) is a USD 34 million, 5-year project supported by the Global Environment Facility (GEF). The project is targeted towards accelerating the adoption and implementation of energy standards and labels in Asia – China, Bangladesh, Indonesia, Thailand and Vietnam – and facilitating the harmonisation of test procedures, standards and labels among these nations. China CSC is in charge of coordinating and implementing the project. It is expected that the project will achieve an average 10% reduction in total residential and commercial energy use in partner countries at the time of peak impact (2030) when compared to the baseline scenario (CECP, 2008).

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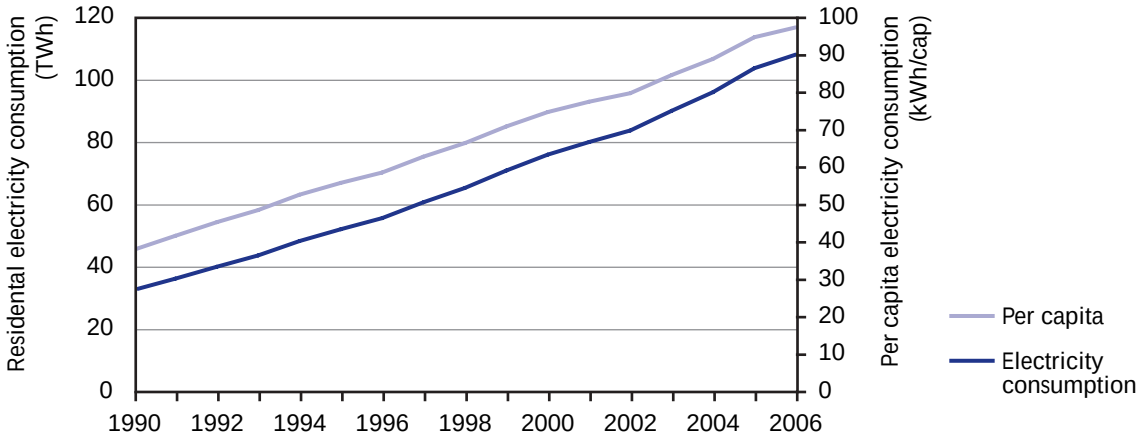
INDIA

Residential electricity consumption has grown consistently at over 7% per annum between 1990 and 2005, and per capita electricity consumption at nearly 5% over the same period (see Figure 66). However, some caution is needed when viewing these figures for the following reasons:

- Approximately 50% of the Indian population is without access to electricity, or 579 million people in 2005; therefore the consumption per capita of those using electricity is double that of the country as a whole (Modi, 2005);
- Over 70% of the population inhabit rural areas where some residential dwellings are considered part of agricultural holdings. As a result some residential electricity consumption may be recorded under an agricultural use category, causing an under-reporting of residential electricity used (OECD/IEA, 2007).

Power shortages are also a common feature of electricity supply in India, leading some householders to install backup facilities. In Delhi, the demand for generators, inverters and batteries is increasing by an estimated 20%-25% per year (OECD/IEA, 2007).

Figure 66 • Total residential and per capita electricity consumption, 1990-2006



Source: IEA statistics.

Over recent decades the urban population of India has swelled considerably giving a larger proportion of the population access to electricity supply, and this, together with the electrification of rural households, has contributed to the increase in per capita electricity consumption (see Figure 67).

The Ministry of Power launched a new national programme for increasing electrification of rural areas in April 2005 (the Rajiv Gandhi Grameen Vidhyutikaran Yojana (RGGVY)) with the aim of providing access to all villages over a period of four years, and access to electricity to all rural households by 2012. The RGGVY also entitles households with incomes below the poverty line to free electricity connection (MoP, 2008b).

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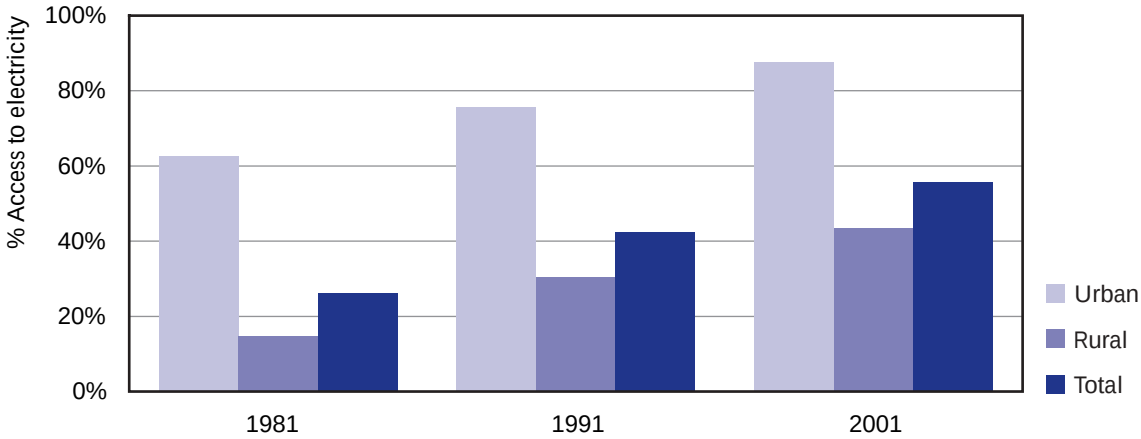
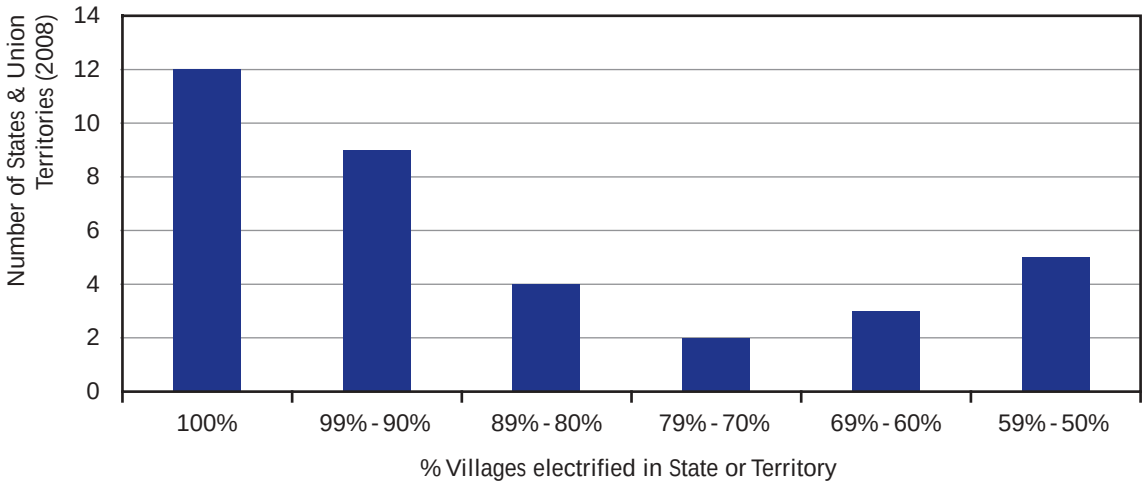
Figure 67 • Proportion of Indian households with access to electricity



Source: NSSO, 2000.

At the end of April 2008, The Ministry of Power estimated that 82% of villages had access to electricity with a further 105 600 villages remaining unconnected (MoP, 2008b; Singh, 2008). The pattern of rural access to electricity shows considerable variation by region, as shown by Figure 68 based on 2004 data.

Figure 68 • Status of rural electrification in States and Union Territories, April 2008



Source: MoP, 2008b.

The economics of end-use energy efficiency are not assisted by low electricity prices for households and some other sectors: for example it is estimated that the removal of subsidies would improve payback periods for efficiency improvement in residential appliances by about one-third (OECD/IEA, 2007) As can be seen in Figure 69, average residential electricity prices have risen steadily in recent years although they are still subject to subsidies, as indicated by the 2001/02 average tariff of approximately USD 0.05/kWh compared to the OECD average which was USD 0.11/kWh for 2002. However, the ratio of average per capita consumption of

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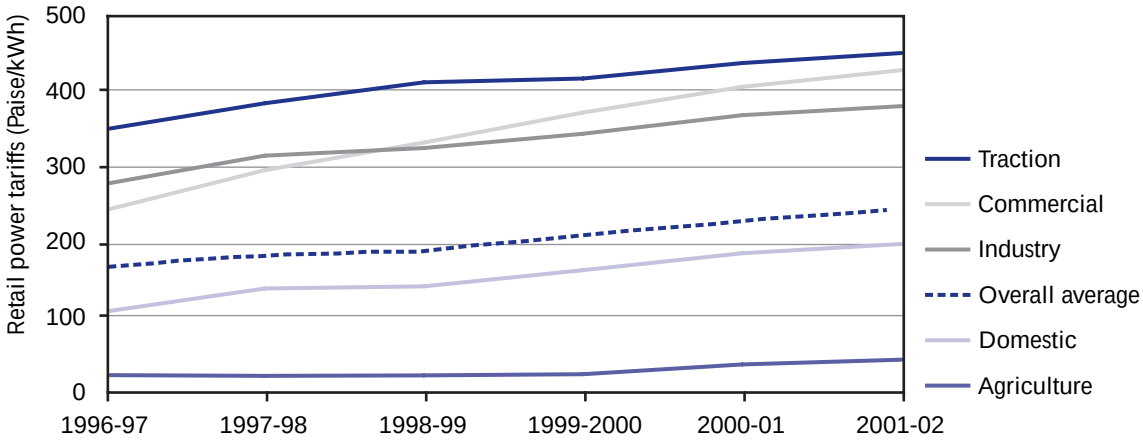
electricity with per capita income (the affordability index) is 15% in India, compared to the OECD average less than 4% in 2005 (Kumar, 2008).

Figure 69 • Retail power tariffs per sector, 2002

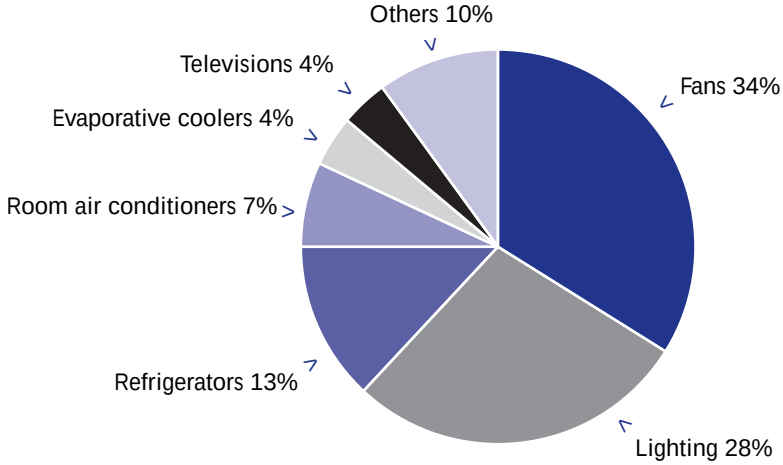


Source: Modi, 2005. 1 paise = 1/100 rupees = USD 0.00023

Information on the use of electricity in the residential sector in India by end-use categories has been patchy, due to a lack of time-series data at a sufficient level of detail. It is further complicated by the considerable variations between different demographic sectors and between urban/rural households. The absence of reliable information hampers the identification of policy priorities and impact assessments. The current estimated allocation of electricity consumption by end-use is shown in Figure 70.

Steps are underway to improve the understanding of end-use electricity consumption in the residential sector. The Bureau of Energy Efficiency, in collaboration with UNDP has commissioned an end use study in major cities of India to measure consumption. The study is likely to be completed by the end of the 2008 financial year.

Figure 70 • Estimated residential end-use electricity consumption, 2007



Source: Tathagat, 2007.

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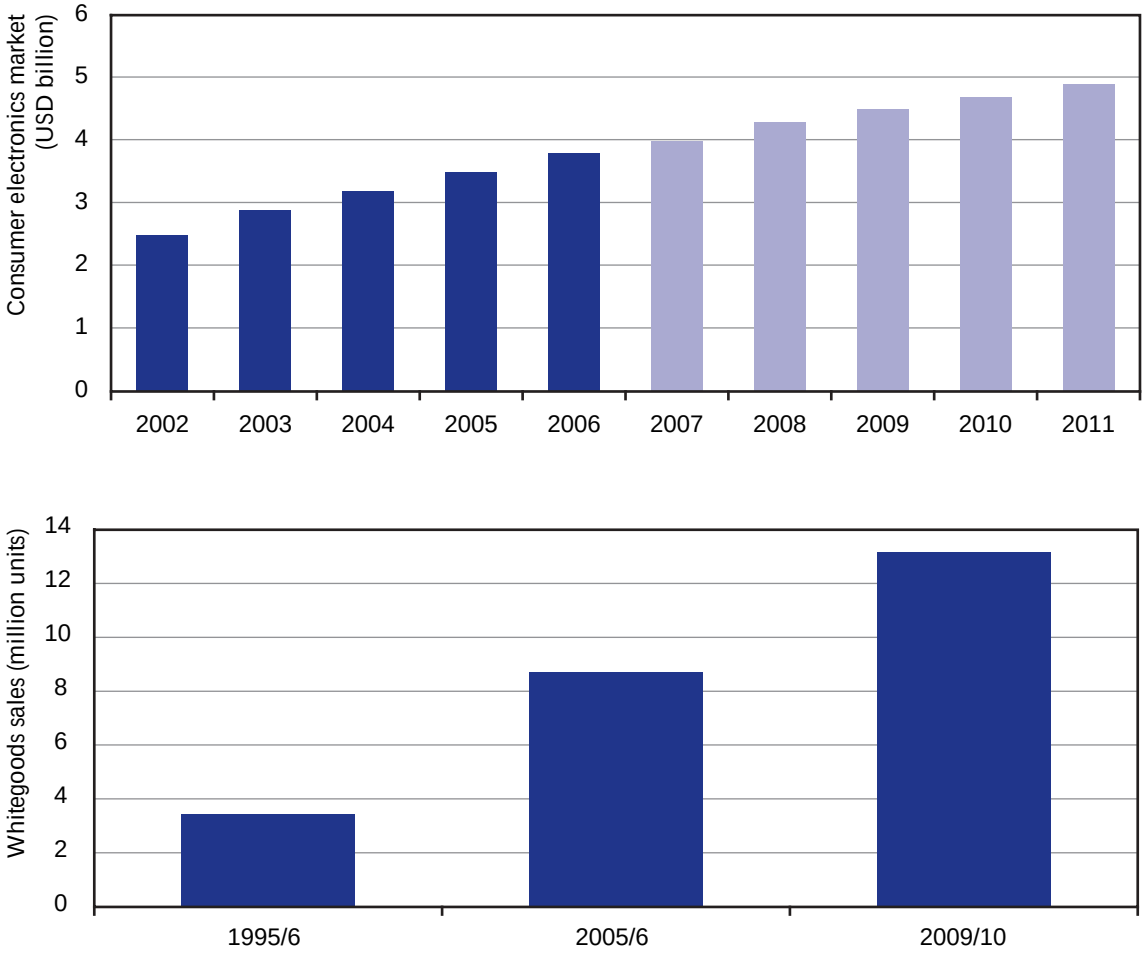
The appliance market in India has recorded considerable growth over recent years, and forecasts suggest that this trend will be maintained in the foreseeable future. Figure 71 illustrates this pattern.

Figure 71 • Historical and forecast information on consumer electronics and whitegoods market



Source: Dube, 2008.

Government involvement in energy conservation and energy management in India began in the 1970s with a focus on productivity improvement and oil conservation in the public sector. In the 1980s up until the current day, the government and numerous donor programmes have launched a number of energy audit programmes, which have also developed the in-country technical capacity. In 2001, the government passed the Energy Conservation Act, which created the Bureau of Energy Efficiency (BEE) to institutionalise public energy efficiency services and provide leadership to the key players involved in the energy conservation movement.

The Act seeks to reduce the energy intensity of the Indian economy by the active participation of all stakeholders and accelerating the sustained adoption of energy efficiency in all sectors.

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It aims to provide a conducive environment by developing appropriate policies and strategies with a thrust on self-regulation and market principles. BEE has initiated a programme to prepare a pool of trained energy management professionals by way of a certification and accreditation programme for energy auditors, adoption of technical standards, and implementation of an energy manager training programme that will improve in-house technical capacity for energy efficiency in industries (World Bank, 2008).

The Act empowers the central government and in some instances the State Governments to:

- Notify energy intensive industries, other establishments, and commercial buildings as designated consumers.
- Establish and prescribe energy consumption norms and standards for designated consumers.
- Direct designated consumers to
  - Designate or appoint certified energy manager in charge of activities for efficient use of energy and its conservation.
  - Get an energy audit conducted by an accredited energy auditor in the specified manner and intervals of time.
- Furnish information with regard to energy consumed and action taken on the recommendation of the accredited energy auditor to the designated agency.
- Comply with energy consumption norms and standards, and if not so, to prepare and implement schemes for efficient use of energy and its conservation.
- Prescribe energy conservation building codes for efficient use of energy and its conservation in commercial buildings
- State Governments to amend the energy conservation building codes to suit regional and local climatic conditions
- Direct owners or occupiers of commercial buildings to comply with the provisions of energy conservation building codes
- Direct mandatory display of label on notified equipment and appliances.
- Specify energy consumption standards for notified equipment and appliance.
- Prohibit manufacture, sale, purchase and import of notified equipment and appliances not conforming to standards.

Institutional organisation, policies and financial issues

The main legislative framework for energy efficiency policy in India is the 2001 Energy Conservation Act, which established the Bureau of Energy Efficiency under the Ministry of Power, and regional and State Designated Agencies (SDAs) in the states. To date 30 SDAs have been created.

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The role of the BEE is to meet the following objectives:

- Develop and recommend to the central government the norms for processes and energy consumption standards.
- Develop and recommend to the central government minimum energy consumption standards and label design for equipment and appliances.
- Develop and recommend to the central government specific energy conservation building codes.
- Recommend the central government for notifying any user or class of users of energy as a designated consumer.
- Take necessary measures to create awareness and disseminate information for efficient use of energy and its conservation (BEE, 2008a).

On June 10, 2003, the government of India notified the *Electricity Act*, 2003 which included extended provisions for the promotion of efficient and environmentally benign policies. Under this Act, in 2005 the Central government announced the *National Electricity Policy* which outlined actions to be taken by BEE, noting that: *"In the field of energy conservation, initial approach would be voluntary and self-regulating with emphasis on labelling of appliances. Gradually as awareness increases, a more regulatory approach of setting standards would be followed"* (Dey, 2007).

The 2006 *Integrated Energy Policy* recommended a reorganisation of these institutional arrangements so that the BEE would be made into an autonomous statutory body under the Energy Conservation Act and operated independently of all the energy ministries but deriving funding through a tax on fuels and electricity. In addition it was recommended that existing national energy efficiency organisations, including the Petroleum Conservation Research Association (PCRA) should be merged with the BEE to ensure that the BEE becomes responsible for energy efficiency for all sectors and all end-uses. Lastly, the report recommends that staffing levels in the BEE should be substantially increased (Government of India, 2006).

Although increases in staff levels have been implemented, the remaining recommendations have not been implemented to date.

Budget

Under the XI 5-year Plan which runs from 2007-12, BEE has requested an allocation of INR 5 020 million (USD 126 million) for the period 2007-2012, to build capacity to manage and implement eight new projects/schemes through the country. This includes a provision of INR 970 million (USD 24 million) for institutional strengthening of energy conservation institutions at central and state levels and to put in place robust monitoring and evaluation techniques.

The energy efficiency standards and labelling programme has an allocation of INR 448 million (USD 12 million) over five years (MoP, 2008a). The Bureau of Energy Efficiency (BEE) currently employs 15 staff and almost 35 others on short and long term contracts (Kumar, 2008).

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Energy performance labelling

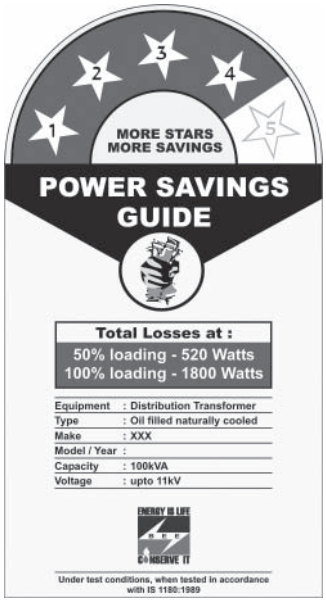
Comparison label

The Indian S&L programme was officially launched in May 2006 by the Minister of Power, with the aim of reducing overall energy consumption by end-use equipment and appliances by 18 TWh in 2012. The programme covers three residential product categories, comprising air conditioners, refrigerators/freezers and linear fluorescent lamps, as well as distribution transformers and motors.

The development of programmes for agricultural pumpsets, ceiling fans, CFLs, passenger vehicles, standby power, and consumer electronics are underway. The programme design is such that participation is voluntary to begin with and will be made mandatory after a predefined period. The mandatory label for air conditioners, refrigerators and tube lights will commence from April, 2009 (Pandian, 2008).

The main principles behind the process for developing and revising the criteria for comparison labels are as follows:

- The involvement of technical committees which draw on manufacturers, experts, test laboratories and consumers;
- Initial label requirements are designed to promote inclusiveness, but stepwise tightening of standards is built into the programme;
- The programme relies upon self-certification, accompanied by independent third-party verification of appliance label claims.



The latest figures available show that many of the leading brands of appliance suppliers in India have adopted the comparison label, as shown in Figure 72 to Figure 74. A total of 45 lamp models, 280 refrigerator models and 157 airconditioner models carried the label in February 2008. It is estimated that this represents 70% of the air conditioner industry, 90% of the fluorescent lamp industry and 70% of the refrigerator industry (MoP, 2008a).

The following products have been identified as the next residential electric products for comparison labels:

- ceiling fans;
- compact fluorescent lamps (CFL);
- water heaters;
- geysers;
- clothes washers.

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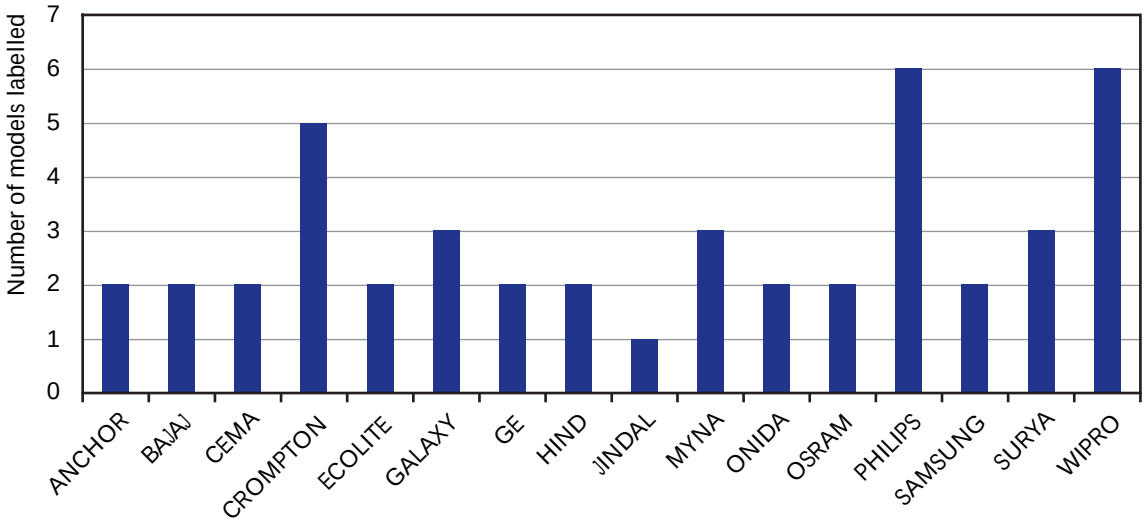
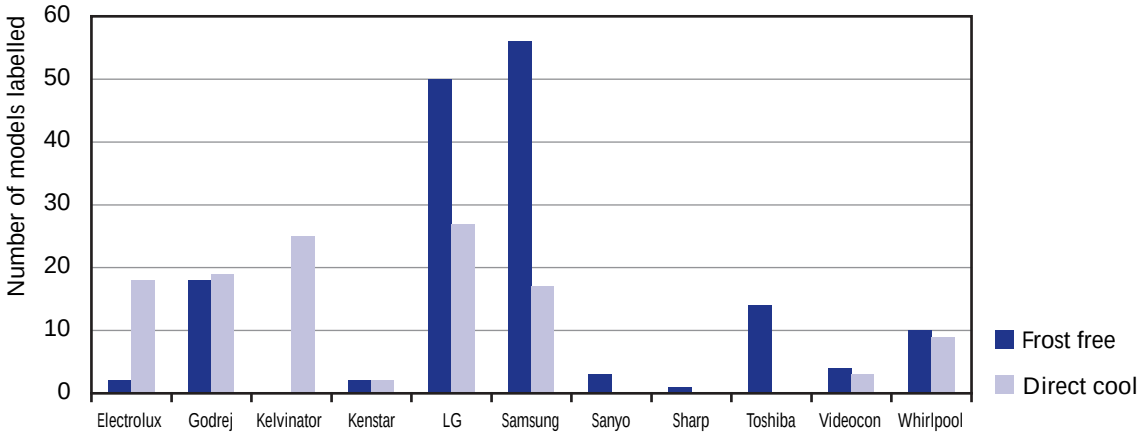
Figure 72 • Number labelled linear fluorescent lamps by supplier, February 2008



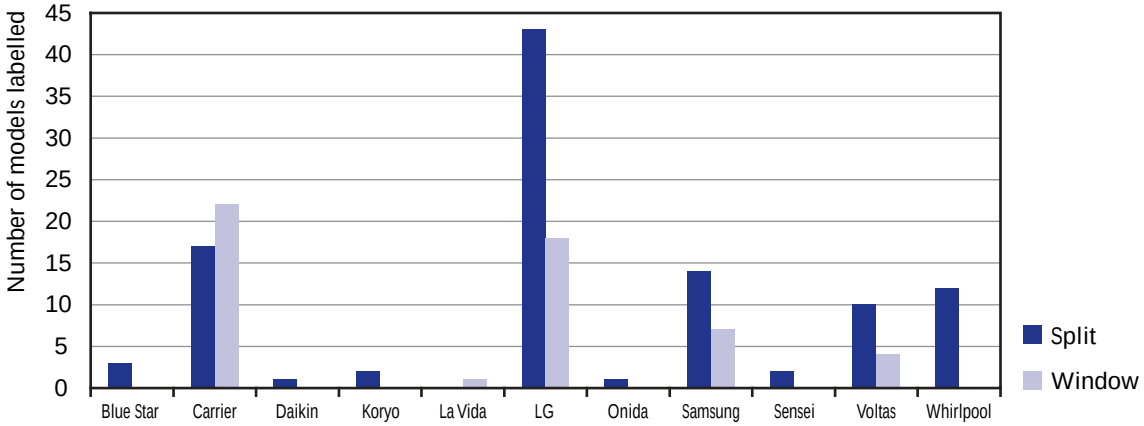
Source: BEE, 2008b.

Figure 73 • Number labelled refrigerators by supplier, February 2008



Source: BEE, 2008b.

Figure 74 • Number labelled air conditioners by supplier, February 2008



Source: BEE, 2008b.

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Endorsement label

India is also proceeding with the development of a new endorsement label designed to identify the best performing consumer electronics products.

Standby Power is an important growing segment in India. Technical evaluation studies are already underway for colour TV's and set-top boxes, which will be the first products to get the endorsement label in India. Market analysis has shown that there are 108 million TV homes in India out of which 82 million have cable & satellite access. CRT TVs still account for approximately 98% of sales in India, however the market is moving towards flat screen technologies, with industry forecasting that LCDs will capture 10% of the market by 2010. By 2030, industry expects that less than 10% of the stock of 300 million TVs will be CRT.

It is also estimated that the number of digital pay TV homes will grow to 38 million by 2012 and 57 million by 2017. By 2017, 32 million homes will have digital pay TV through satellite, 22 million through cable and less than 3 million through IPTV (Dube, 2008).

Although these have not yet been finalised, the recommended criteria to be used for the endorsement label on TVs and STBs are shown in Table 46. It should be noted that additional TV features may be eligible for extra allowances, however these are yet to be identified.

Table 46 • Initial recommendations for endorsement label

	Standby mode	Active mode	Test method
CRT – TV	<8 watts – Till 2008 <5 watts – Till 2009 <1 watt – Till 2010	0.3 – 0.5 watts/sq inch * 0.3 – 0.5 watts/sq inch * 0.3 – 0.5 watts/sq inch *	Standby mode: IEC 62301 Active mode: BIS IS 4545-1 and IEC 62087
LCD – TV	<1 watt	0.3 – 0.5 watts/sq inch	
Plasma – TV	<1 watt	0.3 – 0.5 watts/sq inch	
STB - free to air	< 3 watts*	8 watts	Standby mode: IEC 62301 (CSA 380-06) Active mode: IEA 62087 (CSA 380-06)

* The Technical Committee is required to do some more work to recommend standards for add-on's.

Source: Dube, 2008.

Computer monitors will be the next product to become eligible for an endorsement label, to be followed by the following products.

- uninterrupted power supplies (UPS);
- external power supplies (EPS);
- battery chargers (BCs).

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Minimum energy performance standards (MEPS)

There are currently no mandatory MEPs for products in India, however the power exists under the Energy Conservation Act to introduce these and BEE has indicated that MEPs will be considered in due course. It is likely that air conditioners, refrigerators and linear fluorescent lamps will be the first products where mandatory MEPS will be introduced (Kumar, 2008).

A summary of the major policy measures directed at residential electrical appliances is provided in Table 47.

Table 47 • Summary of major national policy measures for residential electrical appliances

	Comparison label	Endorsement label	MEPS
Refrigerators	V (2006)		
Freezers	V (2006)		
Air conditioners			
– Room	V (2006)		
– Split	V (2006)		
Linear fluorescent lamps	V (2006)		

Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary.

Building regulations

An India-wide Energy Conservation Building Code was issued in 2007 targeted at large, new, commercial buildings with a load of 500 kW or greater. This is currently a voluntary initiative although the intention is that this will become mandatory once there exists sufficient technical capacity to support compliance.

There are no plans to introduce a residential building code at the current time.

Evaluation and enforcement activity

The aim of the S&L programme is to reduce electricity consumption by 18 TWh by 2012, equivalent to approximately 3 000 MW of demand. The estimated annual savings in the residential electricity sector from existing measures is shown in Table 48.

Table 48 • Ex-ante forecasts of savings from comparative labelling, 2007/08

	Sales (m) 2007/8	Labelled 2007/8	Energy savings GWh	Capacity avoided MW
Refrigerators	4.6	1.84	442	90
Air conditioners	1.73	0.43	314	64

Source: Pandian, 2008.

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The system in place in India is based on self-declaration by appliance suppliers with BEE undertaking periodic check tests to confirm that models meet the energy labelling criteria. The first series of check tests are currently underway (see Table 49) for the three product categories where labelling applies.

Table 49 • Check tests undertaken on electric appliances in 2008

City	Refrigerators	Air conditioners	Tubular fluorescent lamps
Delhi	4	2	2
Jaipur	4	2	1
Mumbai	4	2	1
Vadodara	3	1	1
Kolkata	3	1	1
Guwahati	3	1	1
Chennai	3	1	1
Bangalore	3	1	1
Subtotal	*27*	*11*	*9*
Total		**47**	

Source: Pandian, 2008.

Other initiatives

Bachat Lamp Yojana (BLY) Scheme

The Ministry of Power, through the Bureau of Energy Efficiency (BEE), is aiming to replace about 400 million incandescent bulbs currently in use by domestic consumers with high quality CFLs by 2009/10, resulting in a reduction in demand of approximately 4 000 MW. The high initial price of CFLs (normally retailing at USD 2.0-2.5) represents a considerable barrier to penetration in India, and therefore the scheme will provide CFLs at a price of 15 per lamp (USD 0.38), *i.e.*, at a price comparable to that of incandescent bulbs. This price reduction will be achieved by utilising the Clean Development Mechanism (CDM) of the Kyoto Protocol through which the CFL suppliers would earn Certified Emissions Reductions (CERs). To facilitate the project, BEE is preparing an umbrella CDM project under the recently announced Programme-of-Activities (PoA) of the CDM Executive Board. An expenditure of IRS 480 million (USD 12 million) has been approved for BEE to undertake monitoring activities (MoP, 2008a).

The other major schemes that Bureau of Energy Efficiency has proposed under the XI plan are:

- Energy Conservation Building Code (ECBC) that sets minimum energy performance standards for new commercial buildings.
- Agricultural and Municipal DSM targeting replacement inefficient pumpsets, street lighting, etc.

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- Operationalising EC Act by Strengthening Institutional Capacity of State Designated Agencies (SDAs). The scheme seeks to build institutional capacity of the newly created SDAs to perform their regulatory, enforcement and facilitative functions in the respective states.
- Energy Efficiency Improvement in Small and Medium Enterprises (SMEs). To stimulate energy efficiency measures in 25 high energy-consuming small and medium enterprise clusters.

The targeted reduction in demand as a result of these interventions during the XI plan translates into an avoided capacity addition of 10 000 MW (Kumar, 2008).

International engagement

BEE takes an active interest and has built up strong links with equivalent organisations overseas. In particular, BEE joined the IEA's Demand Side Management implementing agreement in 2006, and in April 2008 hosted the ExCo meeting in New Delhi. India also became the first non-OECD country to successfully pilot a new Task in the IEA DSM Implementing Agreement (*Task XX- Branding of Energy Efficiency*).

Also in April 2008, BEE joined the IEA to co-host the two-day International Standby Power Conference, at which a range of overseas speakers and participants shared information with over 150 local participants drawn from industry, government and academia (BEE, 2008c).

The Ministry of Power and BEE staff participate in many workshops at the IEA and elsewhere, and will be formally invited as observers to future Working Party meetings at the IEA.

A long running collaborative project has existed since October 2003 between the German Federal Ministry for Economic Development and Co-operation (BMZ) and BEE. Under this scheme, GTZ staff have been working closely with BEE and the Ministry of Power to advise on developing strategies and practical, market-friendly regulations for implementing the present Indian law on energy saving. By focussing on the most important large industrial consumers, on power utilities, on key technologies, and on the most effective implementation methods and instruments, the greatest possible impact is to be achieved at the least expense: the private sector will be involved early on in all measures. The leadership role of the state as promoter of energy-efficient measures is emphasised in a productive interaction among the principal stakeholders. Furthermore, the programme includes measures for encouraging the transfer of know-how and financial resources from industrialised countries to promote energy efficiency and renewable energies in India (GTZ, 2008).

In addition BEE has ongoing collaboration with GEF, USAID, ADEME (France), Japan, and other bilateral and multilaterals. The aim of all these collaborative efforts is to secure the best possible technical expertise to design, implement and evaluate energy efficiency measures in India.

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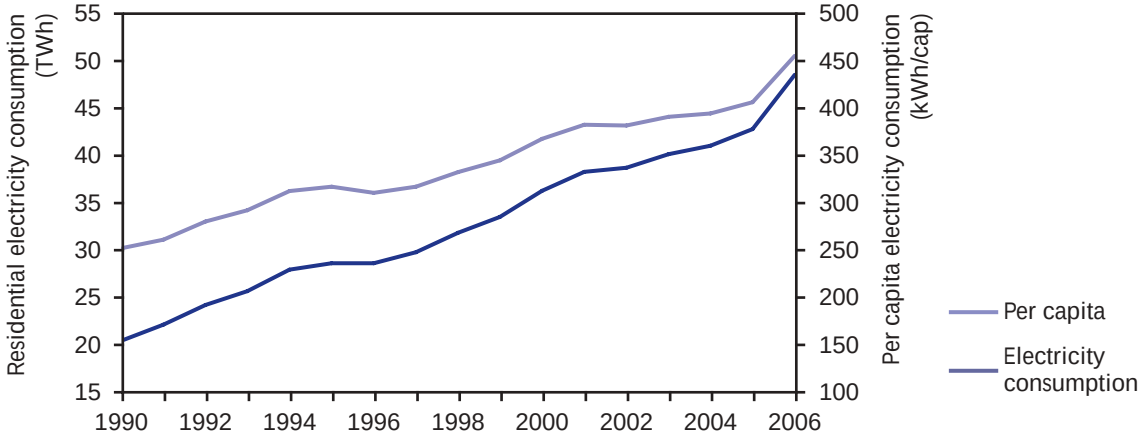
MEXICO

Mexican residential electricity consumption comprised 24.9% of total electricity use in 2004, growing by 3.9% per annum during the previous decade compared to 4.1% for all sectors. Residential electricity consumption would have been higher, but for the implementation of energy efficiency programmes, estimated to have reduced electricity consumption by 7 330 GWh or 14.6% in 2005 (SENER, 2006).

Figure 75 • Total residential and per capita electricity consumption, 1990-2005



Source: IEA statistics.

National forecasts estimate a strong growth in electricity consumption up to 2014, with the residential sector growing by 5.1% per annum, compared to 5.2% for all sectors. Without energy efficiency programmes consumption in 2014 would be higher by an estimated 17 400 GWh or 26% above the predicted total electricity consumed in the residential sector (SENER, 2006).

Increased personal wealth and the subsidised electricity tariffs continue to be major drivers in the growth of residential electricity consumption. The average residential tariff in 2000 covered just 43% of costs and grew by only 183% from 1995-2001, compared to the CPI which increased by nearly 250% over the same period (World Bank, 2004).

The forecasted growth in electricity consumption nationally will place significant demands on the capacity of the electricity supply system, requiring an expansion from 46 550 MW in 2005, to 64 200 MW by 2014 (SENER, 2006). This will also require considerable investment in transmission and distribution infrastructure in regional Mexico, at a time when there will be increasing claims on government funds to meet other important social goals. It is conservatively estimated that the energy sector's capital requirements for the next 10 years are MXN 1 400 billion[23] (USD 135 billion) (World Bank, 2004).

23. Constant 2000 MXN.

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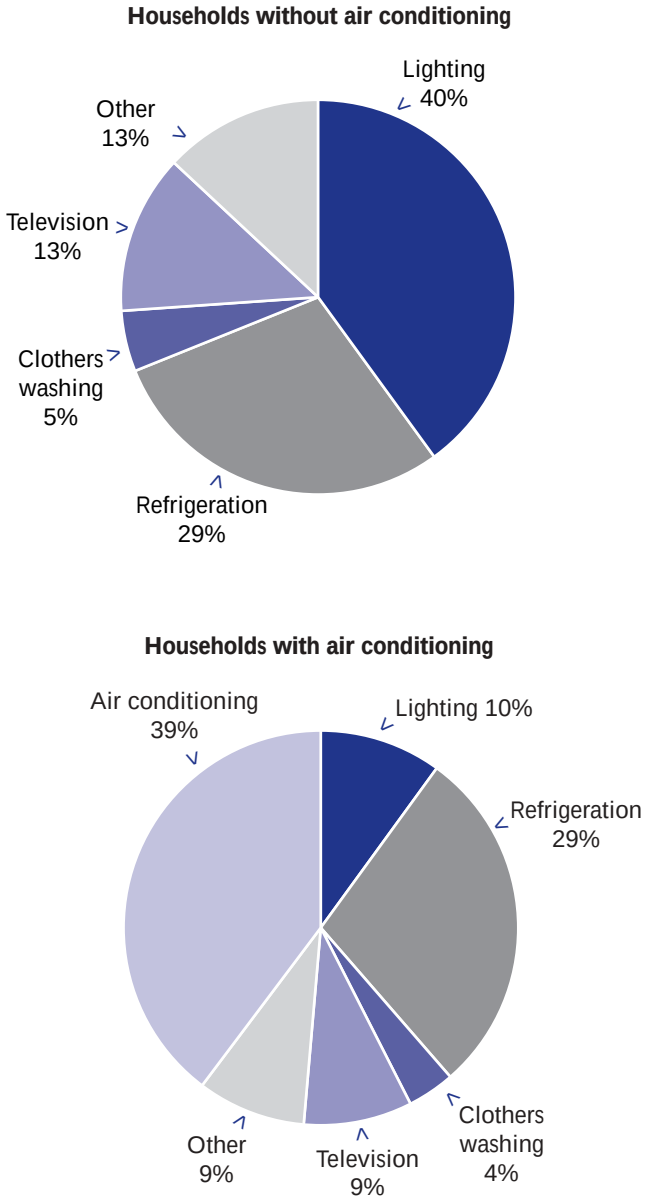
In this context, the Mexican government has taken steps to promote energy efficiency by the establishment of appropriate agencies and organisations, and through the development of programmes targeted at the electricity sector. The average residential consumption by major end-use is shown in Figure 76 for houses with and without air-conditioning. Shipments of room air conditioners increased by over 30% between 2002 and 2005, with the result that in 2006 approximately 16% of households in Mexico owned one or more room air conditioners. A further 3% of households owned an air conditioning system in 2006 (IEE, 2006; INEGI, 2008).

Figure 76 • Estimated electricity consumption per household by major end-use application, 2008



Source: CONAE, 2008a.

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Highlights of Mexico's residential energy efficiency activities include:

- A comprehensive array of policy measures in place for some of the key appliances;
- Regular updates to the stringency of appliance criteria, assisted through strong links with programmes in the United States and Canada;
- An established and technically competent framework for verification activities;
- The first steps towards tackling areas of future growth, such as those in electronic equipment, beginning with the hosting of an International Standby Power Conference in 2007.

Institutional organisation, policies and financial issues

Mexico's mandate for energy efficiency regulations comes from a generic law, the Ley Federal Sobre Metrología y Normalización of 16 July 1992, which defines two types of standards: voluntary Normas Mexicanas – NMX (Mexican Standards) and mandatory Normas Oficiales Mexicanas – NOM (Official Mexican Standards). The NOM are enacted by the federal secretariats, according to their areas of competence. In the case of energy efficiency, it is the Energy Ministry, through the Comision Nacional para el Ahorro de Energia – CONAE (National Commission for Energy Conservation) which enacts the mandatory standards.

CONAE is a decentralised administrative organ of the Energy Ministry that serves as a technical consultant for public federal administration entities, such as state and municipal governments, as well as providing technical assistance in the private and social sectors. The mission of CONAE is the development and promotion of actions on energy efficiency and energy saving, and the use of renewable energies in the country,

To put into effect the energy efficiency regulations, the Law establishes a set of specific and generic public and private organisations, as follows:

- National Standardization Commission: The main function of the Commission is to coordinate standardisation activities at a national level. Its chair rotates among the participating ministries.
- National standards advisory committees: Each committee is chaired by the corresponding ministry. For energy efficiency standards, the advisory committee is chaired by CONAE.
- General Direction of Standards of the Ministry of Economy. The Ministry of Economy enacts NOM related to user safety, commercial information (e.g., food labels), and practices. DGN approves testing laboratories.
- National Metrology Center. This is the primary calibration laboratory.
- Accreditation entities. These, such as the Entidad Mexicana de Acreditación (EMA), are in charge of recognising the technical competence and trustworthiness of certification organisations, testing laboratories, calibration laboratories, and verification units.

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- Certification organisations: These are organisations, such as the Asociación de Normalización y Certificación, A.C. (ANCE), whose objective is to certify compliance with standards. They require approval by the corresponding ministries.
- National normalization organizations: These are organisations whose objective is to elaborate (non-mandatory) Mexican Standards.
- Testing laboratories. These can be either independent or operated by manufacturers (NRCAN, 2008).

Budget

Estimating the total expenditure on energy efficiency programmes is particularly difficult since it is spread across so many organisations, however, as the central body, CONAE's budget and staffing levels are indicative of recent trends. Both total expenditure and staff within CONAE have been reduced since 2001 but they have remained reasonably stable since 2004, as shown in Table 50.

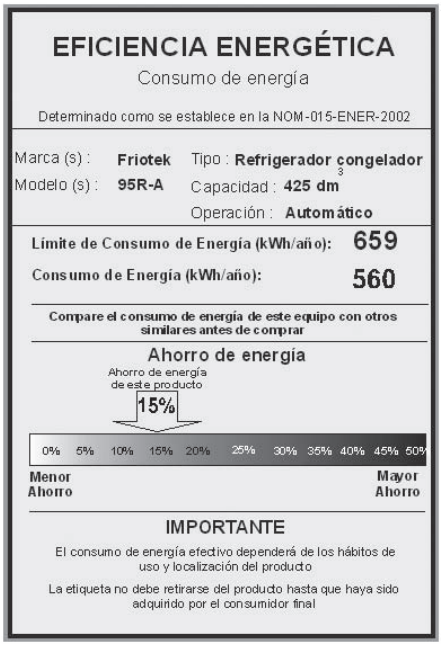
Table 50 • CONAE budget and staffing levels, 2001-2008*

	2001	2002	2003	2004	2005	2006	2007	2008
Budget (MXN million)	96.9	95.4	68.7	71.4	64.5	60.0	57.3	60.8
Budget (USD million)	9.4	9.3	6.7	6.9	6.3	5.8	5.6	5.9
Staff *	164	165	106	102	101	101	99	98

* No information was available regarding the budget and staffing levels of FIDO at the time of publication.
Source: CONAE, 2008a.

Energy performance labelling

Mexico has a system of appliance energy labelling comprising both comparative and endorsement labels. The Comparative label is mandatory for specified products and is administered by CONAE; while the endorsement label, known as Sello FIDE is administered by a private non-profit organisation (FIDE) financed by the largest public utility, the CFE (Federal Power Commission).



Comparative label

The mandatory comparative labelling programme is implemented by CONAE and currently applies to room and central air conditioners, refrigerators and/or refrigerator-freezers, clothes washers and centrifugal residential pumps.[24]

24. Other products covered by the label are in the commercial and gas sectors.

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Products that require mandatory comparative labels are rated as part of the MEPS process, and the labels show the appliances' efficiency levels in comparison to the MEPS level in absolute terms and according to the specified test method. The label also shows the amount of saving compared to the minimum standard required by MEPS in percentage terms.

Additional information included on the label relates to the size/capacity of the equipment, and identifies the relevant NOM applicable to the type of appliance (NRCAN, 2008).

Endorsement label: Sello FIDE

Sello FIDE is a voluntary energy efficiency endorsement seal administered by the Fideicomiso para el Ahorro de Energía Eléctrica - FIDE (Private Trust Fund for Electric Energy Saving), a private non-profit organisation founded in 1990 with the goal to promote rational electric energy use and energy saving.

Introduced in 1995, appliances labelled under this programme include room air conditioners, fluorescent lamps and compact fluorescent lamps (CFLs), refrigerators, refrigerator-freezers, motors, and compressors (NRCAN, 2008). Criteria for the label are decided by FIDE's technical Committee, drawn from electric utilities, industry associations and CONAE.

Manufacturers pay for certification and sign an agreement stipulating the length of validity of the Sello FIDE endorsement and how the label should be displayed. Manufacturers are required to have all products tested by a certified laboratory to verify manufacturer claims (NAEWG, 2002).

Minimum energy performance standards (MEPS)

CONAE issues MEPS on energy efficiency, acting on behalf of the Energy Ministry and in consultation with the National Consultative Committees for Preservation and Efficient Use of Energy Resources (CCNNPURRE) who has the task of drafting regulations (SEPCO, 2008). The final regulations (NOM) include both the minimum energy performance levels required and the test procedure for determining the equipment performance, and once enacted apply to all products that are marketed in Mexico.

Presided by the Director General of CONAE, CCNNPURRE comprises representatives from:

- The federal government (*e.g.* ministries of Economy, Finances, Environment, etc);
- the energy sector (*e.g.* national oil company (PEMEX), the national utilities (CFE and LyFC), etc);
- Research institutions (*e.g.* Mexican Petroleum Institute (IMP), the Institute for Electric Research (IIE), etc);
- Higher education institutions (*e.g.* National University of Mexico (UNAM));
- Industrial associations, (*e.g.* National Transformation Industry Association (CANACINTRA), etc);
- Professional associations (e.g. National Chemical Engineers Association (CONIQQ), etc).

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CONAE also participates in other relevant committees, such as the National Committee on Standardisation for the Electric Sector or the National Committee on Standardisation for Environmental Protection (NRCAN, 2008).

Of the 18 NOMs concerning energy efficiency, 16 relate to the electricity using equipment and 6 of these to the residential sector. The following have either been recently updated or are in the process of introduction:

- Compact fluorescent lamps (NOM-017-ENER/SCFI-2005) : modified version was published January 2008 in the Official Gazette for public consultation;
- Room air conditioners (NOM-021-ENER/SCFI-2005): modified version was published January 2008 in the Official Gazette for public consultation;
- Centrifugal residential pumps (NOM-004-ENER): modification published January 2008 on the Official Gazette for public consultation;
- Clothes washers (NOM-005-ENER): modified version will be published on the Official Gazette for public consultation by the end of 2008;

In addition, the following two new MEPs are being introduced and details will be published in the Official Gazette for public consultation by the end 2008:

- tortilla-making machines (NOM-019-ENER);
- mini split air conditioner. (CONAE 2008b)

A summary of the major policy measures directed at residential electrical appliances is provided in Table 51.

Table 51 • Summary of major national policy measures for residential electrical appliances

Title	Comparative label	Endorsement label	MEPS
Refrigerators (NOM-015)	M	V (2002)	M (1995, 1997, 2003)
Freezers (NOM-015)	M	V (2002)	M (1995, 1997, 2003)
Clothes washers (NOM-005)	M	V (2003)	M (1997, 2000)
Central A/C (NOM-011)	M	V (2002)	M (1995, 2001, 2007)
Room air conditioners (NOM-021)	M	V (2002)	M (2005)
Others categories of A/C (split) (NOM-011)	M		M (2002, 2007)
Compact fluorescents lamps (CFL) (NOM-017)		V (1995)	M (2005)
Televisions		V (2005)	
Residential centrifugal pumps, vertical turbine external motor, centrifugal residential water, submersible clean water, electromechanical systems of vertical turbine pumps (NOM-004)	M		M (2005)

Source: NAEWG, 2002; CONAE, 2008a, 2008b. Bracketed dates indicate the year of implementation and any subsequent updates. M = Mandatory; V = Voluntary.

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Other initiatives

There are several groupings of organisations which undertake educational and promotional activities and more specialised energy efficiency programmes.

For example, in addition to administering the endorsement label, FIDE provides technical and financial assistance for certain measures. In 2004, finance provided by FIDE to five developers was used to ensure the construction of 3 700 energy efficient new houses.

Working with CFE, in 2002 FIDE launched the *Programa de Financiamiento para el Ahorro de Energía Electríca* (PFAEE) to promote electrical energy savings in the domestic sector in most of the national territory, through the provision of financial incentives including grants and loans. By 2005 work of the PFAEE had led to:

- Home insulation for 121 000 dwellings;
- Installation of 196 000 efficient air conditioners;
- Substitution of 356 000 refrigerators with efficient models;
- Replacement of 17 million incandescent lamps by efficient lamps
- Completion of 226 000 energy audits.

These programmes are estimated to save 544 GWh and 352 MW by 2014.

FIDE also administers an annual National Prize of Electrical Energy Savings (SENER, 2006, 2007).

International engagement

North America Security and Prosperity Partnership (SPP)

In June 2005, the North American Energy Working Group (NAEWG), which was established in 2001, became part of a broader trilateral initiative when the Governments of Canada, the United States and Mexico launched the Security and Prosperity Partnership (SPP). The partnership is a voluntary framework with three primary goals: to strengthen regulatory cooperation; streamline regulation and regulatory process, and; encourage the compatibility of regulations where appropriate and feasible.

The energy component of this partnership builds on existing efforts by NAEWG to cooperate on energy efficiency standards. This group meets twice a year and has recently focussed on harmonisation of energy standards for refrigerators, air conditioners and large electric motors. In July 2007, Energy Ministers from the 3 jurisdictions endorsed a work programme which will see strengthened cooperation on standby power consumption and further harmonisation of energy standards. Products for consideration include gas and oil water heaters, clothes washers, dishwashers, fluorescent lamps. Incandescent reflector lamps and single package central AC and heat pumps (CONAE, 2007).

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Standby Power Consumption Workshop, 25–26 September 2007, Mexico

As part of the trilateral cooperation efforts among Mexico, Canada, and the United States the Mexican Ministry of Energy and the National Commission for Energy Saving (CONAE) organised an international standby power consumption workshop in 2007.

With the aim of sharing information and update domestic efforts on standby energy consumption, the workshop included speakers from the United States DoE, United States Energy Star, California Energy Commission, Natural Resources Canada, CONAE, the IEA, the Consumer Electronics Association, consumer product manufacturers, component manufacturers, and utilities (CONAE, 2007).

Evaluation and enforcement activity

CONAE is responsible for the verification of compliance with NOMs, and relies upon the Mexican accreditation entity (EMA) to accredit suitable Test Laboratories. All products covered by any energy efficiency standards are required to gain a certificate which is provided by the Asociación de Normalización y Certificación, A.C. (ANCE), (a private sector entity authorised by the Ministry of Economy), following a test report from an accredited laboratory.

In order to ensure that testing facilities perform correctly and with properly calibrated equipment, laboratories must conform to NMX-IMNC-EC-17025 *"Requisitos generales para la competencia de los laboratorios de ensayo y de calibración"*, which is a translation of ISO/IEC 17025 *"General requirements for the competence of testing and calibration laboratories"*.

To ensure compliance with energy efficiency standards, the Consumer Federal Office (Procuraduría Federal del Consumidor), checks that all products carry the certificate at the points of sale. For imported products, the Ministry of Treasury verifies with the Customs authorities, that all products hold the certification before authorising entry to the country (CONAE, 2008a).

The following testing facilities are available within Mexico, accredited to perform tests to the relevant Nom for residential electrical appliances:

Table 52 • Availability of testing facilities for electrical appliances

Standards	Laboratory
Vertical turbine water pumps (NOM-001-ENER-2000)	2
Centrifugal water pumps (NOM-004-ENER-1995)	1
Clothes washers (NOM-005-ENER-2000)	11
Submersible water pumps (NOM-010-ENER-2004)	6
Central air conditioners (NOM-011-ENER-2006)	2
Single-phase motors (NOM-014-ENER-2004)	3
Refrigerators and freezers (NOM-015-ENER-2002)	9
Compact fluorescents lamps (NOM-017-ENER-1997)	2
Room air conditioners (NOM-021-ENER/SCFI/ECOL-2000)	2

Source: CONAE, 2008a.

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Estimates of current and future energy savings from energy efficiency programmes are published by SENER (see Table 53).

An independent evaluation of the impact of three of the NOMs by IEE in cooperation with the Lawrence Berkeley National Laboratory (for CONAE) in 2006 suggests that the above estimates may be conservative (IEE, 2006). The study estimates that in 2005 the programme savings for these products are approximately:

- refrigerators: 6 292 GWh 1 506 MW
- room air conditioners: 3 849 GWh 867 MW
- clothes washers: 414 GWh

By 2016, SENER estimates that total electricity savings from the NOM will rise to 33 230 GWh. Assuming that the proportion of savings in the residential sector is similar to those achieved prior to 2005, MEPs for residential electric appliances will save over 17 000 GWh and 3 400 MW of demand.

Table 53 • Estimated energy savings from NOM electricity sector in 2007

Application	Implementation date	Units sold in 2007	Savings		
			For units sold in 2007	By accumulated efficient units	
			GWh	GWh	MW
Centrifugal water pumps	Dec 1995	393 625	1	34	125
Clothes washers	Oct 2000	2 028 065	102	647	0
Central air conditioners	Aug 2007	13 467	37	281	39
Refrigerators and freezers	May 2003	1 885 352	734	6 318	1 296
Compact fluorescents lamps	June 1998	515 456	34	173	4
Room air conditioners	June 2001	596 724	269	2 192	325
Total residential impact 2007				**9 645**	**1 789**

Source: SENER, 2007.

Other energy efficiency programmes, such as those organised by FIDE and PFAEE, are estimated to save an additional 540 GWh of electricity and 350 MW of demand (SENER, 2006).

Further electricity savings have been attributed to the policy of moving the clocks forward during the summer months in order to save artificial lighting at times of peak demand. Evaluations which have been made since 1992 estimate cumulative savings of 9 832 GWh between 1996 and 2004, and a reduction of 898 MW of peak demand. It is further estimated that the annual savings from this measure will be approximately 1 558 GWh and 1 488 MW of avoided demand by 2014 (SENER, 2006).

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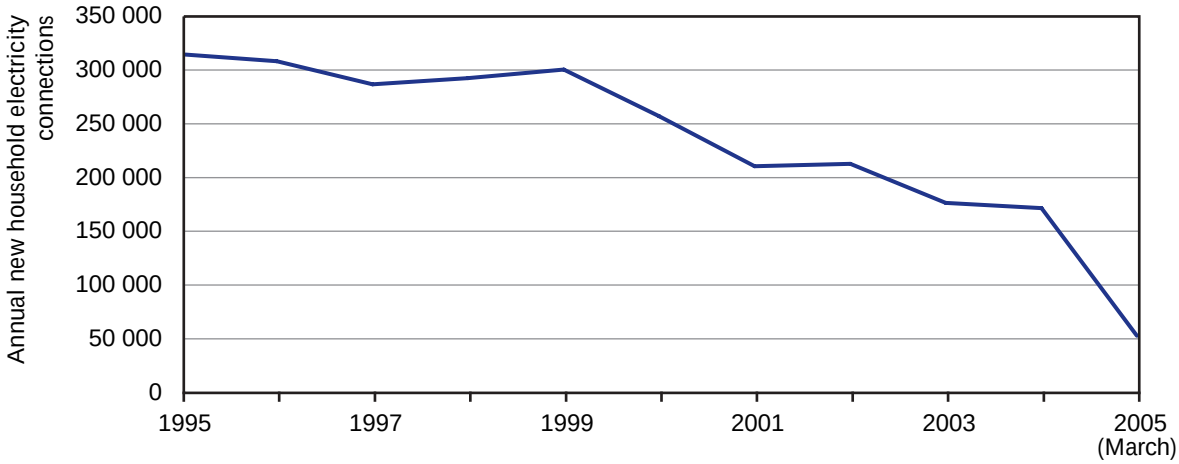
Between 1991 and 2005/6, approximately 3.2 million new households have been connected to the electricity supply (see Figure 77); although a further 3.4 million households remain un-electrified (DPE, 2007). Under the Integrated National Electrification Programme (INEP), the government is committed to full electrification by 2012 (NAEC, 2007).

Figure 77 • Annual new household electricity connections, 1995-2005

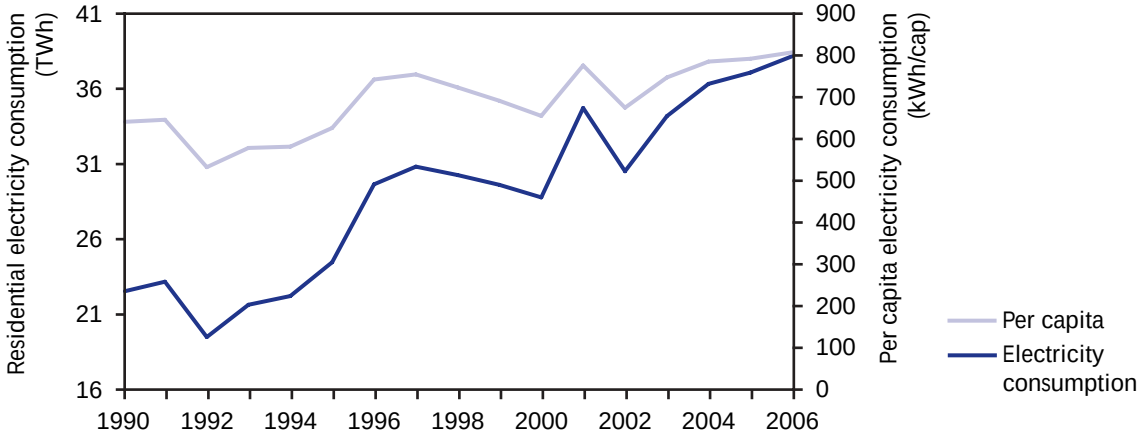


Source: DPE, 2006.

This growth in the customer based has helped to increase residential electricity consumption in South Africa by 3.4% per annum between 1990 and 2005, while per capita consumption rose by 1.4% over the same period (see Figure 78).

Over the next few years, government aims to reduce electricity consumption from the residential sector under the Power Conservation Programme, in response to severe constraints in power supply which result in frequent blackouts. The plan draws heavily on the experience of Brazil and its power rationing practices in 2001 and aims to reduce demand by 3 000 MW over the next three years (DME, 2008d).

Figure 78 • Total residential and per capita electricity consumption, 1990-2005



Source: IEA statistics.

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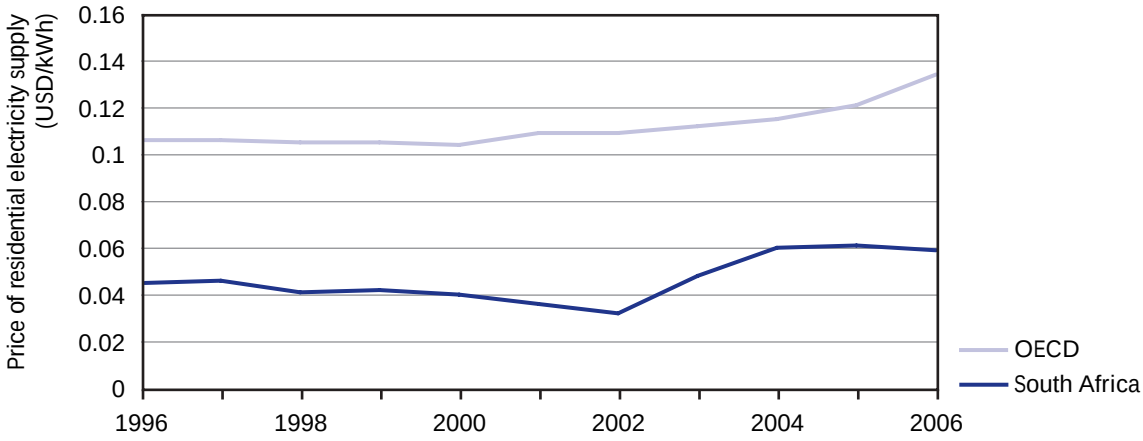
In order to finance new power supply and demand-side investments, the National Energy Regulator of South Africa (NERSA) approved an average annual increase in electricity tariffs of 27.5% in 2008 (NERSA, 2008). This will cause an increase in electricity prices to households, although it should be noted that current household tariffs are less than 50% of the average amongst OECD countries (see Figure 79).

Figure 79 • Household electricity prices, 1996-2006



Source: IEA statistics.

The Power Conservation Programme draws on many of the initiatives which have been developed or outlined previously, and accelerates their implementation.

In 1998, the government launched the *White Paper on Energy Policy* which highlighted the government's intention to prioritise the implementation of energy efficiency in South Africa. Until this time, the majority of energy efficiency initiatives have been run by the national electricity authority (Eskom) as a part of its demand-side management activities.

Following the White Paper, the first national *Energy Efficiency Strategy*, published in 2005, gives priority to the development of a nation-wide appliance efficiency programme, using standards and labelling as the key instruments (DME, 2005).

Thus far, the implementation of the *Energy Efficiency Strategy* has resulted in a voluntary appliance labelling programme which currently applies to refrigerators only. It is envisaged that the *Appliance Labelling Initiative* will be rolled out to additional white goods, and be made mandatory, legislated under an Energy Bill which is yet to be finalised and passed into law.

In the past decade, progress towards improvements in energy efficiency for household appliances has included:

- The publication of two major policy documents: the *White Paper on Energy Policy* (1998) and the *National Energy Efficiency Strategy* (2005);
- The South African government's decision to prioritise the energy efficiency and achieve a 12% improvement by 2015;

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- The building of institutional capacity to support a standards and labelling programme; and
- The launch of the *Energy Efficient Appliance Labelling Program* in 2005 which currently applies on a voluntary basis to refrigerators.

Institutional organisation, policies and financial issues

The South African government has launched a key strategy for advancing energy efficiency and established a Directorate within the Department of Minerals and Energy to provide oversight and co-ordination, as outlined below.

Energy Efficient Strategy for the Republic of South Africa (2005)

South Africa's Energy Efficiency Strategy, officially launched in May 2005, was authorised by the White Paper on Energy Policy (1998), and is the government's first consolidated document aimed towards developing and implementing energy efficiency practices. Development of the strategy was assisted by a four year capacity building project – Capacity Building in Energy Efficiency and Renewable Energy (CaBEERE) – completed in 2005 and funded with Danish International Development Assistance (DANIDA).

The strategy sets a voluntary national target for energy efficiency improvement of 12% by 2015,[25] outlining practical guidelines for the implementation of efficiency practices and describing governance structures for the development of activities, promotion and coordination. It is envisaged that this target will be met by a number of enabling instruments including: regulation (the Energy Act and other laws); mandatory energy efficiency standards and appliances labelling; energy audits and energy management activities; replacement of old technology for new; certification, accreditation, education and training; promotion of energy efficiency awareness, and; a monitoring system to verify progress against sectoral targets (DME, 2005).

The strategy provides for the implementation of sector-specific programmes, covering industry, commercial and public buildings, transport and residential sectors, in a 3-phased approach. The intention is to undertake low-cost initiatives in the first phase, and to subsequently introduce more capital intensive measures during the latter two phases. Technical standards are to be addressed in the early stages to maximise benefits in the long term. It should be noted that the three phases are not mutually exclusive and that some interventions planned for the residential sector traverse more than one phase. The strategy will be reviewed at the end of each phase.

Table 54 shows the residential measures contained in the *Energy Efficiency Strategy 2005*, which has the following timeframes:

- Phase 1: March 2005 to February 2008;
- Phase 2: March 2008 to February 2011;
- Phase 3: March 2011 to February 2015.

25. This target is expressed in relation to the forecast national energy demand at that time, based on the 'business as usual' baseline scenario for South Africa modelled as part of the National Integrated Energy Plan (2003), which uses energy consumption data for the year 2000.

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Table 54 • Residential sector programme implementation and timeframes

Output activity	Measures	Timeframe
Standard for housing	Standard 283 for Energy Efficient Housing	Phase 1
	Incorporate SANS 283 in National Building Regulations	
	Monitoring and Dissemination of Results	Phase 2
Appliance labelling	Establish standards for household appliances	Phase 1
	Label household appliance	
	Make the label mandatory	
	Market appliances with labels	
	Monitor progress	Ongoing
Awareness raising	Development of specific programme	Phase 1
	Implementation	Ongoing
Efficient lighting program	Demonstration in all sectors	Phase 1
	Implementation	
	Monitoring	Ongoing

Source: DME, 2005.

DME's Energy Efficiency Directorate (EED)

A dedicated Energy Efficiency Directorate (EED) under the Department of Minerals and Energy (DME) was established in 2003. Objectives of the directorate are to:

- Promote and develop energy efficiency practices, norms and standards in different energy sectors, including industries, commercial buildings, households, transport and agriculture;
- Develop energy efficiency policies, strategy and guidelines;
- Facilitate information awareness, and capacity building campaigns on energy efficiency and environmental issues;
- Promote energy for sustainable development;
- Mitigate negative impact of energy utilisation on environment;
- Promote energy efficiency technologies, clean energy technologies including environmentally sound energy technologies;
- Promote and facilitate international collaboration and cooperation; and
- Ensure the DME's participation at international forums on energy efficiency and the environment, including the United Nations Commission on Sustainable Development (UNCSD), the Kyoto protocol and the United Nations Framework Convention on Climate Change (UNFCCC).

In preparation for implementation of a mandatory standards and labelling scheme, a *Standards and Labelling Unit* has been established within the Energy Efficiency Directorate and training of new staff is underway.

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National Energy Efficiency Agency (NEEA)

As part of the broader *Energy Efficiency Strategy*, a dedicated National Energy Efficiency Agency (NEEA) was officially established in March 2006. The agency is a wholly incorporated division of the Central Energy Fund (CEF) Pty Ltd.[26]

It is envisaged that the NEEA will initially oversee the implementation of DSM and Energy Efficiency projects undertaken by Eskom and other entities in the country. Currently, DSM funds remain with Eskom as the main implementing agency and who will continue to manage these funds with the oversight of the NEEA governance body.

In 2007, the NEEA awarded funding of over ZAR 500 million through the Central Energy Fund to improve the energy efficiency of facilities in South Africa's national parks. Energy efficient appliances such as solar water heaters and CFLs will be installed (TGN, 2007).

Draft energy bill

The Draft Energy Bill 2004 will establish the National Energy Act 2004 and will come into operation on a date determined by the President. The content of the Energy Bill addresses the following:

- The establishment of a National Energy Advisory Committee to advise the Minister on energy policy matters;
- The establishment of a National Energy Data Base and Information system, providing for mandatory collection of energy data by the Department of Minerals and Energy;
- The establishment of an Integrated Energy Planning capability;
- The establishment of a Renewable Energy Programme;
- The establishment of an Energy Efficiency Programme;
- The establishment of an Energy, Safety, Health and Environment Programme not provided for in another legislation;
- The establishment of a Programme to address the access of energy to households;
- The provision for the fulfilment of international commitments and obligations pertaining to energy;
- The establishment of a national energy research programme. This provision will provide for sustainable energy supply through national directed research and development. Such research and development is currently fragmented and insufficient for future national development needs (DEAT, 2005).

26. CEF (Pty) Ltd. is involved in the search for appropriate energy solutions to meet the future energy needs of South Africa, the Southern African Development Community and the sub-Saharan African region, including oil, gas, electrical power, solar energy, low-smoke fuels, biomass, wind and renewable energy sources.

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The KYOTO Protocol and its CDM Projects

Following ratification of the KYOTO Protocol on 18 November 2004, the Department of Minerals and Energy (DME) established a Designated National Authority (DNA) designed to screen potential Clean Development Mechanisms (CDM) projects.

There is a strong overlap of the activities of the DNA with that of the DNA's efforts to introduce energy efficiency and renewable energy; with CDM finance potentially providing a small but significant contributor to the commercial viability of energy efficiency projects.

Budget

Between 2001 and 2005, the Danish funded Caber project help South Africa kick start developments in Renewable Energy and Energy Efficiency. Specifically, the project contributed by resourcing the South African Department of Minerals and Energy (DME) and relevant stakeholders to formulate and facilitate the implementation of strategies and legislation promoting energy efficiency and renewable energy.

The table below specifies Caber funding amounts allocated to specific projects relating to energy efficiency of appliances under the programme. The total Caber budget over the 4 year duration of the programme was ZAR 5.8 million (USD 0.74 million) (Golding, 2008).

Table 55 • CaBEERE funding for relevant energy efficiency projects

CaBEERE projects	Date of funding	Amount in ZAR	Amount in USD*
Energy efficiency baseline study	Jan 2003	126 000	16 100
Appliance labelling study	Jan 2003	65 000	8 300
Energy efficiency - projected savings report	Apr 2003	120 000	15 300
Energy efficiency strategy	Mar 2004	650 000	83 000
Energy efficiency household tips	Jul 2005	165 000	21 100
Appliance labelling implementation	May 2006	250 000	32 000
Total		**1 376 000**	**175 800**

* These figures are approximate and derived from currency conversion on 22/06/08.

Source: Golding, 2008.

Since the end of the CaBEERE programme, DME's new Energy Efficiency Directorate (EED) has been allocated a Departmental budget of approximately ZAR 1 million per year (USD 127 800) which has permitted the Department to run one modest project per year. In 2006, the EED project budget funded a public awareness campaign. In 2007, the funds supported research and development of an energy efficiency standard for buildings (commercial and residential). The Designated National Authority for CDM projects was established with funds from the Danish International Development Agency (DANIDA)[27] of DKK 11 million (USD 2.3 million) (Golding, 2008).

27. DANIDA is an organisation within the Department of Foreign Affairs of Denmark, set up to provide humanitarian help and assistance in developing counties.

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At the time of writing, the DME with assistance from the UNDP had submitted an application for GEF funds to further assist the introduction of a mandatory standards and labelling programme for all appliances in South Africa. Financial support has been requested to help analyse and address the proposed policy, financial, communication and technological barriers that continue to impede the introduction of more energy efficient domestic appliances in general, and to provide technical assistance and improve the institutional capacity in relation to standards and labelling policy. Special attention will continue to be given to sourcing additional funding to support standards and labelling long-term.

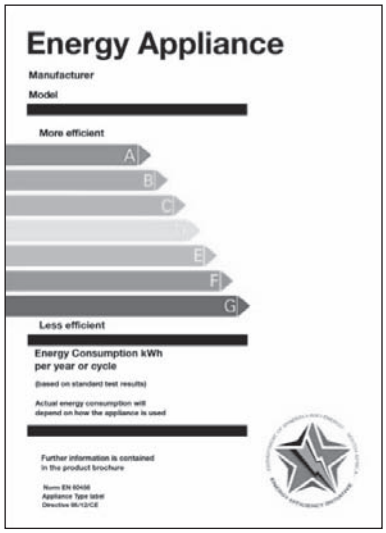
Energy performance labelling

Comparison label

A number of studies, both by government and other entities, have been undertaken to looked into the feasibility of introducing labelling for household appliances in South Africa (DME 2005). The DME first commissioned a project in 1995 to study the scope for appliance labelling. This was the first phase which was to be followed up by two subsequent phases to design and implement the system. This was, however, not followed through. Then, with the support of the CaBEERE project, the DME initiated a second appliance labelling study for South Africa to ascertain the state of affairs related to energy labelling, review existing laws and the requirements or desirability for new legislation and/or regulation. Drawing on the expertise of a large group of stakeholders from both government and industry, the study was completed in February 2002 and proposed a 'plan of action' to implement appliance labelling, including recommendations for suitable legislation / regulation. Products covered in the report include electric water heaters, electric stoves, refrigerators/freezers, clothes washers, tumble dryers, dishwashers, room air conditioners, and electric lamps and luminaries (DME, 2003).

Energy efficient appliance labelling programme

An *energy efficient appliance labelling programme* was officially launched in May 2005, coinciding with the launch of the *Energy Efficient Strategy*. The programme is currently voluntary and is limited to domestic refrigeration at this time. It is foreseen that this initiative will become mandatory in the latter half of 2008, subject to the current Draft Energy Bill which is yet to be finalised and passed into law.



For practical purposes, South Africa has effectively adopted the EU energy efficiency comparative label, which is logical since South Africa's appliance safety standards are based virtually entirely on the EU standards[28] and the EU remains the nation's strongest trading partner. Energy consumption on the label is denoted by a grading from "A" to "G" – "A" appliances being

28. *Safety standards are largely based on the International Standards Organisation (ISO) and International Electrical Commission (IEC) standards.*

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the most energy efficient. The label also includes a unique South African symbol, the Green Star, which indicates that the product is produced in South Africa. This South African Green Star Program was supported by the Capacity Building in Energy Efficiency and Renewable Energy (CaBEERE) project. The energy efficiency grading is not necessarily required to be placed on the product at the time of sale but at minimum, must be illustrated in instruction manuals that accompany products (DME, 2008a).

The government is currently considering revising the technical standards for dryers, cook tops and ranges/ovens to include voluntary energy efficiency labelling.

Supporting standards

SABS/SANS safety standards and performance specifications for refrigerators were amended to include the energy label in 2005. The performance grading A-G is described in these standards and is determined by South Africa's standards authority, the South African Bureau of Standards (SABS).

During this voluntary phase, the SABS has agreed to accept to test reports from internationally-recognised testing authorities before issuing permission to use the label. This means that all appliances imported from overseas must be accompanied by a test report from an accredited test laboratory. In the absence of a test report, the importer must have the product tested locally at an accredited laboratory at their expense. Local manufacturers are also required to produce a report from an accredited test laboratory (DME, 2008a).

Minimum energy performance standards (MEPS)

South Africa has a well-developed system of standards and codes of practice for appliances that, in some cases, may be amended to include energy efficiency aspects, without the need to establish radically new standards (Bredenkamp *et al.*, 2006). Many of the safety standards that apply to domestic appliances are compulsory; however the energy performance aspects of relevant standards are voluntary.

No minimum energy performance standards currently exist in South Africa, however, it is envisaged that once the energy label is in place and there is a shift in efficiency levels in the market, MEPS can be introduced to remove the least efficient products from the market. The Draft Energy Bill 2004 gives the Minister of Minerals and Energy substantial authority to make standards compulsory (DME, 2005).

Capacity building

It is important to note that despite intentions anticipated by the *Energy Efficiency Strategy*, South Africa still faces the challenge of overcoming numerous barriers to both the introduction of high-efficient appliances in general, and to the adoption and implementation of the programme. Unlike developed nations that currently operate mandatory standards and labelling programs for appliances, South Africa currently lacks the institutional capacity, expertise and funds to support such a programme (Bredenkamp *et al.,* 2006).

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Building regulations

Although both the *White Paper on Energy Policy* and *White Paper on Renewable Energy* mention energy efficient housing design, very few measures have been implemented due to lack of funds (DEAT, 2005). Amendments to technical standard SANS 204 (to facilitate minimal lifetime costs and adequate thermal comfort) are due to be released for public comment early in 2008. It is expected that the standard will be finalized by the end of 2008. It is intended that the standard will be incorporated into the National Building Act, becoming a mandatory provision.

In collaboration with the Department of Public Works and Eskom, the DME is retrofitting government buildings to make them more energy efficient. This contributes a saving of about ZAR 600 000 (USD 73 500) in electricity bills per year (DME, 2008b).

Eskom demand side management policies

DSM initiatives undertaken by Eskom (South Africa's National Electricity Supply Body Eskom responsible for 95% of electricity supply) have focussed on load management, industrial equipment and efficient lighting. Launched in 1999, a local Efficient Lighting Initiative (ELI) called *Bonesa* was one of the first DSM activities in South Africa, jointly funded by Eskom and the Global Environment Facility (GEF) over a 3 year period.[29]

The overall objective of the ELI project in South Africa was to significantly accelerate the penetration of energy efficient lighting technologies by reducing market barriers. Specific programmes in the residential sector included:

- Subsidy Program – partnerships were established with ELI-approved manufacturers of CFLs to subsidise the initial high capital cost of the technology. The incentive to use the ELI logo and qualify for the subsidy encouraged manufacturer participation that led to the sale of over 1.5 million CFLs during the campaign.
- RDP Housing and New Electrification – This project was aimed at introducing CFLs to the low-income market. Linked to a reconstruction and Development Program (RDP), more than 38 500 CFLs and luminaries were distributed for installation in low cost housing projects.
- Electricity Basic Support Services Tariff (EBSST) – The aim of this rebate was to assist in poverty relief. Low income households (combined monthly income of less than ZAR 800) were provided with two free CFLs plus 40 kWh of free electricity. The local community was extensively involved in the project from luminaire assembly to distribution and awareness creation. Skills in training and development were offered to these community members.

Other activities under ELI included education in schools about energy efficiency, lighting and energy efficiency auditing in public buildings, and the installation of energy efficient street lighting, among others.

Since ELI, CFLs continue to be promoted via customer education, advertising and marketing. Eskom DSM reported that CFLs represented 32% or 64 MW of the total MW savings for 2004

29. ELI programmes have also been undertaken in Argentina, Hungary, Latvia, Peru, the Czech Republic and the Philippines.

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and that the price of CFLs dropped from between ZAR 60-80 in 1996 to ZAR 13-20 in 2004 due to joint sales promotions with local suppliers and increased volumes of CFLs (DEAT, 2005).

In 2005, over 3 million CFLs were given away to low-income residential communities to help manage peak demand and to communicate and demonstrate the benefits of energy efficient lamps and encourage their use. In 2006, over 5 million CFLs were exchanged for incandescent lamps, free of charge to the consumer via door-to-door and exchange point campaigns. Eskom's 2007/08 CFL roll-out is focussing on the western region, where 800 000 CFLs will be installed over a 6 week period (ELI, 2008a).

Eskom is now implementing DSM through collaboration with DME and the National Energy Regulator (NER). The DSM Initiative, which officially commenced in 2003, is informed by the following three policy documents:

- DME's White Paper on Energy Policy;
- DME's Energy Efficient Strategy;
- NER's Energy Efficiency and Demand Side Management Policy (DEAT, 2005).

Eskom's overall target or objective is to save 4 255 MW over a period of 20 years. This target is divided into energy efficiency and load management. The programme also aims to promote the creation of a sustainable energy efficiency market environment in which independent Energy Service Companies (ESCOs) implement DSM. DSM portfolios in the residential sector include the Efficient Lighting Initiative, residential hot water load control, insulation of houses and the time-of-use tariff (ESKOM, 2005).

Evaluation and enforcement activity

South Africa's *Energy Efficiency Strategy* provides information about the monetary and energy savings potential from full implementation of the strategy. If South Africa does indeed reach its energy savings target of 12% by 2015, projected savings are 101 PJ and ZAR 27.3 million (USD 3.4 million). Bredenkamp estimates initial savings of 2 million tones of CO_2 over 10 years due to standards and labelling (Bredenkamp *et al.*, 2006).

Although South Africa's appliance labelling scheme is currently voluntary and subject to little enforcement, it is envisaged that SABS will be the body responsible for monitoring compliance of products with test reports and that this authority will be supported by a system of local/regional inspectors that monitor the energy efficiency label at factories, distributors and retailers sites (Bredenkamp *et al.*, 2006).

International engagement

CABEERE Project

Between 2001 and 2005, South Africa and Denmark worked together on a joint project called the Capacity Building in Energy Efficiency and Renewable Energy project (CaBEERE). This project provided resources to the South African Department of Minerals and Energy (DME) and

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relevant stakeholders to formulate and facilitate the implementation of strategies and legislation promoting energy efficiency and renewable energy. The Energy Efficiency Appliance Labelling Study (2002) and the Energy Efficient Strategy (2005) are two initiatives derived from the efforts of this joint project. The project initiated and facilitated many more public energy efficiency initiatives including: energy savings projection studies; energy efficiency baseline studies; a brochure of household energy saving tips; an energy management programme in national government buildings; study tours to Denmark, and; many other projects relating to renewable energy (DME, 2008c).

Efficient Lighting Initiative (ELI)

Funded by the GEF and Eskom, and implemented by the International Finance Corporation (IFC), South Africa took part in the Efficient Lighting Initiative Program between 2000 and 2003. The aim of the project was to accelerate the penetration of high efficient lighting products. The ELI also took place in 6 other emerging markets including the Philippines, Peru, Argentina, the Czech Republic, Hungary, and Latvia) (ELI, 2008b).

International Conference of Domestic Use of Energy

South Africa is home to the International Conferences on Domestic Energy Use. This forum is for professionals and practitioners in the field of domestic energy to discuss developments in the effective use of energy in the domestic sector. The conference focusses on promoting sustainable development particularly in Southern African countries through the more effective use of energy. The event is widely recognised as the excess capacity of electricity in South Africa is rapidly being consumed. The event in 2007 focussed on National energy strategies and energy for the rural sector, with more emphasis on end-users.

South Africa also participates in the following energy efficiency and environment international forums:

- The United Nations Commission on Sustainable Development (UNCSD);
- The United Nations Framework Convention on Climate Change (UNFCCC).

Conclusions

Increased potential

There is every indication, from studies undertaken by countries or regions included in this review that further cost-effective savings are feasible, even in products that have been targeted previously. Engineering and market examinations of the potential for additional improvements continue to demonstrate that technological advances and increases in fuel prices shift the goalposts, providing opportunities for programmes to lift the average efficiency of products sold.

Furthermore, as most regions are experiencing a growth in appliance penetration and access to a wider range of appliance types, the potential for increased energy savings appears to be expanding. This is acknowledged by most governments and over the past five years a greater

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priority has been given to the role of energy efficiency within national and regional energy strategies. This has resulted in an increased focus on the potential for maximising energy savings from the residential appliance sector. Existing programmes in this sector have benefitted from this attention, although as would be expected, many of the resources and structural changes have taken a while to eventuate.

The design and implementation of appliance energy efficiency programmes is a complex process, which involves many stakeholders; technological, market and capacity issues; and a considerable amount of administration. Therefore it is not a trivial matter to realise the energy efficiency potential from appliances, and requires continuous attention to many of the key factors that contribute to making the programme successful. All programmes in this review have made improvements in many of these areas, but all need to continue their efforts if the large opportunities available are to become reality. The following conclusions and recommendations should be seen in this context.

Scope and effectiveness

As shown in Table 56, all countries and regions under review run programmes to promote increased efficiency in electrical appliances, with widescale coverage of the major traditional residential appliances such as refrigerators, clothes washers, air conditioners, fluorescent lamps and ballasts. Most economies use a range of programme types, including minimum performance standards and both comparison and endorsement labels, with regulatory measures heavily focussed on the traditional appliance types.

Table 56 • Summary of major electrical appliance energy efficiency programmes by appliance category, 2008

Appliance category	AUS	CAN	EU	JAP	KOR	US	BRA	CHN	IND	MEX	SA
Refrigerators and freezers	■ ● ◆	■ ● ◆	■ ●	■ ● ◆	■ ●	■ ● ◆	■ ●	■ ●	○	■ ● ◆	○
Clothes washers	● ◆	■ ● ◆	●	◇	■ ●	■ ● ◆	●	■ ● ◆		■ ● ◆	
Clothes dryers	● ◆	■ ●	●	◇		■					
Dishwashers	● ◆	■ ● ◆	●		■ ●	● ◆					
Air conditioners	■ ● ◆	■ ● ◆	●	■ ● ◆ ◇	■ ●	■ ● ◆	■ ●	■ ●	○	■ ● ◆	

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Table 56 • Summary of major electrical appliance energy efficiency programmes by appliance category, 2008 (continued)

Appliance category	AUS	CAN	EU	JAP	KOR	US	BRA	CHN	IND	MEX	SA
Fans		◆			■ ●	■ ◆	●				
Space heaters	◆	■ ◆		◆ ◇		■ ● ◆					
Heat pumps		■ ◆				■ ● ◆					
Water heaters	■ ◆	■ ●		◇		● ● ◆	●	■ ◆			
Ovens/cookers		■ ●	●				●	■			
Microwaves				■ ◆			●	◆			
Lighting fixtures		◆		■		◆					
Fluorescent lamps	■	■	●		■ ●	■ ◆	●	■ ◆	○		
Lamps ballasts	■	■	■		■ ●	■ ◆	●	■ ◆			
CFLs		◆			■ ●	◆	■ ◆	■ ● ◆		■ ◆	
External power supplies					◆	■ ◆		■			
CE	◆	◆	◆ ◇	■ ◆ ◇	◆	◆	● ◆	■ ◆			
ICT	◆	◆	◆ ◇	■ ◆ ◇	◆	◆	●	■ ◆			
Rice cookers				■ ◆	■ ●			■ ◆			
Water pumps										■ ●	

The Japanese Top Runner Programme is here categorised as a MEPS programme.

Key: ■ = MEPS; ● = Mandatory Comparison label; ○ = Voluntary Comparison label; ◆ = Endorsement label, ◇ = Voluntary agreement.

Table 56 shows the presence of programmes for twenty end-use and appliance categories, but this simplifies the large range of appliance types that exist in the residential sector. A more accurate assessment would show at least 60 appliance types which could be covered by policy measures, and would reveal many more gaps than appear in Table 56. A good example is in the lighting area where only a few of the relevant lamp types are covered and

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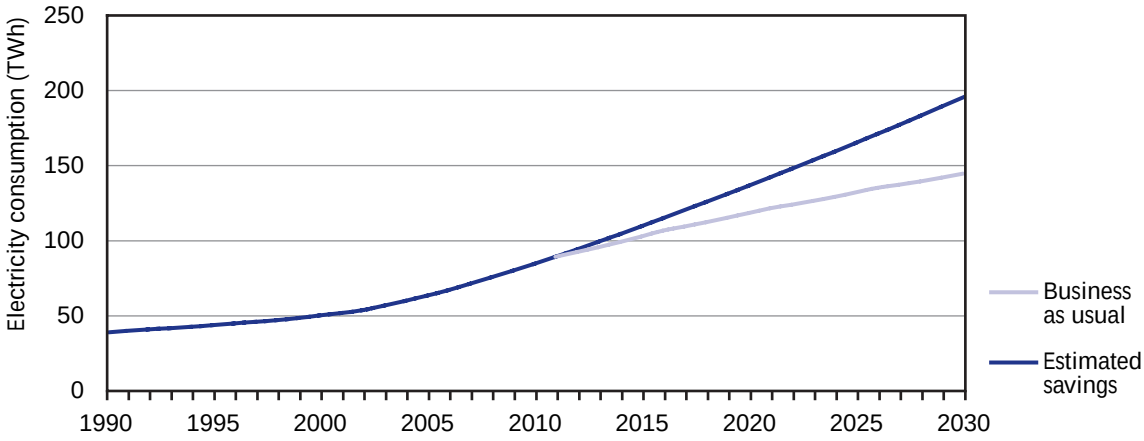
policies for luminaires are scarce. In the ICT and CE fields, several of the programmes in this table cover only a small number of the many individual technologies that fall within these categories.

Just as significantly Table 56 says little about the effectiveness of programmes, which is a function of the stringency of requirements and how well they are implemented and maintained.

To illustrate the importance of these factors in achieving energy savings, Figure 80 shows a typical estimate of the savings from an energy efficiency policy measure made prior to implementation. This particular example is for a single appliance type (televisions) in one major region (OECD North America).

Figure 80 • Example of estimated savings from policy measure



The key factors that can reduce the actual savings achieved by this measure include:

- Delayed implementation: for example due to capacity constraints or protracted negotiations with stakeholders;
- Poor compliance: caused by a lack of adequate procedures, resources and enforcement activities;
- Stringency not maintained: caused by not updating programme requirements to keep pace with technological advancements.

The impacts of these factors will vary according to the product, market developments and the rate of technological advancement. The case modelled below shows that over 40% of the expected savings are lost due to a combination of a two year delay, modest non-compliance and slippage in the stringency of requirements (see Figure 81 and Figure 82). This not only represents a considerable missed opportunity for energy savings, but also nearly halves the cost-effectiveness of the policy measure and may have further consequences in terms of the programme credibility.

Poor implementation is unlikely to affect only one product category within an energy efficiency programme. The cumulative savings foregone as a result of implementation issues are therefore significant when multiplied over the many products within a national programme.

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Figure 81 • Estimated impact of implementation failures on energy efficiency programme savings

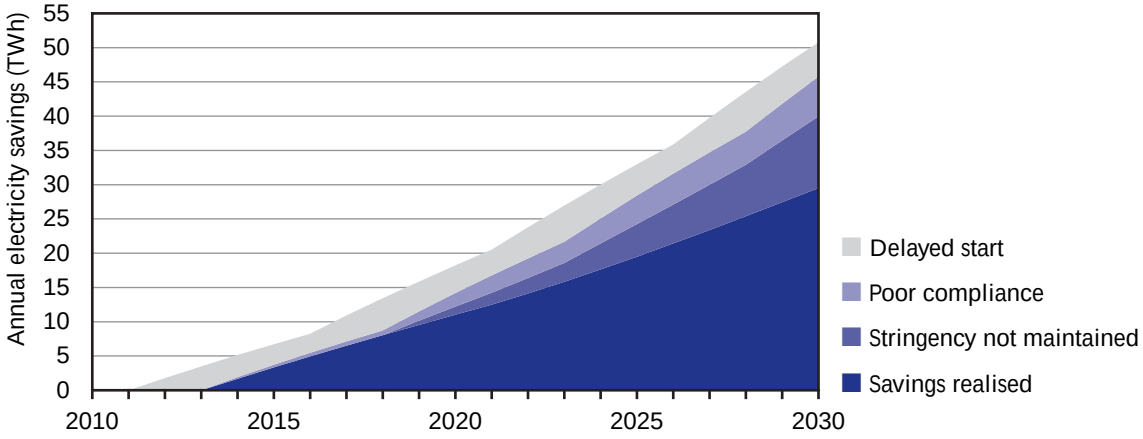
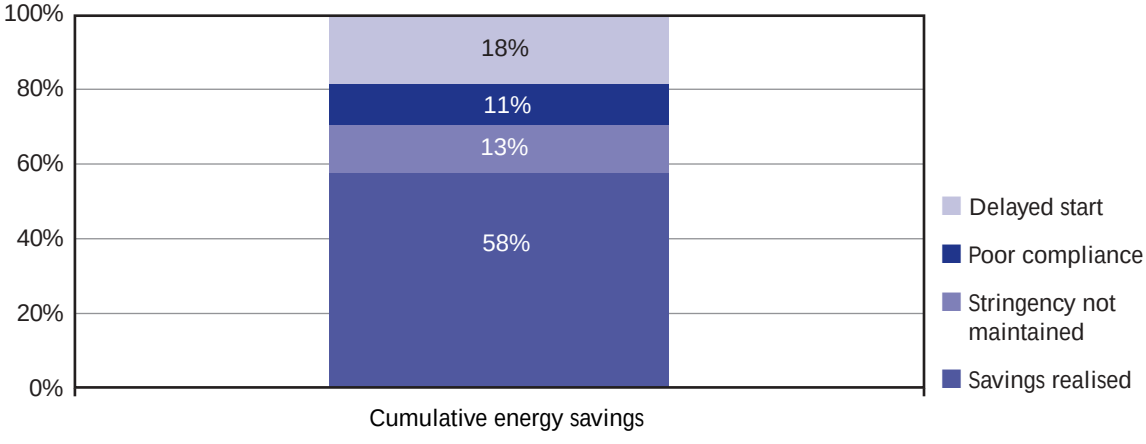


Figure 82 • Estimated impact of implementation failures on cumulative energy efficiency programme savings



This explains why it is increasingly important to examine issues beyond just the presence of policy measures. Evidence of efficient consultation processes, compliance and enforcement regimes, regular reviews of stringency and other programmatic details are all good indicators of whether energy efficiency programmes are likely to meet their policy objectives.

Development trends and constraints

Highly dynamic by nature, most appliance energy efficiency programmes are at different stages of development and each face unique challenges. While some can be categorised as still in the initial development phase, others are clearly mature programmes seeking to expand and refine.

As the Korean example has demonstrated, many of the more recent programmes have been able to grow extremely rapidly through learning from overseas programmes and adapting measures

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to suit their national circumstances. Although the Chinese programme has been in existence for longer, it has also used international partnerships and experts extensively to assist in developing a major S&L programme. India also appears to be following this same path and is likely to expand over the next few years. Another beneficial characteristic of these programmes is that they tend to have fairly broad policy remits which allow them to expand without recourse to further legislation, and provide the necessary powers to develop mandatory or voluntary measures, as appropriate.

The longer-running programmes have faced a number of constraints during the 2000s which have tended to inhibit their continued expansion and development. Some have experienced a withdrawal of political support and resource constraints, while others have found that their initial mandate required amendment to allow the work programme to be extended. Others have simply discovered that the process of updating pre-existing measures to keep pace with technological advances, consumes all their current resources. As a result, a number of these programmes have been through periods where development has slowed considerably during the 2000s.

Australia and the United States have both repeatedly failed to meet published deadlines for the introduction of new or updated MEPS levels. While many factors contribute, both programmes have been enmeshed in complicated processes of consultation and cost-benefit analysis which have blocked progress. Similarly, slow and cumbersome procedures within Europe's S&L programme, together with a lack of adequate legislation and resources have caused the programme to stagnate during the first half of the 2000s.

Some of these constraints have now been overcome, although further improvements would increase their capacity to make significant additional energy savings. The United States programme, for example, has received a strengthened mandate and introduced more streamlined processes for the managing new and revised regulations, while still maintaining reasonable checks and balances. Europe has passed a range of new policy measures, and increased resources, which has already resulted in a large expansion of activity in the residential electrical appliance sector. This expansion is helped considerably by the support shown for mandatory programmes by several major European industry bodies over recent years.

In general, residential energy efficiency S&L programmes form a very small part of the overall energy efficiency budget within most major economies, yet they have continued to deliver significant quantities of energy and greenhouse gas savings at a lower cost compared to many other types of government programmes.

At the same time, the lack of adequate resources continues to be an issue and many programmes are squeezed between their national policy aspirations and a shortage of staff able to manage complex and multi-facetted appliance programmes. While budgets and staff allocations have increased in many countries, this has generally not kept pace with the demands of programmes which have grown in scope and complexity. To remain effective, existing policy measures require an on-going commitment to maintain, update and enforce, in additional to any further resources required to expand coverage to new product categories. In many cases, the development of policies for new categories of products often demand higher levels of resources, as they may be technically more difficult, less understood and require new product testing capacity.

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If government aspirations for energy efficiency in the residential sector are to be met, governments will need to more closely match their allocation of resources to the opportunities for cost-effective energy savings.

Even if appropriate resources were available, it is clear that the impact of programmes cannot be ramped-up overnight. Where policy measures from other countries are suitable, these can be copied to speed up implementation, however preparatory processes such as community consultation, market and impact assessments will usually need to be undertaken prior to implementation. In the case of regulatory measures, additional lead times of 3-5 years are typical to enable industry to adjust.

Where new test methods and performance specifications need to be developed, the process is further extended; and as programmes try to expand their product coverage it is increasingly the case that there are not pre-existing models which can be adopted.

Product coverage

While most countries target policy measures towards those appliances which consume the most electricity, the quality of national assessments of consumption by end-use is variable and often insufficiently accurate for policy prioritisation. Bottom-up estimation methods have proved the most reliable means to track end-use in sufficient detail, and they are increasingly used to estimate current and future energy consumption profiles. Although it is recognised some investment is required, data collected for these assessments is also useful for the accurate *ex ante* and *ex post* evaluation of policy measures.

In terms of product coverage, most programmes now include traditional major appliances such refrigerators, freezers, clothes washers, air conditioners and some types of lamps; some of which include 20 or more products. However, as noted in IEA *Experience with Energy Efficiency Regulations for Electrical Equipment*, coverage should really be compared to approximately 60 types of residential electrical appliances which are in common use (IEA, 2007). Further comments made in this report include:

"In addition to the expansion of these mandatory programmes which is already planned there is still room for extending coverage, in particular within the areas of lighting, home entertainment and ICT equipment.

In residential lighting...further attention needs to be given to measures for luminaires, CFLs and in some markets, to Tungsten halogen lighting and transformers.

There is considerable potential to introduce new mandatory measures in the home entertainment and ICT field, focussing on electronic products with substantial electricity consumption, and covering all modes of operation. Despite the growing electricity consumption from small electronic products entering households, no existing regulations cover the standby power consumption of the full range of these products.

For water heating there are some opportunities to improve efficiency by introducing MEPS for electric water heaters where countries have not yet done so. However the most significant energy and greenhouse gas savings will result in shifts towards solar water heating and other

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more efficient technologies. Similar options exist to meet lighting, space heating and cooling, and some cooking demand through a co-ordinated mix of demand reduction policies and switching to alternative technologies."

Voluntary endorsement labels have proved extremely effective in extending product coverage, having the advantage over regulatory approaches that they often have shorter lead-in times. The most well-known and widely used label, Energy Star, began by establishing performance thresholds for appliances in standby mode, but has progressed to establish label criteria which cover all modes of operation for many types of equipment. In addition, it has developed new test methodologies for the measurement of efficiency for many appliances, which have subsequently formed the basis for protocols used by other programmes. Similarly, the European Code of Conduct has worked with industry to identify specifications for several types of appliances which have benefitted programmes elsewhere.

The success of Energy Star in the United States has demonstrated that an endorsement label can be a highly effective means of promoting the most efficient products in the market when it has achieved a high public profile and is leveraged by other types of programmes such as procurement policies and financial incentives. Most other countries which have adopted Energy Star, or other endorsement labels, have not yet had the sustained investment needed to establish a credible and well-recognised brand, or to build the linkages with other programmes; however developments in Europe, China and New Zealand suggest that these initiatives are underway.

The role of national voluntary agreements appears to have diminished over recent years, although they are still used in Japan. One key factor for the demise of voluntary agreements in Europe and elsewhere has been the growth in international trade which has opened up markets to a larger proportion of imports. With a smaller market share, local producers face increasing competition from companies outside such agreements.

It is not often that we see a major new type of policy tool, however the planned use of a 'warning label' in Korea represents a new approach. Rather than promoting the best performing products, the warning label is intended to be used on products which fail to meet the target established by government. Although in this instance, it will be applied on products with high standby energy consumption, it may have wider applications.

Standby power

Since the launch of the IEA's aspirational 1-Watt target in 1999, the number of countries that have policies addressing standby power has been growing steadily. Almost all recent national policy statements mention standby power explicitly and standby power is addressed by various policy tools. The IEA 1-Watt target was endorsed by the G8 leaders in the 2005 Gleneagles Plan of Action (GPOA 2005). Further detail was added in the IEA recommendation to the 2006 G8 Summit which called for the adoption of a 1-Watt mandatory horizontal standard for all products covered by the IEC definition (IEA, 2006). Follow-up processes to the Asia Pacific Partnership, APEC and the Commission on Sustainable Development Marrakech accord have all called on Governments to make a greater commitment to the IEA 1-Watt standby target and other programmes to tackle standby power.

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Many countries have started to address the standby energy question through a number of considered and carefully constructed policy approaches. Japan, which effectively regulates standby power through the Top Runner programme and a series of voluntary agreements with industry, is the only country which has measured a reduction in overall standby power. Like Japan, most approaches to date, specify standby power requirements for individual products, raising questions about their ability to cope with the increasing number of products with standby, the increasing number of relevant modes and the blurring of product definitions.[30]

However, under the Ecodesign Directive, the European Commission has proposed limiting standby power consumption of most electrical and electronic household and office equipment to 1 watt from 2010. Similarly, Australia has announced a uniform 1 watt requirement for all electronic appliances and equipment by 2012.

Monitoring compliance and enforcement

Increasing compliance through verification and enforcement activities is important to maintain the credibility of all types of programmes and one area where all countries can make improvements that will result in a substantial increase in energy savings. An IEA workshop on the issue held in 2008 noted:

"The workshop heard many instances of where energy efficiency measures were failing to deliver between 25% and 50% of anticipated savings targets due to poor implementation, including poor compliance and enforcement.

Regarding the consequences of poor compliance, too often low rates of compliance with policy measures lead to a gap between the intended goals of a policy and its actual outcomes. Industry representatives also noted other serious consequences resulting from perceptions that compliance with both mandatory and voluntary policy measures are not being upheld. They noted that wholehearted participation by industry is threatened when investments in energy efficiency are not safeguarded by effective compliance regimes.

The risk of not addressing these issues is that governments fail to meet targets for energy or greenhouse savings, or improvements to energy security. Yet examples also exist to indicate that it is possible to ensure effective and cost-efficient compliance, monitoring and evaluation procedures.

Based on several case studies provided at the workshop, the costs of improving compliance and evaluation appear modest while the additional savings potential is considerable – suggesting that investment in compliance and enforcement regimes are likely to be one of the most cost-effective means to increase energy and greenhouse gas savings. Increasing the effectiveness of existing policies may also delay the need for the introduction of new policies and the outlay of additional resources for the implementation of new policies.

Participants noted that increasing the transparency of compliance activities would be a positive first step by governments and industry. The workshop heard of many instances where the results

30. These issues are described in more detail in later chapters.

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of market surveillance or enforcement actions were not made available to consumers or other industry stakeholders – despite evidence that public notification is highly effective in increasing rates of compliance." (IEA, 2008)

While this review found many shortcomings, it is also clear that governments are beginning to take compliance activities more seriously. Australia stands out as having one of the most effective compliance regimes, being comparatively well-funded, transparent and committed to publicising its activities and results. High profile and successful enforcement actions have also contributed, as evidenced by recent examples where companies have volunteered information on their own non-compliance rather than risk penalties. The actions by the European Commission in issuing infringement notices to member states, and greater attention to compliance verification in China and India also demonstrates that all governments are aware that this area needs greater attention in order to maximise impacts.

Evaluation

While most energy efficiency programmes produce pre-implementation energy saving projections, and in the case of regulations, these usually take the form of cost-benefit analysis, *ex post* evaluations are rarer and usually less exhaustive. In the United States, where evaluation is more widely undertaken than many other regions, 3% to 5% of energy efficiency programme costs are typically allocated for evaluation. This has led to the development of substantial capacity and expertise. By contrast, in many other regions, evaluation activities are carried out in a rather ad hoc manner, using a variety of methodologies and often no attempt is made to compare with a business-as-usual scenario.

With the growing emphasis placed on energy efficiency programmes as a means of delivering greenhouse gas mitigation, energy security and other policy outcomes, there is a need for governments to have access to high quality data on the performance of these programmes. The provision of this information will be important to ensure the continued and growing allocation of resources to this area.

International links

On a more positive note, there has been an increase in the degree and quality of international liaison, through a range of mechanisms. There are now a number of bilateral and multilateral arrangements which cover information sharing, mutual recognition of testing facilities, and the sharing of personal and policy harmonisation. In addition, fora such as the Asia-Pacific Partnership and the recently formed IEA Implementing Agreement on Efficient End-use Electrical Equipment (4E), provide platforms to increase the dialogue between countries, share information and promote co-operation on policy development specifically for electrical appliances.

One tangible result is that there has been increased harmonisation between energy efficiency programmes, as programmes co-operate on the development of new criteria or existing specifications and test methods are adopted by more countries. Nevertheless, an area which has not yet been fully explored is the potential to improve compliance of internationally traded goods through the sharing of verification information.

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Policy recommendations

In summary, all national appliance energy efficiency programmes continue to progress, developing in scope, ambition and expertise. Several of the more mature programmes have needed to make adjustments to their mandate or framework and are now emerging considerably strengthened. Newer programmes show every sign of learning valuable lessons from these, and with support from their governments, should progress rapidly.

The following recommendations for policies directed at residential appliance energy efficiency follow from this review:

- Policy frameworks, supporting legislation and organisation structures should provide a broad and flexible mandate to enable the implementation of a range of measures, and their maintenance, without recourse to further legislation but subject to specified checks and balances.
- Governments should establish transparent threshold conditions[31] before new policies can be implemented, and undertake such examinations necessary to demonstrate whether these have been met. Care needs to be taken to ensure that important processes, such as cost-benefit analysis and consultation, do not become excessively burdensome.
- Budget and staff allocations need to be set at levels which are commensurate with the policy aspirations of countries. These should take into account the requirements for the maintenance and development of policy instruments, and as well as verification and enforcement activities.
- Governments should ensure that programme performance thresholds are sufficiently ambitious to meet policy aspirations, and undertake regular reviews to keep pace with technological advances and changes in fuel prices.
- All countries need to improve their capacity to undertake appropriate verification and enforcement activities in respect of programme requirements (voluntary and mandatory). In this regard, the recommendations made by the IEA to the 2008 G8 Summit should be noted:

  Governments should ensure that both voluntary and mandatory energy efficiency policies are adequately monitored, enforced and evaluated so as to ensure maximum compliance. At a minimum, this should include:

  - *Considering and planning for optimal compliance, monitoring and evaluation procedures at the time new policies and measures are formulated;*
  - *Establishing legal and institutional infrastructure for ensuring compliance with energy efficiency requirements;*
  - *Ensuring transparent and fair procedures for assessing compliance; including specification of the methods, frequency and scope of monitoring activities;*

31. Threshold conditions may include, for example, minimum cost-benefit ratios, minimum predicted energy savings, etc.

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- *Ensuring regular and public reporting of monitoring activities, including instances of non-compliance;*
- *Establishing and implementing a suite of enforcement actions commensurate with the scale of non-compliance and the value of lost energy savings; and*
- *Establishing and implementing a robust system for evaluating policy and programme success during and after implementation.*

- More attention needs to be given to tracking end-use energy consumption and identifying areas of high growth. Improved monitoring of end-use consumption is also required to assist in evaluating the impact of policy measures.
- Policy measures need to be developed and implemented for electronic equipment, particularly for home entertainment, and information and communication technologies (see detailed recommendations in later chapters).
- Governments should continue to participate in international collaboration and co-operation in order to share information and development costs, improve the alignment between programmes and improve compliance.

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Chapter 4 • THE CASE OF ELECTRONIC APPLIANCES

Why electronics are important

Many people are now more aware than ever before of the need to improve the efficiency with which they use energy. Mainly this has occurred because of the link to climate change and sustainability issues, although saving money is also a motivator for some. And thanks to the policies adopted by most OECD countries in the past few years, it's easy to select an efficient refrigerator or washing machine because of the labels that rank their energy performance. In fact, for most of these larger household appliances, including water heaters and air conditioners, it is now fairly easy to find the most energy efficient models. More and more people are also aware that it will save energy if they switch conventional light bulbs to compact fluorescent lamps, or add insulation in the roof.

So, just how much more efficient is it possible to be? Haven't we made all major items which use energy in our houses more efficient, and exhausted the opportunities to make further savings? To see if this is true, let's go for a tour through a fairly typical family home, identifying all the things that would still use energy, even if you switched off all of your major appliances.

Firstly, we'll start with the living room. Perhaps you have a new flat screen TV, and you may have another older one in a bedroom or kitchen which doesn't get used quite so much. You probably also have a DVD player or two, and maybe one of these can record, or you may have an old VCR for tapes. Perhaps you even have a set-top box to get pay-tv or to receive a digital signal via satellite or cable? Under the TV you have an amplifier connected to a CD player and surround-sound speakers, and, of course, the kids have a games console there too. So that comes to maybe seven devices just in one corner of your living room, no doubt plugged in all the time.

Looking around there is also a PC and screen at the desk in the corner, beside a small printer. Alongside these sit a portable phone and answer machine, a modem and wireless router, and several mobile phone chargers. In fact, looking beneath the desk it's obvious that all the slots on the power strip plugged into the mains are completely full of small black power supplies, all warm to the touch. There's even one going to the desk lamp. So there are another eight devices to add to the seven around the TV, and we still haven't got out of the living room!

Before we move on, just check whether there is a smoke detector or home security sensor in the room, because they are probably permanently connected to your electricity supply. The same goes for any air conditioners, or any room heaters with timers. Ok, time to go to the kitchen.

Even if you have gas for cooking, you probably have an electronic clock on the oven, and maybe a range hood with an extractor fan. In fact, you may have another clock on the microwave which is running all the time. You might also have a radio or CD player in the kitchen, or even the extra TV, just so you can catch the news in the mornings or while you are cooking the family's dinner.

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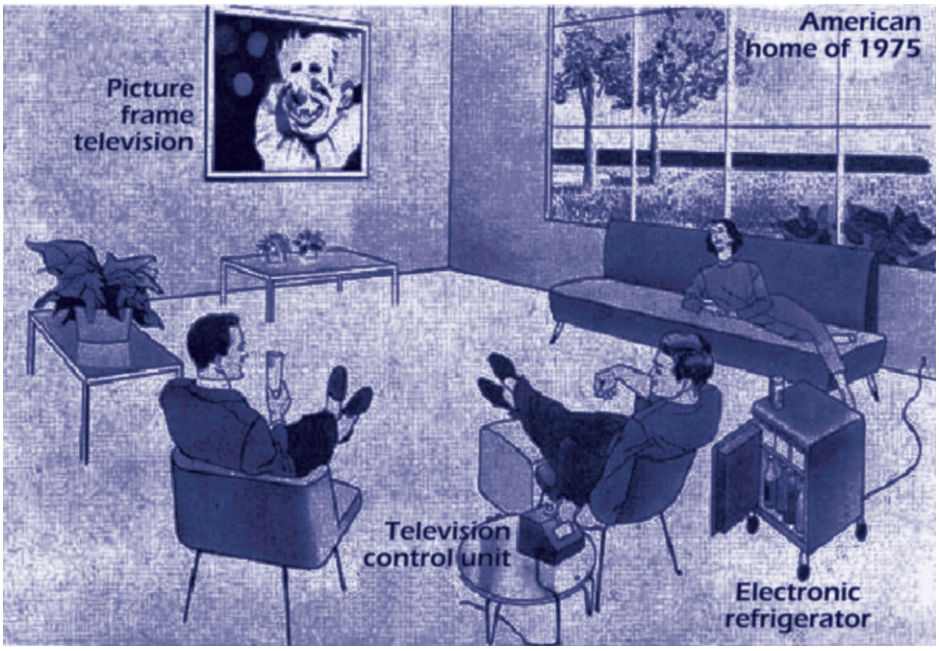
Flat-Screen TV Prediction in 1995



Note: Picture frame TV, electronic refrigeration and remote electronic controls illustrated in this RCA sketch of the American living room of 1975 are just a few of the amazing devices which will provide conveniences for the consumer, and servicing opportunities for qualified technicians. During the coming years, and even effective in many areas today, the rapidly growing use of communications and electronic control equipment in industry will offer many attractions.
Source: Cartoon supplied courtesy of Technician Magazine (www.tvhistory.tv).

> **I think there is a world market for maybe five computers.**
>
> Thomas Watson (1874-1956), Chaiman of YBM, 1943

Moving into the bedrooms, you'll probably find one or two clock radios, a couple of portable CD players, a laptop computer and many, many more power supplies to charge anything from iPods to mobile phones, digital cameras, camcorders and battery chargers. You may even have one of those electronic picture frames to display your digital photos.

In fact, it would not be surprising if you could count between 20 and 30 separate electronic devices spread throughout your house. And so far we haven't included small electrical appliances such as toasters, breadmakers, kettles, juicers, food processors, electric toothbrushes, coffee machines and shavers, all of which consume some small amount of electricity.

And that's the thing about these electronic devices: none of them except perhaps televisions actually use very large amounts of energy individually, but they have become so common in all our households that as a group they now make up a sizeable amount of our energy consumption. In fact, if you compare how much electricity is used by the most common electronic devices with traditional large appliances, you'll find that actually the electronic gadgets use more - not in every house, but in many households in OECD countries (see Figure 83).

Not only is this surprising, but it is the major reason why residential electricity consumption is increasing in most countries, as are greenhouse gas emissions from this sector and household energy bills.

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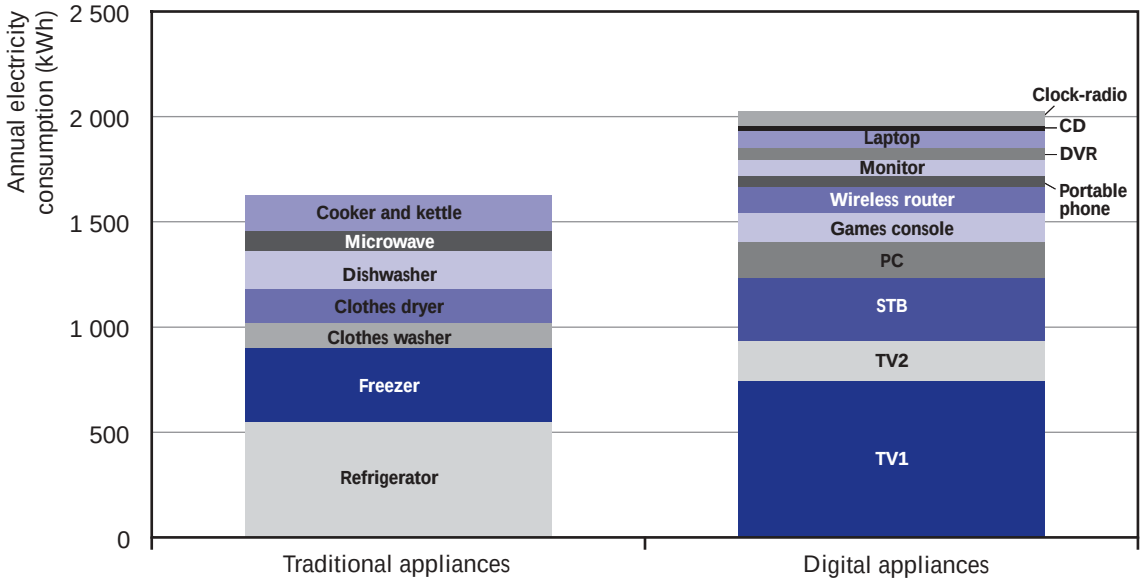
Traditional appliances are using less electricity partly because all those labels telling us which are the most efficient refrigerators, washing machines and air-conditioners have actually worked! Consumers have bought the better performing appliances, encouraging manufacturers to keep improving so that a refrigerator today consumes around one-third of the electricity it did 15 years ago, even though it is larger. And a similar story applies to many traditional appliances, with the result that these consume a smaller share of total household electricity.

Figure 83 • Typical OECD household electricity consumption of major traditional and digital appliances



Note : The information presented above is illustrative, based on annual usage for a typical OECD household. Electricity used for water heating, space conditioning and lighting are not included.

Key:

TV1	*Primary television*	*DVR*	*DVD player with integral hard disk*
TV2	*Secondary television*	*CD*	*Compact disc player*
STB	*Set-top box*	*PC*	*Personal computer*

More recently, along came the digital revolution and all of a sudden, almost without anyone noticing, our houses are full of a mass of electronic gadgets, which enable us to do things we never dreamed of previously. We have wireless broadband to surf the net from anywhere in the house or garden, access to thousands of programmes to play on our widescreen digital television or record on a hard disc, internet telephones to connect throughout the world at a fraction of the cost of a normal call, and digital cameras the size of a credit card. One can even buy a refrigerator with a TV in the door and internet connection.

In fact, the capabilities of digital electronic devices have expanded exponentially, largely driven by the increasing capacity[1] of integrated circuits ('chips') which has doubled approximately every two years[2] (see Figure 84), while costs have plummeted.

1. The number of transistors that can be placed on an integrated circuit.
2. Known as Moore's Law.

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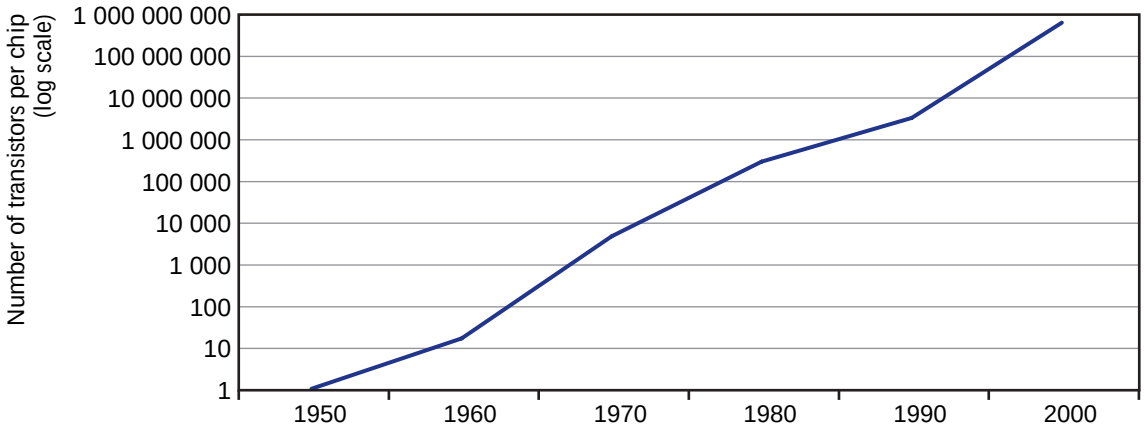
And these developments are not only benefitting people in wealthier nations. In Africa, one in nine people now have a mobile phone using a network which is extending across the continent in a way which fixed telecom lines could never match.

Figure 84 • Growth in transistors per chip, 1950s-2000s (Moore, 1965)



So householders almost everywhere have access to an expanding choice of electronic products and a wider range of services.

But as we have seen, the amount of electricity consumed by these products is now considerable, and there is every indication that the next wave of technology developments will demand even more power. This poses a serious challenge to attempts by governments and individuals aiming to reduce the impacts of energy consumption on the environment. But does it need to be so?

How can we repeat the kinds of initiatives in this emerging sector that worked so well for refrigerators, freezers and clothes washers so that we can benefit from this new technology without increasing electricity consumption and greenhouse gas emissions? How much electricity could we really save and what would it cost? How can government policies be designed and implemented so that innovation is not stiffled?

These are just some of the important questions which the following chapters will attempt to answer.

An overview of energy efficient electronic appliances

The case of electronic appliances provides an excellent example of the challenges and opportunities which face policy-makers intent on maximising energy efficiency resources. Information and communication technology (ICT) and consumer electronics (CE) form an important part of our life today, not only in the commercial world but also in our homes. Although evidence of the growing significance of electronic equipment surrounds us, there have been few global assessments of the resulting energy impacts, now and into the future. ICT and CE equipment is currently responsible for close to 15% of total residential electricity consumption, which is similar to the share for other major appliance categories such as water heating or refrigeration (OECD/IEA, 2003). However, unlike many appliance categories,

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electricity consumption by ICT and CE equipment has grown by over 7% per annum since 1990. In addition, even with foreseen improvements in energy efficiency, consumption by electronics in the residential sector is set to increase by 250% by 2030. The share of electricity consumption by these appliances is therefore increasing to the extent that they will most likely comprise the largest end-use category in many countries before 2020, unless effective steps are taken.

These estimates suggest that total residential electricity consumption will increase more than many previous forecasts, and therefore pose a serious challenge to all governments with policy ambitions to increase energy security and economic development, and to mitigate climate change. They also suggest that policies aimed at stabilising or reducing energy consumption will need to be more stringent than previously thought, both in this sector and in others.

From an energy efficiency policy perspective, ICT and CE equipment have some unique features which are challenging. Apart from televisions and computers, the sector comprises many different appliances, none of which represents a significant capital cost nor individually consumes very much energy. Products have shorter design and production cycles than many traditional appliances, but also tend not to have such long lifetimes.

However, improving the efficiency of residential ICT and CE equipment would lead to benefits beyond the residential sector, since many of the technologies used in businesses are similar. Additionally, there is a large potential to use electronics to better control energy consumption in all types of equipment.

For these reasons, the case of electronic appliances provides an excellent example of the challenges and opportunities which face policy-makers intent on maximising energy efficiency resources. The following chapters look in some depth at the major energy-using technologies in this field, their costs, efficiency and market trends, thereby illustrating the degree of specificity which is needed in designing effective end-use efficiency policy.

Global trends in residential ICT and CE electricity consumption

ICT and CE equipment span a wide range of appliances found in varying quantities in residences. In addition to televisions, desktop computers and laptops, these include DVD players and recorders, modems, printers, set-top boxes, portable telephones, answering machines, games consoles, audio equipment, clocks, battery chargers, mobile phones and children's games. In fact there are at least 40 different appliances which can be included within this sector.

Together they consume nearly 700 TWh of electricity each year, requiring over 180 GW of generating capacity and costing consumers USD 80 billion in annual electricity bills. Driven by increasing penetration rates, particularly in non-OECD countries, and the adoption of larger TVs and digital broadcasting, final residential electricity consumption by ICT and CE equipment grew by nearly 7% per annum between 1990 and 2008. This sector now accounts for nearly 15% of residential electricity use, and can make up a much higher share in some households. Although growth is expected to slow to 4.5% per annum in the period up to 2030, electricity consumption is expected to rise to over 1 200 TWh by 2020 and 1 700 TWh by 2030, as shown in Figure 85.

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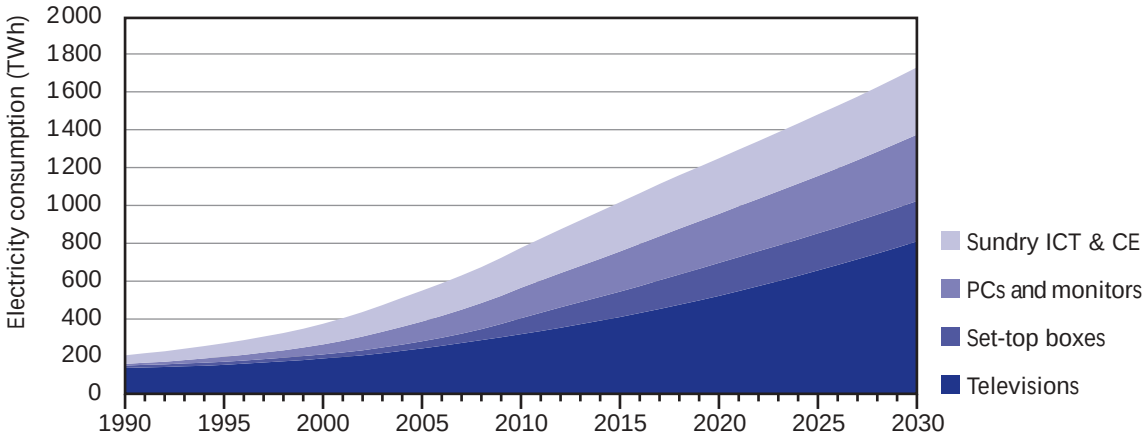
Figure 85 • Estimated global electricity consumption from ICT and CE equipment, 1990-2030



Source: IEA estimates.

There are a number of competing trends that are masked by these aggregated figures, but which are explained in more detail in the following chapters. For example, new television and computer screen technologies in the form of flat LCD panels have replaced less efficient traditional CRT screens extremely rapidly in OECD countries and a similar trend is now occurring in non-OECD countries. However, the energy benefit has been outweighed by consumer demand for larger screen sizes, so that the average energy consumption of display technologies has risen and continues to do so.

Falling consumer prices for electronics have fuelled the rapid uptake of technologies and the availability of broadband and wireless has allowed multiple users within the same household. This has led to an increase in average viewing hours, as householders make greater use of their screens to watch material from the Internet, view stored digital photos or recorded TV programmes and play video games.

Increasingly ICT and CE equipment is connected either to other devices in the home, or via the internet to external devices and service providers. Various modems and set-top boxes are examples of relatively new types of connected appliances which have increasing importance. With the switch to digital broadcasting in many countries by 2015, the increasing penetration of pay-TV, and more people adopting bundled TV and telecom services over the Internet, the energy used by such devices will grow.

On the other hand, there will be efficiency benefits from the convergence of some technologies, such as set-top boxes, DVD players and recorders. In the longer term, computers may play a more central role, replacing many individual audio and home entertainment devices. Computers themselves are getting more energy efficient and the growing use of laptop computers in the residential sector is helping to moderate energy consumption.

While individual technology and market trends are complex, the overall key drivers in this sector can be summarised by Figure 86 and Figure 87, which show the estimated change in stocks and average unit energy consumption (UEC) of all ICT and CE appliances between 1990 and 2030 in the residential sector.

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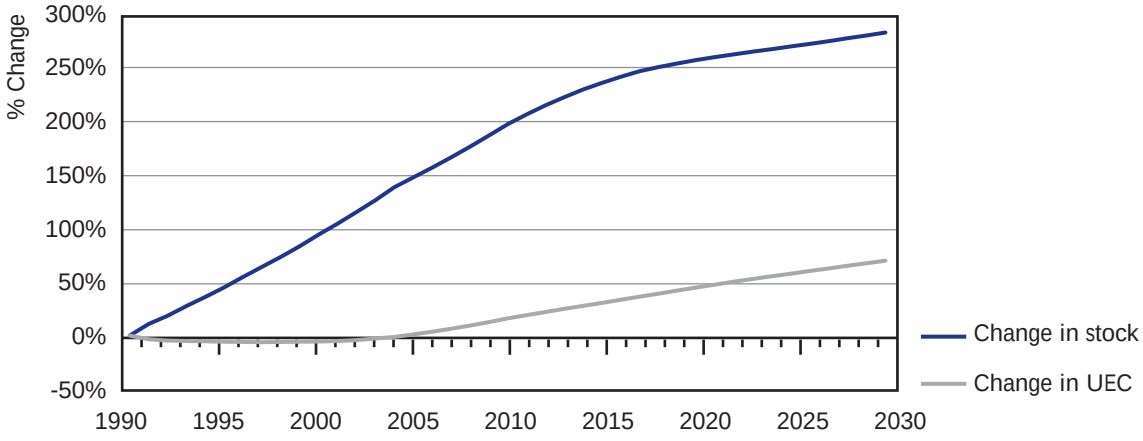
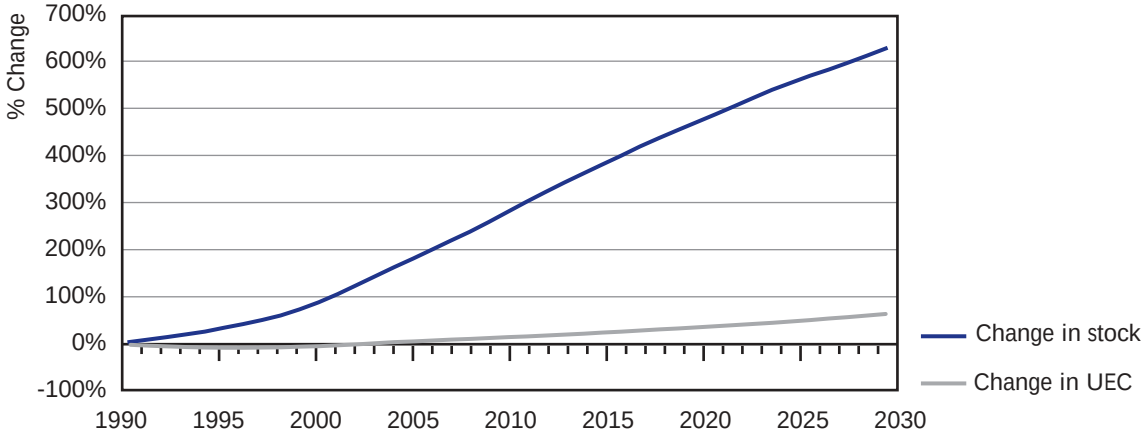
Figure 86 • Estimated change in stocks and average unit energy consumption (UEC) of residential ICT and CE appliances in OECD, 1990-2030



Source: IEA estimates.
The effect of structural changes, mainly the switch to flat screen technologies and laptop computers, is evident in the reduction of UEC values prior to 2005.

Figure 87 • Estimated change in stocks and average unit energy consumption (UEC) of residential ICT and CE appliances in non-OECD countries, 1990-2030



Source: IEA estimates.
The effect of structural changes, mainly the switch to flat screen technologies and laptop computers, is evident in the reduction of UEC values prior to 2005.

These figures show the rapid and growing penetration of electronic appliances in both OECD and non-OECD countries, and the increase in the energy consumption of individual appliances after 2005. While convergence and saturation will see the growth rate of devices in the OECD fall after 2015, this trend is unlikely to be mirrored in non-OECD countries. Although non-OECD countries already account for the majority of sales of most ICT and CE equipment, the potential markets are extremely large and even modest penetration levels, far less than for the OECD, will lead to a large increase in energy consumption, as shown in Figure 88.

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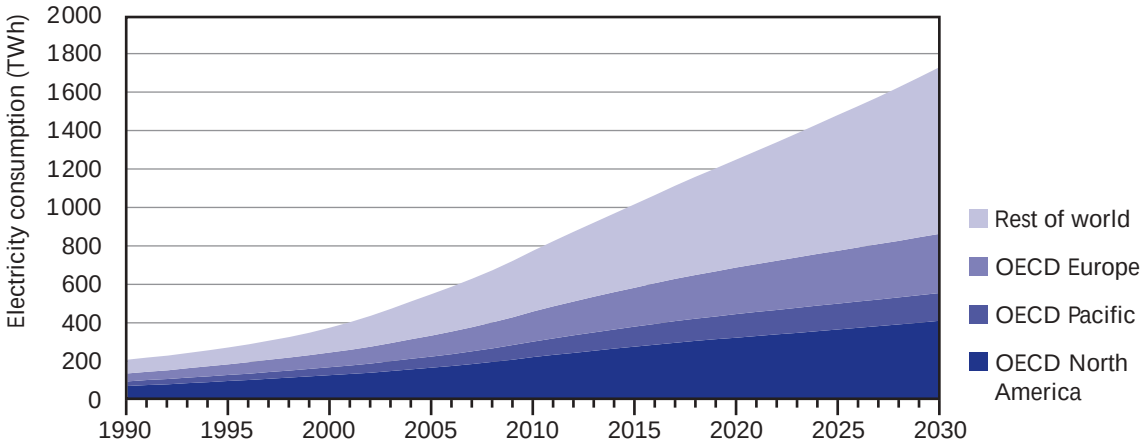
Figure 88 • Estimated global electricity consumption from ICT and CE equipment by region, 1990-2030



Source: IEA estimates.

The potential for improvement

The IEA estimated the impact of various policies on global electricity consumption based on two potential scenarios for energy efficiency measures, a Best Available Technology (BAT) scenario and a Least Life-Cycle Cost (LLCC) scenario.

This analysis found that electricity consumption from residential ICT and CE devices could be cut by more than half through the use of the best technology and processes which are currently available and being used in some markets, slowing growth in consumption to less than 1% per annum to 2030. Some of the savings under the BAT scenario are possible through the use of better equipment and components, but the majority will be achieved through improved power management to ensure that energy is only used when, and to the extent that, it is needed.

These savings are considerable. For example, they represent 7% of the total estimated new electricity requirements between 2005 and 2030, a reduction to consumer energy bills by over USD 130 billion in 2030 and the avoidance of 260 GW in additional power generation capacity – more than the current generation capacity of Japan (OECD/IEA 2007b).

Over 30% of electricity savings could be forthcoming from a combination of measures which results in the lowest total cost to consumers. The Least Life-cycle Cost (LLCC) scenario includes all technologies and processes currently available which provide energy savings at no increase in the combined capital and running costs discounted over the appliance lifetimes. This scenario can therefore be followed without imposing any additional costs on consumers, with the extra benefit of avoiding 140 GW of power generating capacity.

These scenarios also provide very considerable reductions in greenhouse gas emissions, stabilising emissions by switching to the best available technology, and cutting 2030 emissions from this sector by 30% through adoption of LLCC technologies (see Figure 90).

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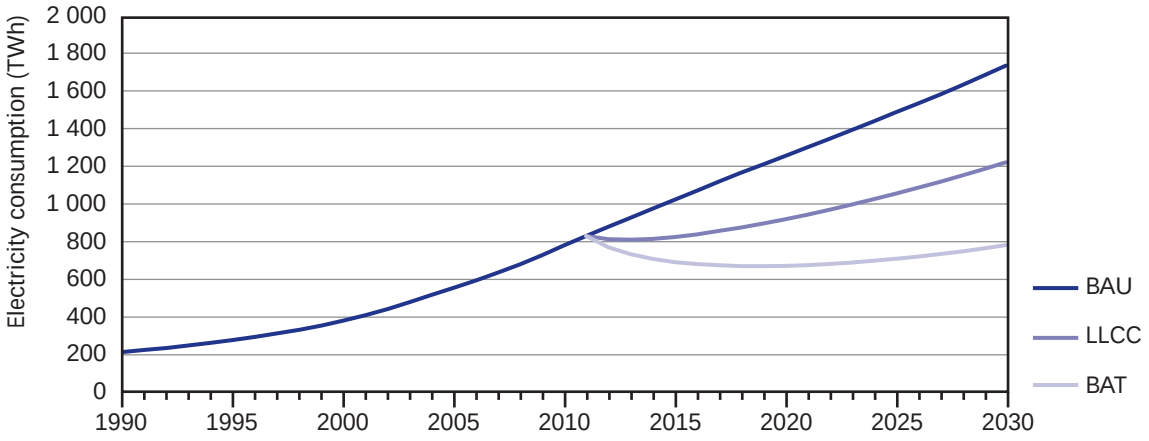
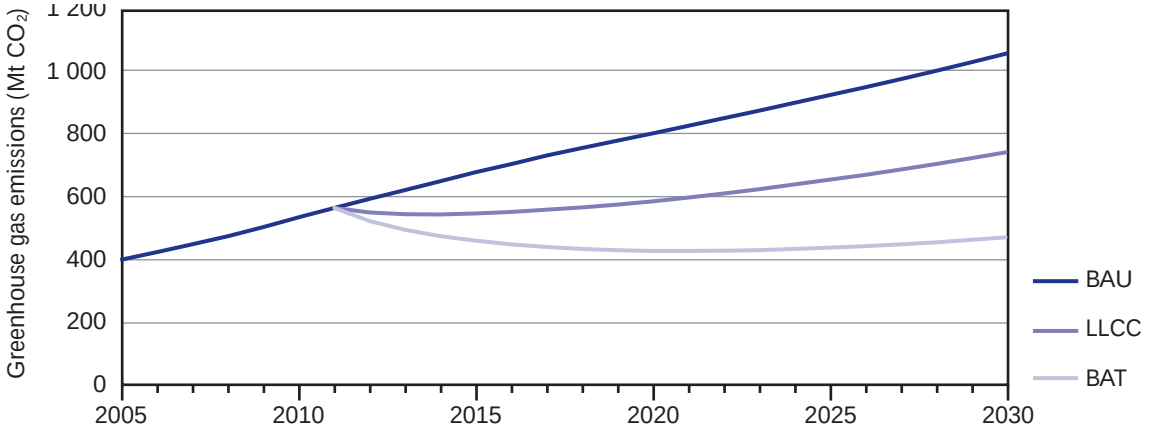
Figure 89 • Estimated impact on global electricity consumption by ITC and CE equipment by energy efficiency policies based on least life-cycle cost (LLCC) and best available technology (BAT), 1990-2030



Source: IEA estimates.
BAU = Business as usual: LLCC = Least life-cycle cost: BAT = Best available technology. The LLCC and BAT scenarios assume policy implementation in 2012.

Figure 90 • Estimated impact on global CO_2 emissions by ITC and CE equipment by energy efficiency policies based on least life-cycle cost (LLCC) and best available technology (BAT), 1990-2030



Source: IEA estimates.
BAU = Business as usual: LLCC = Least life-cycle cost: BAT = Best available technology. The LLCC and BAT scenarios assume policy implementation in 2012.

Since these savings estimates are based on currently available technologies and processes, it is likely that advancements in technology and understanding will open further opportunities before 2030, increasing the potential savings under the BAT and LLCC scenarios. If the current trend of continuing reductions in the capital costs of appliances continues, this will also increase the cost-effectiveness of BAT technologies, bringing them within the LLCC scenario. Similarly

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changes in electricity prices will alter the equation. With more countries exploring options for reflecting greenhouse gas intensity within fuel prices, it is likely that electricity prices will rise in some countries, bringing the LLCC and BAT scenarios closer together.

How to get there

There are some unique characteristics of ICT and CE markets which are key to understanding the trends which are emerging. These include:

- The combination of (relatively) low purchase costs, short lifetimes and consumer trends allow electronic appliances to reach high ownership rates more rapidly than many traditional household appliances.
- Unlike many major appliances where technology saturation levels are fairly predictable and rarely exceed much more than one per household, the ceiling for ownership levels of electronic appliances is not well understood.
- For many electronic appliances, the rate of increase in ownership has intensified in recent years as new appliances come onto the market offering increased functionality.
- Increased features and functionality is a major driver in markets for electronic devices, often causing products to be replaced prior to the technical end of life. Technologies are frequently displaced and used by other household members.
- Electronic appliance models are designed to be used in many different ways by consumers, from those requiring high performance and full features, to others which require more basic functionality. Most electronic goods are shipped with a high level of features enabled, which usually have an energy cost, even though the average user may not make use of these capabilities.

Although the energy performance of electronic devices is improving, achieving the level of savings represented by the LLCC and BAT scenarios will not occur without policy intervention as a result of considerable market barriers and imperfections. Some barriers are specific to particular technologies or market segments, however a number are more general. These include:

- An emphasis on achieving low purchase cost within highly competitive markets, with a low market value placed on lifetime costs;
- Poor consumer information on the performance and running cost of most ITC and CE equipment;
- Energy saving opportunities spread over a large number of different devices, with small financial benefits from improving the energy performance of individual items;
- Long and complex supply chains between component manufacturers, software designers, OEMs and product suppliers, which case market signals to be diffused;
- Hidden costs and risks, including time spent in developing energy efficient products and potential for additional consumer confusion/complaints;
- Failures due to principal agent issues in some market segments.

Where there are clear market drivers for energy efficiency, such as with mobile devices where size, weight and extended battery life are valued features, the industry has demonstrated an ability to be highly innovative in reducing energy consumption. Levels of efficiency are far

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higher in these devices than in equipment which draw power from the mains electricity supply, illustrating that the market does not provide a strong incentive for energy efficiency for the majority of technologies.

The presence of market imperfections justifies government intervention. However the potential to promote other key objectives, including energy security, greenhouse gas abatement and provision of least-cost energy services, suggests that governments need to pay urgent attention to policies for ICT and CE equipment. The following section explains the recommended approaches to policy development in this area.

Key policy approaches

Information and communication technology has played an important role in increasing the overall energy efficiency of most of the world's economies. Concerns about the growth of energy consumed by ICT, and government action to ensure that ICT technologies and systems are as efficient as possible, will not impact on this sector's ability to continue to play this important role. There are numerous examples where use of ICT has resulted in more efficient energy use. Teleworking, automated production techniques, virtualisation in computer servers, and optimising electricity grids are amongst the many cases where ICT has helped to produce economic outputs for less energy input. While the contribution of ICT to overall economic gains is hard to disentangle from other influences, it is estimated that ICT has been responsible for a large proportion of the halving of energy intensity in the United States' economy between 1970 and 2008. In this period, approximately 75% of the increased demand for energy was met by energy efficiency resources, and it is estimated that much of this is due to pervasive use of ICT (Laitner, 2008).

Several other studies have indicated the potential to harness ICT to bring about a further revolution in energy usage patterns (WWW, 2008), and this message has been reinforced at a policy level by statements made by Japan, the European Commission and the OECD (Sumita, 2008; EC, 2008; OECD, 2008).

The focus on the positive effects of ICT is to be welcomed and warrants considerable further investigation. However, as noted in all of the above studies and fora, consideration must also be given to the energy (and environmental resources) consumed in providing ICT services. It is evident that the benefits of ICT will be even larger than those currently estimated by improving the energy efficiency of service provision in the ICT sector itself.

The following section identifies some of the key policies for achieving reductions in the energy used by ICT equipment, together with some significant opportunities where ICT can play a role in improving the efficiency in other appliance categories and sectors.

Long-term policy objectives

Successful policies on energy efficiency are the product of a process which brings together many stakeholders, working collaboratively to achieve the public policy objectives established by government.

As a result, the clear communication of government policy goals to all stakeholders is an important component of any energy efficiency effort and particularly necessary when a new

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group of stakeholders becomes involved. While ICT and CE devices have a long history of regulation (for safety and other issues), in many parts of the world this industry has not been involved in government policy processes on the topic of energy efficiency. Similarly, while many government energy efficiency departments and their agencies have worked with the whitegoods industries in the past, they may not have experienced direct dealings with the electronics industry.

Therefore, governments need to place considerable emphasis on establishing clear and effective lines of communication with industry. Governments also need to recognise the complexity and global structure of the ICT and CE industry by allowing sufficient lead-in times. This can be achieved by governments defining key long-term policy objectives for technology in this field, and working with industry and other stakeholders to agree on implementation plans which meet these objectives.

For example, policy objectives should include performance targets by specified dates for individual appliances categories, based on assessments of technical feasibility and projections of cost-effectiveness which factor in the cost of carbon, economies of scale and learning by doing. Such individual national targets should be decided with reference to targets established in other countries, and where possible, aligned.

These policy objectives should be supported by a range of measures identified in the implementation roadmaps, which should also include items such as interim targets and processes for monitoring and verification – if necessary – for enforcing these targets. Traditional policy measures such as voluntary agreements, product labelling, minimum performance standards, government procurement and others would be included as appropriate within these plans, clearly establishing the role played by such instruments in meeting the long-term objectives.

The benefit of this approach is that it defines the desired outcome and therefore provides industry with the long-term view on which to base their business models. It allows all stakeholders the opportunity to agree on a range of activities which will be most effective in reaching government objectives.

Horizontal policy approaches

One of the major challenges in establishing policies for ICT and CE equipment relates to the difficulty in closely defining individual devices and establishing appropriate energy performance targets or thresholds. The entrance of new product categories and the changing functionality of existing types of products often occur in electronic devices at a faster pace than can easily be accommodated by energy efficiency programme managers. To overcome this issue, policy measures should attempt to be horizontal in nature, spanning as broad a cross-section of devices as possible. This is explained by the following examples.

The IEA proposal made in 1999 for limiting products to a maximum standby power level of 1 watt per device is an example of a horizontal approach since it is intended to apply to all electronic appliances (with some minor exceptions). While measures designed to limit standby power in targeted appliances have been successful, they are likely to cover less than 30% of total standby energy consumption (see chapter 9 on *Standby Power*). Therefore the horizontal

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1-Watt policy is designed to maximise the energy saving potential by covering the full range of products, and it remains a relevant policy approach today. The IEA included this as one of the 25 recommendations to the G8 and encourages governments to implement measures which will ensure all devices achieve this target (OECD/IEA, 2008).

However, the scale of energy use by electronic equipment and predicted growth patterns call for a more comprehensive suite of policies than the 1-Watt standby measure. In particular, policies are needed which recognise that the lower standby power modes (covered by the 1-Watt initiative) represent only a small part of the overall electricity consumption of electronic appliances. Policies therefore need to expand to cover all energy consuming activities currently undertaken by types of appliances, including times when they are performing their primary function.

In the chapter on standby power (Chapter 9), it is recommended that the 1-Watt policy should be seen as a transition to a new horizontal approach that focusses on the functions that are commonly provided by appliances. Essentially this approach considers that the standby energy consumed by a device is related to the services that it provides, which is particularly relevant when considering some of the more complex modes of operation. For example, the functions active in a particular product in standby mode might include a display/timeclock, internet connection and the ability to wake up in response to a command from a remote control. Suppose that it is reasonable for each of these functions to require 0.5 watts of power, then it would be expected that the power drawn by this device would be the sum of these components, equal to 1.5 watts. By extension any device which provided these services should require the same power, regardless of what the appliance is called or how it looks!

It should be noted that this way of setting energy efficiency policy measures horizontally by function is not confined to low-power modes, and nor is it entirely new. The EU Code of Conduct introduced a similar system for broadband equipment and set-top boxes, and Energy Star has developed programmes designed for groups of similar equipment, for example imaging equipment and set-top boxes, where some of the boundaries between individual types of equipment have become less clear.

Display technologies provide another good example where a focus on functionality makes sense. The energy attributes of display screens are similar whether they are packaged as televisions, computer monitors, displays in shopping centres, hotels or conference centres. In these instances, energy performance differs as a result of additional components required to provide additional services, such as TV reception, connection to other devices and the like.

This illustrates how, as further convergence occurs, products are going to be defined more by the functions that they perform, rather than by their form or a traditional product category. And similar services are going to be provided by a wider range of different devices. For example, already there are a diverse group of appliances which can be used to play a DVD. However, there is no fundamental reason why the energy used to provide this service should differ greatly between these appliance types.

In practical terms, most types of policy measures, whether mandatory or voluntary, can incorporate this type of approach by establishing targets horizontally for common functions provided by any device.

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Horizontal policies based on functionality offer several major benefits for electronic appliances. As noted, they are not product-specific and therefore cope with the changing design and functionality of appliances, and new market entrants. They are highly transparent - product designers know what is expected well in advance, and do not have to consider whether their particular products will be covered by policy measures.

In recommending that governments need to adopt this approach more comprehensively, the IEA believes that some actions can be taken immediately, while others require further investigation.

Where the following have not yet been adopted, they should be without delay:

- Measures to ensure that the majority of products consume less than 1-Watt in the lower-standby power modes;
- Horizontal policies for all external power supplies;
- Horizontal policies to improve power management in all devices, including requirements for auto power- down (see following section);
- Policy measures covering all modes for a wide range of technologies providing the following services: visual display, computing, audio and video recording and playback, printing and copying, TV reception (including decoding and conversion of signals).

Expansion to cover more services provided by ICT and CE technologies will require further technical investigations and a commitment to allocate additional investment by governments. However, this can be minimised by international collaboration under an appropriate forum, such as the IEA Implementing Agreement on Efficient End-Use Electrical Equipment (4E) or other bodies.

Power management

While the savings from the technical improvement to efficiency of electronic appliances are considerable, the largest proportion of savings result from ensuring that products are able to modulate their power requirements according to the services they are providing. This means, for example, that a device which is no longer being used for a prolonged period automatically reduces its power load to a minimal amount, until it receives further input from an operator. It can also include computers which reduce their processing speed according to demand.

Depending on the technologies involved, there are numerous ways in which all devices can better match power requirements to the services they provide by co-ordinating appropriate features within the hardware and software. In most cases, the cost of power management is not so much an increase in capital expenditure, but in the additional design times involved and delays in product development. There can also be concerns that some power management features may confuse consumers and result in more enquiries which add costs to product suppliers.

While power management may include consumer interfaces, power management functions need to be fully automated so that input from consumers is not required for the device to work as efficiently as possible. Experience with ICT and CE appliances demonstrates that most consumers do not switch appliances to low power modes when they are not being used unless it is very apparent that the appliance is still on. So, while householders switch off televisions, most do not switch off VCRs, DVD players via a remote. Similarly, because they can see that a

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computer monitor is still on they are likely to turn it off, but are far less likely to enable power management in the computer module itself. While it is theoretically feasible to change consumer behaviour through improved education, this is likely to cover only the most obvious activities and larger appliance types, will be limited to those people that are receptive to such advice and will require frequent reinforcement. As electronic devices become more complex, these limitations will become even more significant.

The inclusion of auto power-down facilities within all electronic appliances is therefore a vital component in maximising energy savings. In general, this means that if a device receives no input indicating that it has been actively used by a consumer over a specified period of time, then it would automatically move into a low-power state. In some cases it will be appropriate to verify that the device is not being used by asking the consumer if it should proceed with shutting down. Consumers should also have the opportunity to change the settings for these power management options, for example by selecting the duration period of inactivity before auto power-down starts. Governments and industry should consider whether there should be disincentives for disabling power management completely.

However, experience with computers shows that most consumers do not alter factory settings unless they become very inconvenient, and therefore it is important that power management features are the default option, fully enabled within all products supplied to consumers.

Given the potential to reduce energy consumption through power management, it is important that governments introduce requirements horizontally for all electronic appliances at the earliest opportunity.

Additional encouragement for advanced power management features within electronic appliances, such as scaling down the power draw of components, is also important. Energy efficiency programmes which compare products on the basis of the total amount of energy they consume over a period of time will be more effective in promoting power management, than if only the power requirements are considered.

Specific policy measures

A range of policy measures has been used in the past with respect to appliances and equipment with great success. There is little to suggest that these same measures cannot work equally effectively for electronic appliances as long as they are well designed, and applied correctly, for example to the aspects of devices which are responsible for energy consumption. The previous comments regarding the need for horizontal approaches focussing on functionality are important in this regard.

As with other sectors, it is extremely unlikely that single policy measures will be sufficient to influence all the actors involved in the ICT and CE sector, and that combinations of measures will need to be implemented. The selection of the best policy measures has to take into account a range of factors, such as what are the policy objectives, how does the market operate for particular products, what is the current range of efficiencies amongst devices and the potential for cost-effective improvement, and similar issues.

As such, the optimal suite of policies needs to be decided on a case-by-case basis from the large portfolio of potential options. In some cases, there will be a need for short- and longer-term policy measures, including items such as well-targeted R&D efforts for new technologies. For example, measures should be implemented which increase the uptake of the most efficient

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display technologies currently available, while at the same time governments support the development of OLEDS.

Most policy measures ultimately require the establishment of energy performance targets, thresholds or limits on products or functions, whether these are mandatory or voluntary. In the past, these thresholds have included a scaling factor such that the energy which is allowed to be used by products is related to their capacity, size or volume. This provides a reasonably accurate method of comparing the energy efficiency of appliances. However, when this information is used as the basis for consumer information, consumers may infer that products with the same label rating, or which carry an endorsement label, consume similar quantities of electricity, which can be far from the truth.

This is an important issue since the penetration of larger appliances has played a significant role in reducing the savings from improvements in the energy performance of appliances. Policy measures would better reflect national policy objectives for energy savings and greenhouse gas reduction through restructuring these thresholds so that larger appliances were required to have higher, but attainable, efficiency levels.

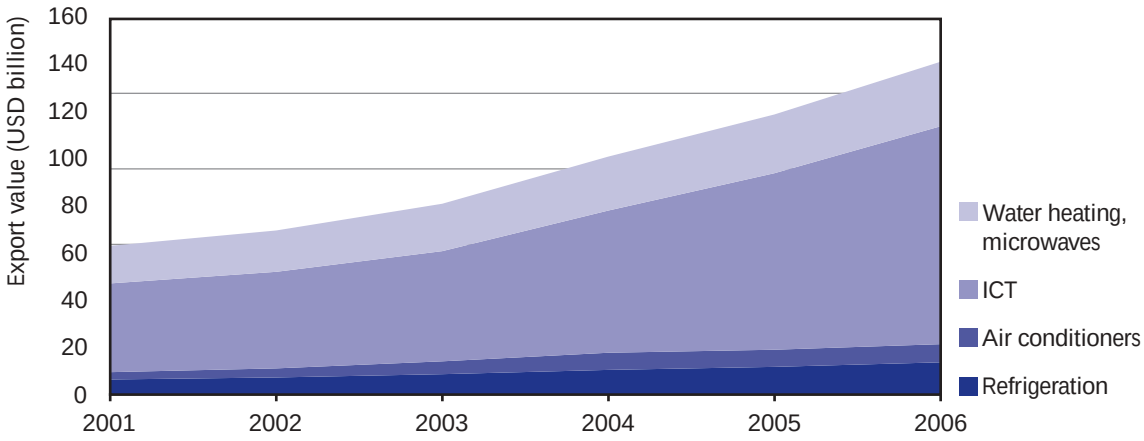
End-use monitoring and evaluation

Given the speed with which electronic devices arrive on the market and gain significant penetration rates, there is a need for more attention to tracking activities that are sufficiently in-depth and frequent to provide a reliable picture of the energy consumption trends in ICT and CE equipment. This would include the monitoring of sales, stocks and typical energy performance of the more significant energy consuming electronic appliances. Such procedures will also be helpful in assessing the impact of policies in this area.

International co-operation

International trade in electronic devices has grown by nearly 20% per annum since 2001 which makes this the most globally traded of all household appliances (see Figure 91).

Figure 91 • Value of trade in major household appliances, 2001-2006



Source: International Trade Centre, TradeMap database.

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The high level of trade of many categories of residential appliances, and electronic goods in particular, has led to widespread calls for increased international co-operation in the development of energy efficiency policy and measures. The G8, APEC, APP and the World Bank amongst others have encouraged greater links between countries and between governments and industry in order to develop harmonised approaches. The potential benefits to both policy-makers and technology suppliers have been discussed at some length in *Cool Appliances* (OECD/IEA, 2003) and are summarised as:

- greater market transparency;
- reduced costs for product testing and design;
- enhanced prospects for trade and technology transfer;
- reduced costs for developing government and utility efficiency programmes;
- enhanced international procurement.

There are, in fact, a large number of regional or international organisations which have some involvement in policy measures for electronic appliances. In addition to those listed in Table 57,

Table 57 • Examples of regional organisations involved in energy efficient ITC and CE equipment

Regional economic organisations	Expert working groups on energy efficient appliances	Advocacy Groups/ NGOs for energy efficiency	International/ regional standards authorities	Consumer electronics trade associations
Asia-Pacific Economic Cooperation (APEC)	Experts Group for Energy Efficiency & Conservation (EGEE&C)	Association for the Conservation of Energy (ACE) (UK) EUROACE (Europe)	American National Standards Institute (ANSI)	AEEMA (Australia)
ASEAN	Energy Efficiency and Conservation Sub-sector Network (EEC-SSN)	American Council for an Energy Efficient Economy (ACEEE) (U.S.)	COPANT (Pan American Standards Commission)	CEA (USA)
Asia-Pacific Partnership (APP)	Appliance & Building askforce	Alliance to Save Energy (ASE)	International Electrotechnical Commission (IEC)	EIA (USA)
Economic Commission for Latin America and the Caribbean (ECLAC)	Sustainable Development and Human Settlements Division	Australian Business Council for Sustainable Energy (BCSE)		EICTA (Europe)
European Union	Central Eastern and European Appliance Policy (CEECAP)	Collaborative Labelling & Appliance Standards Program (CLASP)		Intellect (UK)
North American Alliance (NAA)	North American Energy Working Group's Expert Group on Energy Efficiency (NAEWG-EE)	European Council for an Energy Efficient Economy ECEEE (Europe)		ITIC (USA)
		Renewable Energy & Energy Efficiency Partnership (REEEP)		JEITA (Japan)

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there exist government-industry partnerships such as *Climate Savers* and the *IT Access For Everyone Initiative*; multilateral initiatives and run by the World Bank Group, UNEP, Global Environment Facility, Asian Development Bank, European Bank for Reconstruction and Development, and the Inter-American Development Bank.

These organisations have all played important roles in providing an impetus for co-operation, however much of the detailed work involved in achieving harmonisation has been the result of bilateral and multilateral collaborations between national energy efficiency programmes and the larger product supplier companies. Considerable progress has been made in recent years and there is probably more international alignment of policies on ICT and CE equipment than for other categories, particularly due to the influence and widescale use of Energy Star programmes. Many examples of on-going harmonisation initiatives have been highlighted in previous chapters and those that follow.

However, this situation can quickly reverse without continuing attention to grass root activities such as maintaining the relevance of test methodologies, information sharing about current and future policy intentions and dialogue between energy efficiency programme managers. This is a time-consuming process and unfortunately seems to be one of the first items to be cut when there are resource constraints. It should also be noted that there is often a point at which programme managers and standards bodies face conflicts between national interests and the pursuit of international harmonisation. The success of further alignment therefore requires not only strong political support, but the mechanisms to disseminate and reflect this through all decision-making processes.

In order to provide an international framework for co-operation, IEA governments launched a new Implementing Agreement in 2008, focussing on Efficient Electrical End-use Equipment (4E).[3] The aim of this initiative is to bring together countries and other stakeholders to share expertise and develop their understanding of end-use equipment and policies and to facilitate coordination of international approaches in the area of efficient end-use equipment. The agreement, which is open to membership from any national government and its representatives, has an emphasis on providing information to support the development of appliance policy, including the wider promotion of existing policy measures. This forum is intended to reduce duplication of effort and pool resources for important research tasks.

In the same spirit of developing policies built upon a better understanding, the following chapters draw together some of the key technological, market and policy issues for electronic appliances, and provide policy recommendations for all governments.

3. See *http://www.iea-4e.org/*

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Chapter 5 • WHAT'S ON TV?

Introduction

With a global stock of about 1.9 billion in 2005 and an average of over 1.3 sets in homes with access to electricity, televisions are probably the most mature of residential electronic appliances. Indeed there is evidence that in many parts of the world a television is no longer considered a discretionary purchase, but ranks alongside lighting and refrigeration as essential electrical items. Despite the fact that TVs have been around for many decades, this past decade has seen probably the greatest shake-up in their history, the combined effect flowing from the introduction of new display technologies, more access to TV delivery platforms including IPTV, and of course the switchover to digital broadcasting. These, together with the advent of DVD players and digital recording devices, have given many households far more choice regarding what they watch, and when they watch. But televisions have also become more than just a means of enjoying live or recorded broadcasts. People connect them to other devices to play video games, to view digital pictures and in some cases to listen to the radio.

These dramatic changes have enabled householders to access a wider range of entertainment and information experiences but also have implications in terms of electricity consumption and the emission of greenhouse gases. The full extent of these implications have not yet been fully explored due to the speed with which technology and TV services have changed in recent years, and because it has been difficult to disaggregate the contribution from TVs from other end-uses. The following chapter highlights some of the recent trends in the television sector and the impact on electricity consumption. It identifies current and future technologies, and examines the opportunities for reducing the amount of electricity used by TVs.

TV technologies

Until a few years ago, there really was only one TV technology – the cathode ray tube (CRT), which was invented around 1890 and used in the first commercial black and white television sets from the late 1930s. In the mid 1950s colour televisions were developed, also using the cathode ray tube, although it took a further decade for the broadcast of programmes in colour to become widespread.

Although CRT technology has been continually refined, televisions remained much the same until the 1990s when the first commercial LCD and plasma televisions began arriving on the scene. These three types of displays are the major technologies used in the manufacture of televisions today, and each has its their advantages and drawbacks. Although the screen for displaying images is the most obvious part of a television, other important components include the receiver, which tunes into the TV broadcast signal and provides amplification, speakers for the audio content, and associated power supplies and circuitry. Some televisions also include recording and playback functions using media such as VCR, DVD and hard discs.

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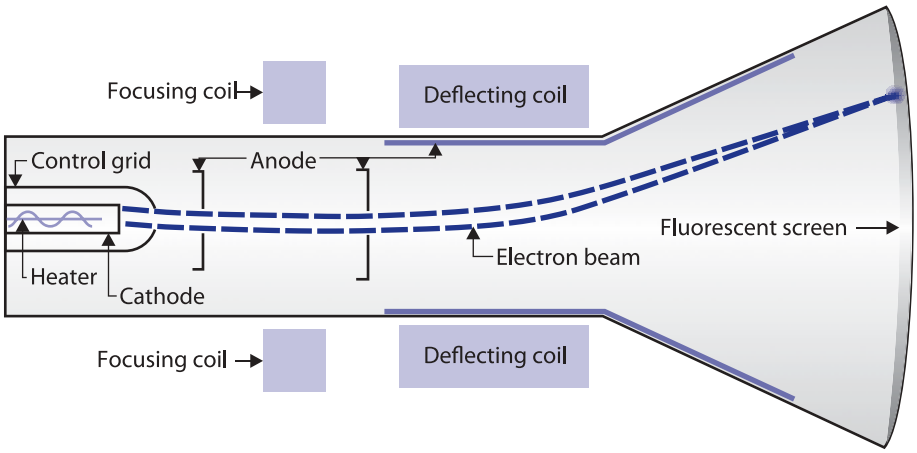
In the fiercely competitive market, manufacturers continue to invest heavily in ways to make their products more attractive and cheaper, often developing patented solutions. As a result there are many variations within each technology. The basic characteristics of each of the major types are identified below.

Cathode ray tubes (CRT)

CRT technology is the oldest display technology used for televisions. The image is produced by firing an electron gun at a fluorescent glass screen. A magnetic or electric field is used to deflect the electrons fired at a screen, which is covered with a phosphorescent coating and emits visible light when excited by the electrons. An image is produced by modulating the intensity of the electron beam with a received video signal (or another signal derived from it).

The extensive use of glass, together with the cabinet depth needed to house the cathode ray tube, means that CRTs are heavier and bulkier than flat screen technologies such as plasma and LCD. It is rare to see a CRT in excess of 86cm, however CRTs continue to be cheaper than flat screen technologies (although the margin is decreasing continuously) and their ability to provide clear moving pictures make them popular for some applications.

Figure 92 • Cathode ray tube television



Plasma display panels (PDP)

Plasma Display Panel (PDP) is a self-emissive flat panel display where light is created by a plasma discharge which is used to excite different coloured phosphors. A panel comprises hundreds of thousands of tiny cells, each filled with a mixture of noble gases (neon and xenon), which are sandwiched between layers of electrodes and glass plates. A voltage difference between the electrodes causes the gases to form a plasma and to emit photons, which in turn produce visible light when they strike the phosphors in each cell. By using red, green and blue phosphors and varying the current flowing through the different cells, the control system can increase or decrease the intensity of each cell colour to create the desired image.

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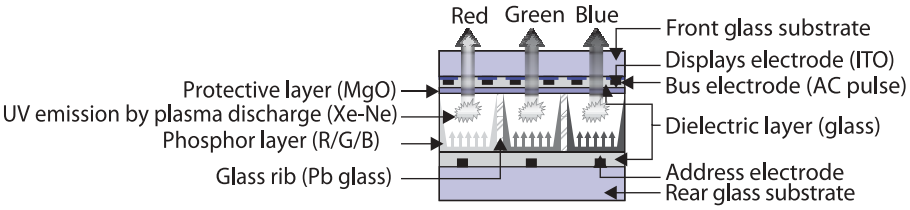
Figure 93 • Plasma television



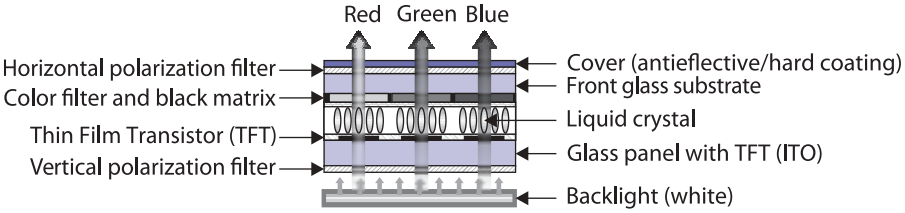
The brightness of the display is dictated by the quantity of plasma produced, which is one reason why these displays tend to be made for large screen sizes. The economics of production also contributes to larger screen sizes. It is therefore rare to see plasma screens smaller than 106cm, with displays reaching as large as 256cm.

Liquid crystal displays (LCD)

LCD is a non-emissive technology which uses a backlight as a light source, typically a cold cathode fluorescent lamp (CCFL), to shine through liquid crystals (pixels) which alter their transparency when a voltage is applied. Light passes through a polarization filter and is modulated by the liquid crystals, creating a blue, red or green pixel after passing through another polarisation and colour filter. Thin Film Transistor (TFT) technology on glass is used to drive or control the orientation of the liquid crystals. The display is protected on the front side with an antireflective hard coating.

LCDs are inherently much lighter and suitable for a range of screen sizes; from the smallest to screens well over 100cm (DCE, 2007; Fraunhofer, 2007a).

Figure 94 • LCD television



Rear projection (RP) displays

Rear-projection systems work by projecting an image on the back of a television screen, however there are a number of different technologies currently in use.

Originally most rear projectors used three small CRTs (one for each primary colour), coupled with a light magnifying lens, which projected an image onto a mirror and which was reflected onto the screen. CRT units are bulky and therefore are now less commonly available.

A rear-projection LCD television works by passing a powerful light source through a transparent LCD chip made up of individual pixels (which display the moving video image) and projecting that image through a magnifying lens, to a mirror, which then reflects that image onto the screen.

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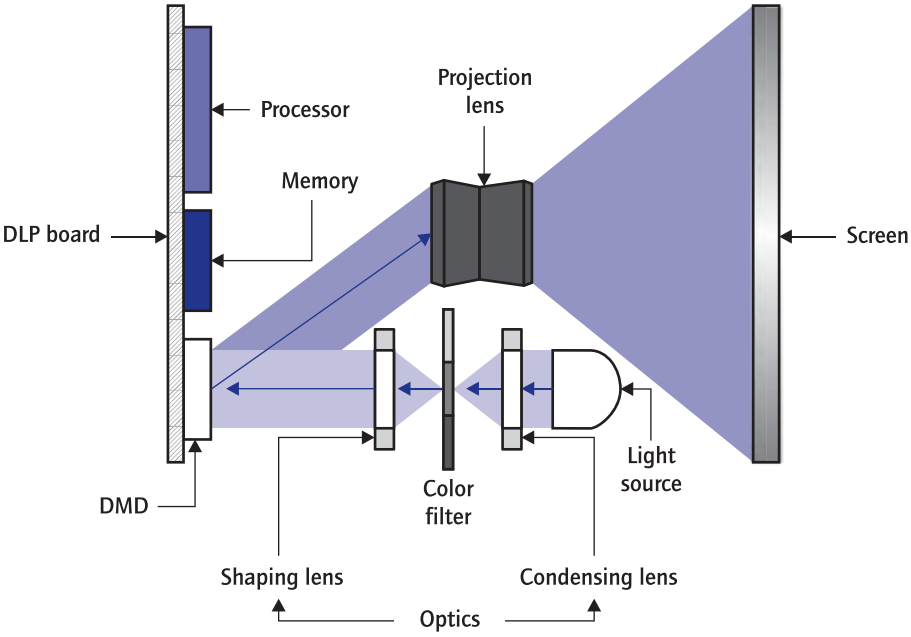
Earlier versions of LCD projectors suffered from the 'screen door effect' where the image appeared pixellated.

Digital Light Processing (DLP) technology uses a light source to shine on a digital micromirror device (DMD) which contains millions of microscopic mirrors, each of which create one pixel of the final image. When a mirror is tilted away from the projection lens the pixel is black, but when it is pointed towards the lens the pixel is illuminated, with the brightness dictated by the length of time the mirror is in this position. In most DLP televisions, a colour wheel spins between the lamp and the DMD, adding red, green and blue light to the picture. The use of the spinning wheel can lead to what is called the "rainbow effect" – a brief flash of colours when the viewer rapidly looks from side to side on the screen.

Figure 95 • DLP projection television



Courtesy Texas Instruments

Liquid crystal on silicon (LCoS) works like a combination of LCD and DLP technology. In LCoS, liquid crystals are applied to a reflective mirror substrate. As the liquid crystals open and close, light passing through a liquid crystal layer is either reflected from the mirror below, or blocked. This modulates the light and creates the image. Most LCoS projectors use separate devices for red, green and blue, and a lens combines the three colours. LCoS technology is usually very high resolution, and typically higher in price than most LCD and DLP products.

Surface-conduction electron-emitter display (SED)

SED was devised in the early 1980s and comprises one tiny electron transmitter mounted behind every single pixel on a screen – in effect replacing one large CRT electron gun with thousands of small ones. This enables SED displays to be as thin as other flat screen types, while having the picture quality and lack of ghosting provided by CRT displays (Smith *et al.*, 2007).

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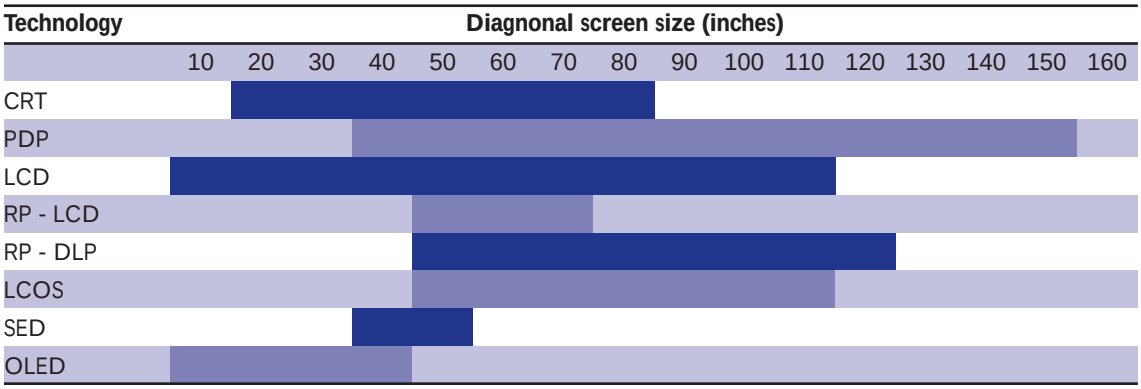
Although only prototype SED TVs are currently available, industry spokespeople have claimed that SED displays (like conventional CRT TVs) will have lower consumption than equivalent Plasma and LCD displays (Electronic House, 2007).

Organic light emitting diodes (OLED) displays

OLED displays are based on sandwiching organic compounds between a grid of positive and negative electrodes, so that they generate light when they are fed with an electric current. OLED pixels can be turned on and off very quickly which makes for pictures that move more smoothly, and they can provide a greater range of colours, brightness, and viewing angles compared to LCD screens. OLEDs can also be printed onto any suitable substrate so that they may eventually be cheaper than other technologies and suitable for a range of new applications.

While OLED screens have been used in mobile phones and displays on other portable devices, only small sized OLED televisions are currently available. Larger prototypes up to 79 cm (31 inches) have been shown, but panel longevity continues to be a major issue since the organic compounds degrade with use, especially those that emit blue light.

Figure 96 • Approximate range of currently available screen sizes by technology



Source: Derived from data in Fraunhofer, 2007a.

The television market

Most OECD countries have experienced a very quick transition away from CRTs towards flat screen technologies, mainly LCD displays, with PDP and RP technologies following a similar trend but taking a much smaller share of the market. However, in non-OECD countries, this transition is not yet so pronounced, with the result that CRTs still account for about the same number of global sales as LCDs.

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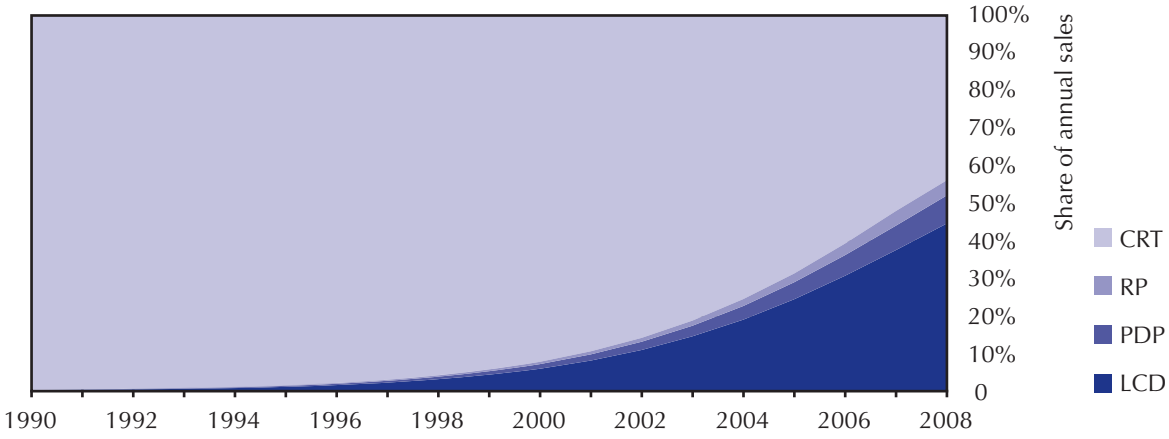
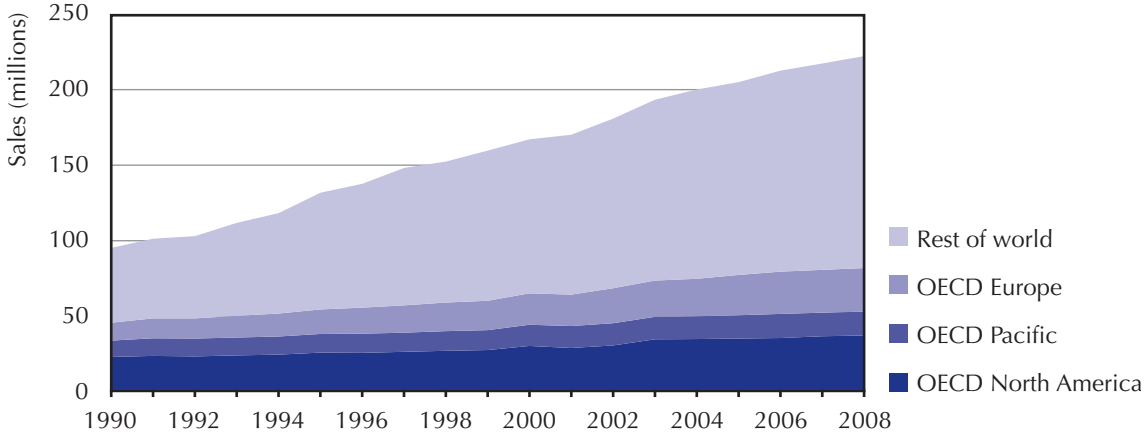
Figure 97 • Share of global TV sales by technology type, 1990-2008



Source: IEA estimates.

The global market for televisions has grown by 3.7% since 1995 and now totals approximately 220 million units per annum (Figure 98). While all regions have experienced a rise in sales since the late 1990s, the share of sales in non-OECD countries has risen from under 50% in 1991 to over 60% by 2008, accounting for the majority of the CRT market.

Figure 98 • Number of global TV sales by region, 1991-2008



Source: IEA estimates.

In fact, TV sales in non-OECD countries are growing faster than the growth in the number of households gaining access to electricity, which is around 2% per year, meaning that the average number of TVs per household in existing households is also going up. In OECD countries also, ownership rates are rising (Figure 99) and it is now not unusual for a household to have three TVs.

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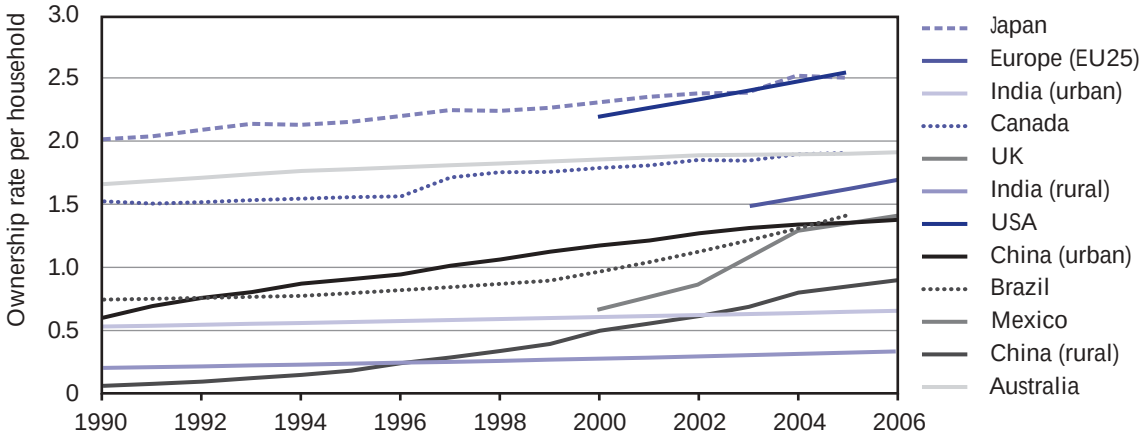
Figure 99 • Examples of national TV ownership rates, 1990-2006



Source: IEA estimates.

It seems that many of these newly purchased televisions are not replacements for broken sets, most of which are still functioning perfectly well. Televisions typically last for 10 to 15 years, depending on use, and may go on for a lot longer. While new and larger flat screens tend to take the place of the older set as the primary household television, the old one is not thrown away; rather it tends to become an extra set often relegated to a bedroom or kitchen.

Market drivers

It is difficult to distinguish the relative importance of the combination of factors that have led to increased TV ownership. Indeed it is likely that this is largely a matter of the individual priorities of consumers.

Clearly larger and thinner televisions appeal to many people; however when flat screen technology first became available they were expensive, and perhaps less reliable than existing CRT technology, and so tended to be purchased only by wealthier consumers in OECD countries. However, breakthroughs in manufacturing processes, together with economies of scale have seen prices fall very considerably from the 1990s to the present (see Figure 100). In the first half of this decade, with most personal incomes growing steadily, consumers seemed to be prepared to spend more for a larger screen, and were more confident in the newer technologies.

The consumer preference for larger flat screens in OECD countries has been so strong than many of the major manufacturers have now completely withdrawn from some markets, and it is actually quite hard to find a CRT television in many retail outlets in Australasia, Europe and North America.

A further reason for consumers to purchase a new television is the opportunity to access digital TV broadcasts. Most countries have indicated that they will turn off the analogue broadcast

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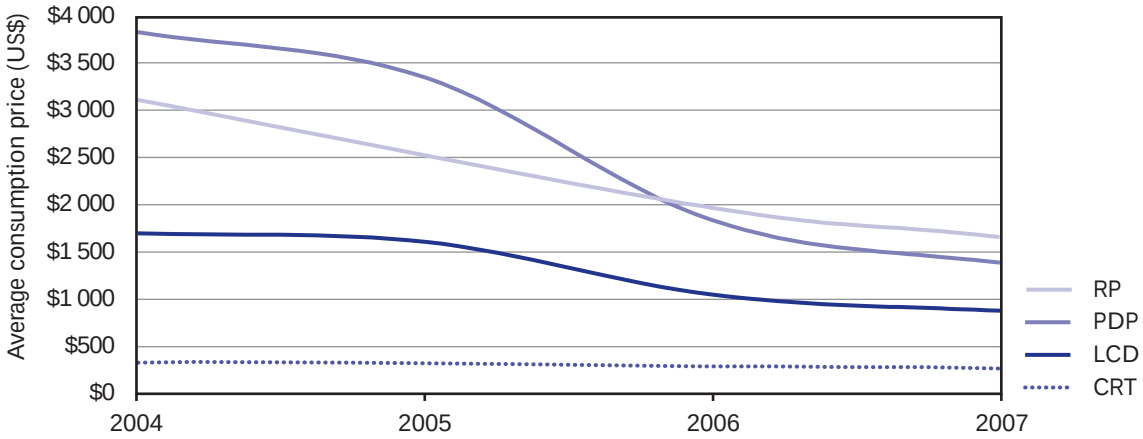
system at some time between 2006 and 2015 (see Figure 101), which means that households will need either a digital TV or a converter box (sometimes called a set-top box) in order to continue to receive programmes.

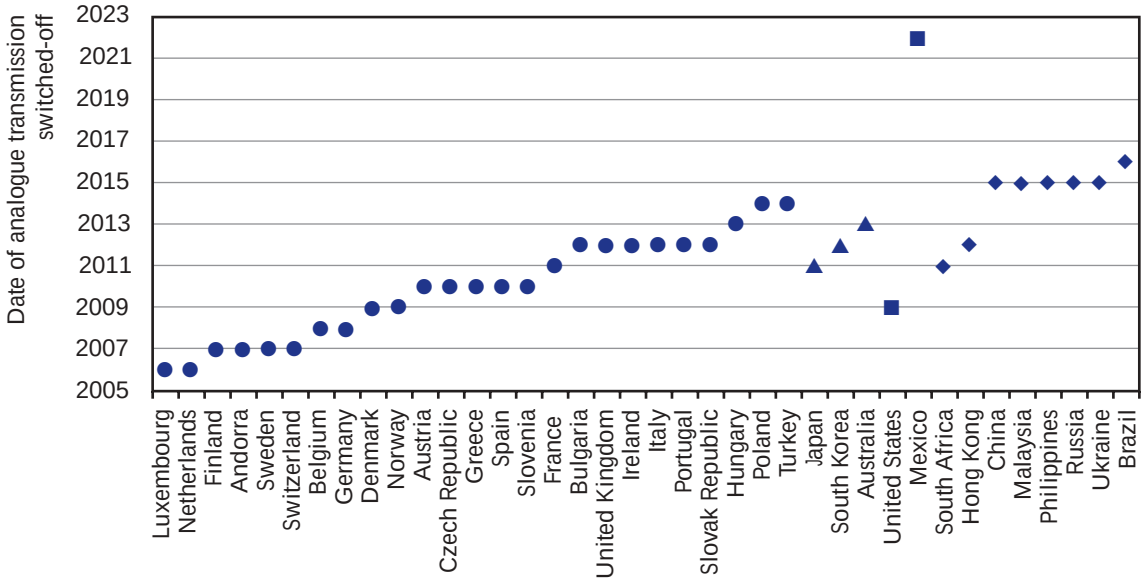
Figure 100 • Average prices of televisions in the United States, 2004-2007



Source: Energy Star, 2006; CNET, 2005; Displaybank, 2006; Digital Trends, 2007.

Some consumers also want to access high definition digital TV which requires a television with the capacity to show high definition pictures. Whereas a standard definition picture can be viewed adequately on a small screen, the demand for greater picture clarity provided by high definition has become increasingly necessary with the larger screen sizes.

Figure 101 • Date for switching-off analogue TV broadcast services



Source: OECD, 2007.
Note: Countries are grouped by regions.

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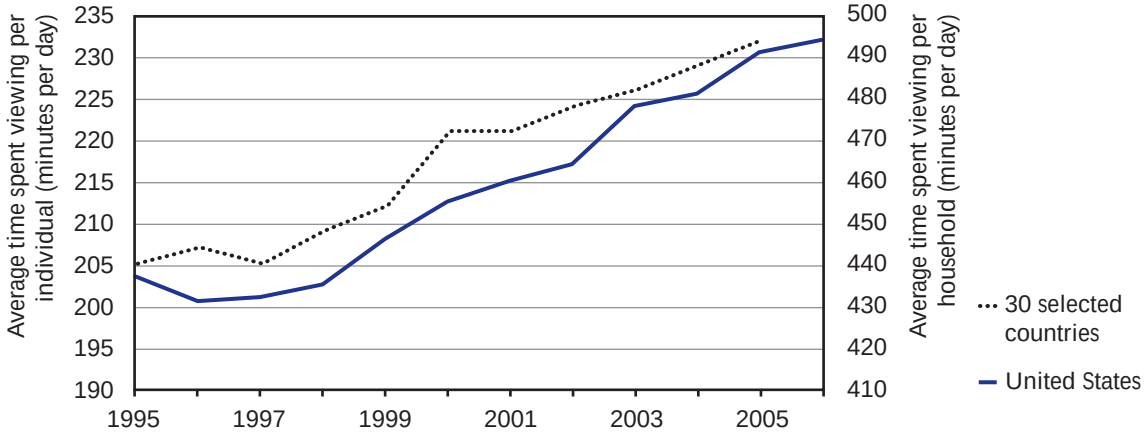
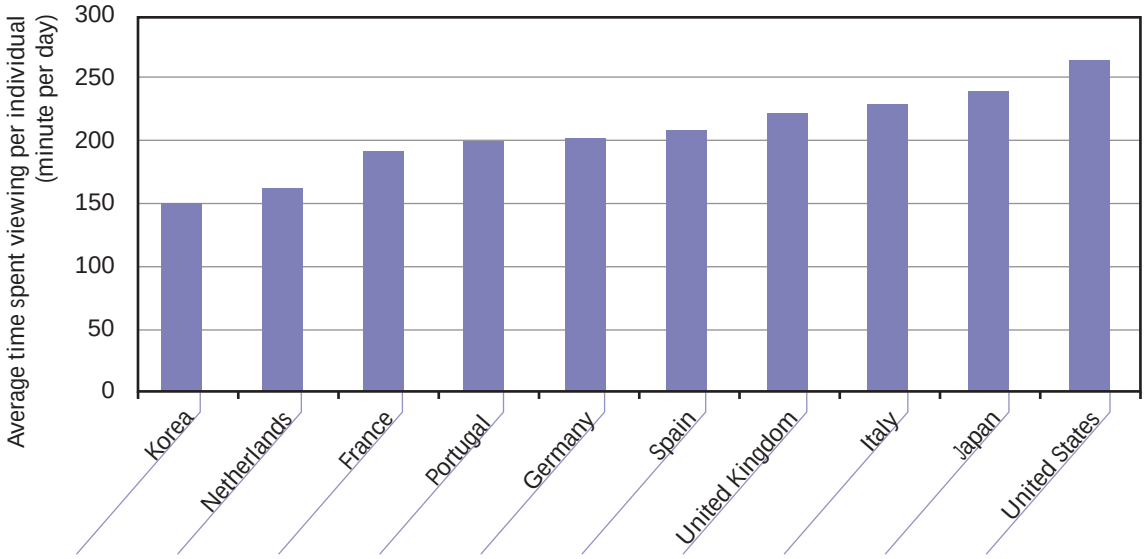
Changing usage of televisions

It used to be that televisions were primarily used for watching broadcast programmes, but this began to change with the introduction of recording and playback technologies such as video cassette recorders (VCRs). More recently VCRs have been largely replaced by DVD players and a range of recording devices including hard-discs. With the ability to select what can be watched, viewing hours have increased, nearly doubling in the past ten years in the United States and other selected countries (see Figure 102).

Figure 102 • Television viewing hours, by time and country



Source: TV Basics, 2008; Eurodata, 2008.



Source: GfK, 2006.

But other important trends are emerging in the way in which televisions are being used. For example, video games are now very popular amongst some groups of householders, while others use their television screen to view digital photographs. In some markets where digital

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radio is popular, TVs are increasingly used to listen to radio programmes. Research in the United Kingdom shows that around 20-30% of digital radio listeners do so via their TV (Rajar, 2008).

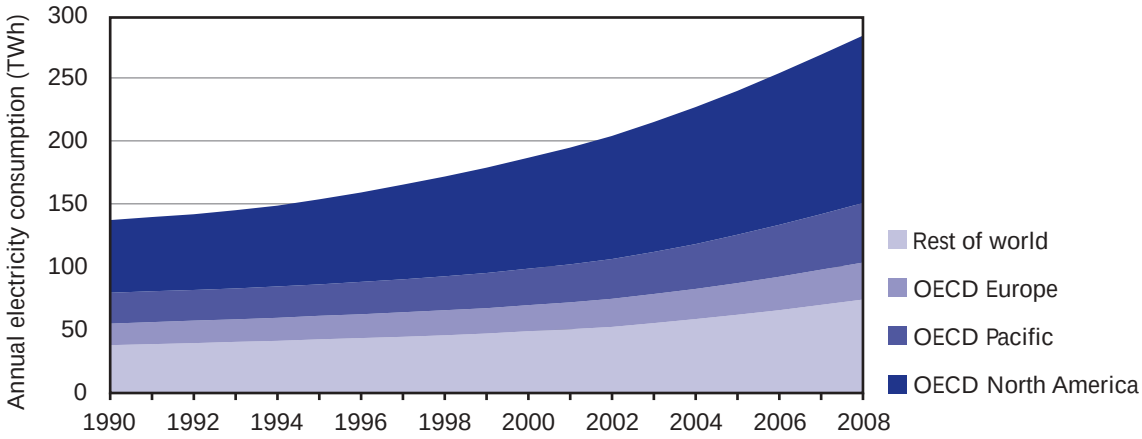
On the other hand, the growth in home computing and particularly the rise of the Internet may be expected to compete with time in front of the television. However, while it is true that this is the case for some householders, it appears that simultaneous usage is quite common (Pilotta, 2005).

In fact, we know remarkably little detail about how televisions are used, despite their importance in our lives. Consumer surveys have tended to focus on "viewing hours"but may not capture use of games or even times when the TV is on but not being actively watched. In a busy household with several televisions, it may not actually be possible for surveys to get an accurate picture of how each set is being used on a regular basis. Certainly there is often an inconsistency between the results of consumer surveys and those based on metered data, although it is difficult to say which better reflects reality.

Implications for energy consumption

Televisions currently use over 250 TWh of electricity per year, or over 5% of the total global residential electricity consumption, costing householders USD 30 billion each year to run. Even though all regions have experienced growth since 1990, this has been particularly strong since 2000, especially in non-OECD countries which now account for half of all TV electricity consumption (Figure 103).

Figure 103 • Estimated electricity consumption by televisions by region, 1990-2008



Source: IEA estimates.

CRT televisions continue to use by far the largest proportion of electricity, responsible for around 80% of the total in 2005; however this situation is changing rapidly, as shown in Figure 104.

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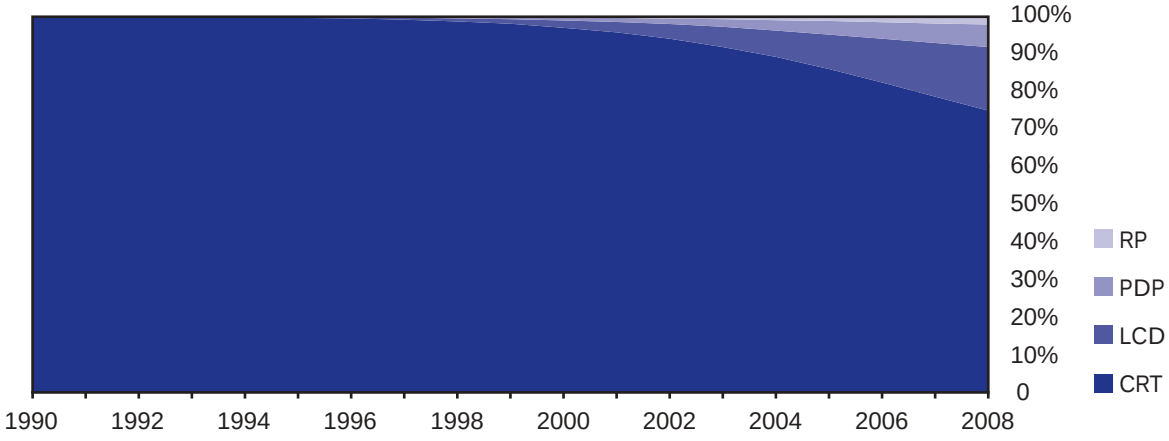
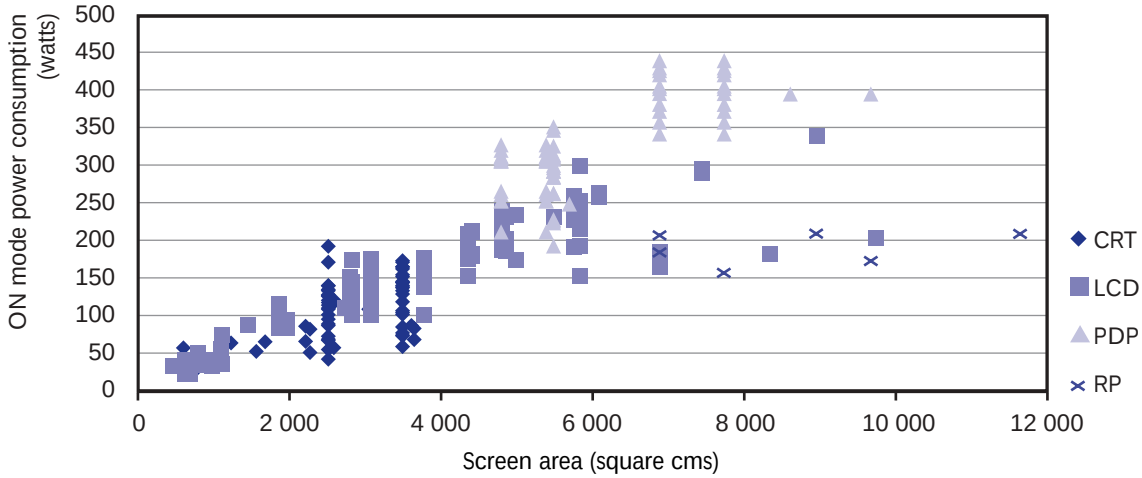
Figure 104 • Estimated electricity consumption by televisions by technology, 1990-2008



Source: IEA estimates.

To understand more about what is going on it is necessary to appreciate the key role that screen size and technological change play in determining energy consumption. As shown in Figure 105, the amount of electricity a TV uses is very dependent upon the size of the screen for most technologies. In rear projection televisions this relationship is less obvious. So the larger the TV – whether CRT, LCD or plasma – the more electricity it uses. However, it is also important to note the large variation in performance that exists within each technology for different models with the same screen size.

Figure 105 • Variation of on mode consumption with screen size for a sample of televisions from Australia, United Kingdom and United States, 2007



Source: Data assembled from TV measurements taken in Australia, United Kingdom and United States in 2007 according to the revised test procedure in draft IEC 62087.

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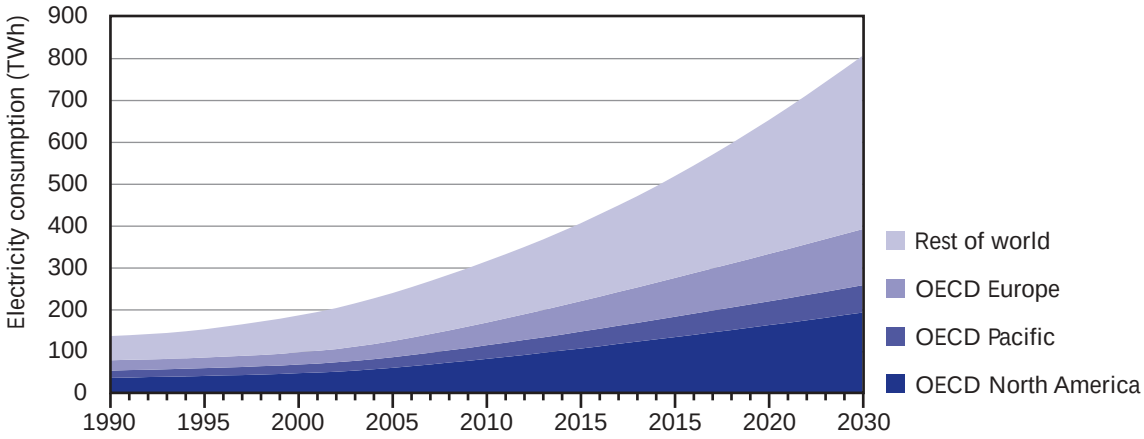
Between 2005 and 2008, the average size[1] of all televisions sold around the world increased by over 9% per annum, while the size of LCD TVs grew by over 20% per annum over the same period. Although it takes time for these effects to be seen clearly in global figures, this is the reason we are beginning to see a sharper increase in electricity consumption over the past few years.

Options for shaping the future of TV energy use

Given the large remaining CRT stock and the strong consumer preference for larger screen televisions which continue to get cheaper, it appears highly likely that current market trends will continue. The switch to digital and high definition broadcasting (and recorded materials) will provide an additional boost to sales. Becoming less a means of viewing broadcast material and more as the final means to display images sourced from a network of connected devices in the home, the range of functions provided through the television has expanded, and as a result, energy consumption has also increased.

Therefore, without technological improvements, we can expect to see electricity consumption from televisions grow at approximately 5% per annum to 2030, increasing nearly threefold to at least 800 TWh by the end of this period (see Figure 106).

Figure 106 • Estimated electricity consumption by televisions, 1990-2030



Source: IEA estimates.

However, all of the current technologies used for televisions have drawbacks, and there are vigorous efforts to develop a range of new display technologies and make improvements to the existing ones. Driving these research efforts is the prospect of greater market share in the vast global television market available to a product that can provide the clearest, brightest, picture, in a large screen format, all at an affordable price to consumers.

1. *Typically measured in terms of the diagonal dimension.*

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A key question, given our current knowledge, is what impact these innovations are likely to have on energy performance. Due to proprietary issues, pre-market information on some options is often very restricted, however some of the most promising options for promoting efficiency that are likely to be available in the foreseeable future focus on the following areas:

- Improved efficacy of lighting sources;
- Backlight dimming, occupancy and ambient light sensing;
- Improved luminosity for plasma TVs;
- New technologies;
  - OLED (organic light-emitting diode);
  - SED (surface-conduction electron-emitter display);
- More efficient power supplies;
- Standby power.

Improved efficacy of lighting sources

Both LCD and DLP require lighting sources to illuminate the screen, with more light required to meet the demand for larger, brighter screens. In fact, because these screen types require continuous lighting irrespective of the picture being shown, the efficiency of the lamp is a major influence on the energy that they consume.

For LCD displays one option is to replace current lamp technology with light-emitting diodes (LEDs); there are some higher priced premium televisions available today which use this technology. The major advantages offered by LEDS are their small size (which enable screens to be produced which are lighter and thinner), their colour qualities, their longevity and their ability to be dimmed (see below). Although LEDS have the potential in the future to be more efficient than either Cold or Hot Cathode Fluorescent Lamps which are used today, they currently have a lower efficacy and therefore switching to the current generation of LEDs doesn't offer energy savings at the present time.

LEDS can also be used in DLP screens, and the first products have now entered the market. DLP screens typically use an ultra high pressure (UHP) mercury vapour or occasionally Xenon lamp as their lighting source, together with a spinning colour wheel to separate the white light into beams of red, green and blue light (TVtechnology, 2004). One major advantage of LEDS is that by replacing a single source of white light with coloured LEDS, the colour wheel is made obsolete and with it the *spinning effect* which is often seen as a major drawback of DLP technologies.

A comparison of the energy consumption of some current DLP televisions (Figure 107) shows that the LED TV uses less electricity than all but one of the others, although the difference is less pronounced when compared with equivalent sized displays. It is therefore difficult to be conclusive, although the longer lamp life, better colours and size provided by LEDS are important features which could drive more DLP televisions to use LEDS.

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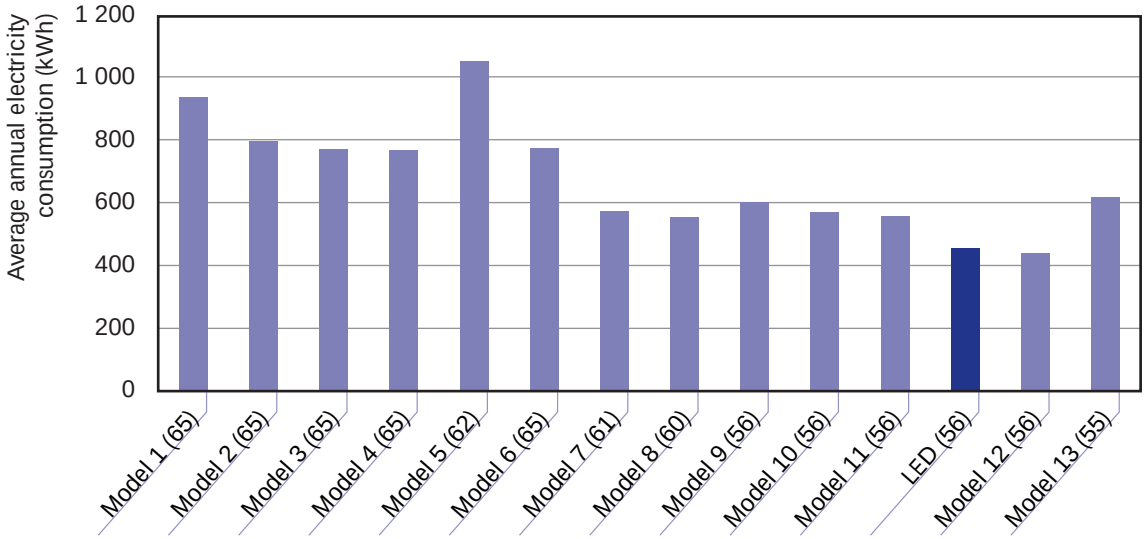
Figure 107 • Sample of on mode consumption of DLP televisions in United States, 2007



Source: CNET, 2008.
Assessment based on 8 hours on, and 16 hours in standby per day. Bracketed values refer to the diagonal screen size in inches.

Although only prototype displays using laser-based illumination technology are currently available, precisely coloured laser beams should enable screens to show a much wider range of colours compared to current lamp technologies. Claims have been made that laser DLP will be both cheaper and use less power than other available screens, however these have yet to be substantiated (Smith, 2007; Ausmedia, 2008).

Backlight dimming

Reducing lighting in non-active areas of LCD screens has considerable potential for improving the performance of existing technologies, and there are several ways in which this can be achieved. For example, Hot Cathode Fluorescent lamps enable the progressive lighting of pixels for a far shorter duration which not only reduces energy consumption but also some image blurring effects. While LEDs may not in themselves be more efficient than fluorescent lamps at the present time, they can be more effectively dimmed to match the picture brightness than fluorescent lamps, and up to 70% savings have been estimated (Greef, 2007; Anandan, 2006). Other claims include the potential to cut energy consumption of new LCD models in 2010 by 50% from current levels (DCE, 2007).

Improved luminance efficiency for plasma TVs

Most current plasma panels have a luminance efficiency of up to 2 lm/W, the relationship between the light output and power input, corresponding to a total efficiency of around 0.5%. Industry estimates for the improvement potential are encouraging, suggesting that 3 lm/W should

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be feasible for HD-ready plasma panels by 2010, while improvements to full HD TVs will take longer. Prototype screens have demonstrated a luminance efficiency of up to 5.7 lm/W which would cut energy consumption by approximately half compared with current technology (Fraunhofer, 2007c).

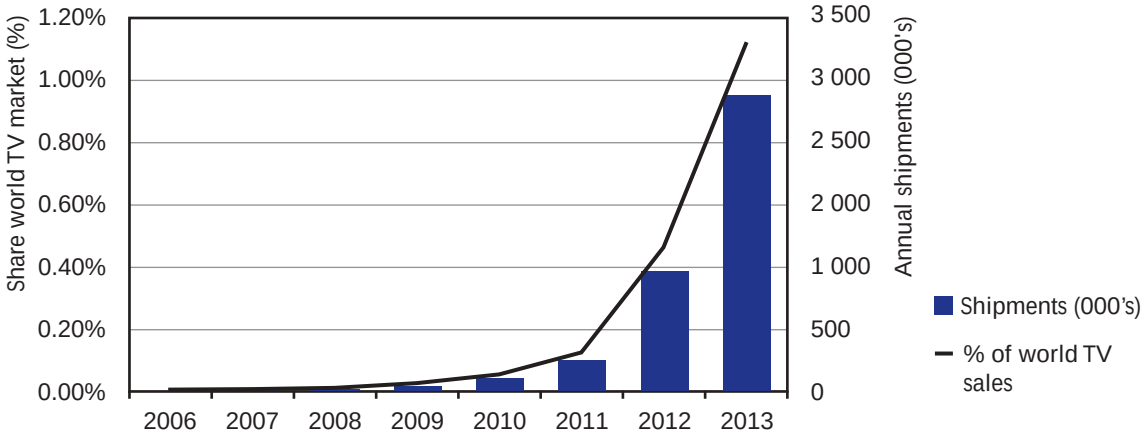
OLEDs

Display screen based on OLEDs appear to offer substantial savings over other flat panel technologies: research undertaken by Sony based on a comparison between the OLED model and a conventional LCD found that the OLED consumed 40% less electricity (Tech-on, 2008a).

However, there are still many issues to overcome before OLED panels can make serious inroads into the market for large screen TVs. Relatively short lifetimes and an inefficient manufacturing process hinder progress, as do the tightly held intellectual property rights (Engineer Live, 2008; Smith, 2007).

Although several other manufacturers have indicated that they will move towards OLEDs in forthcoming years (Engineer Live, 2008), and Sony has announced a USD 205 million investment in manufacturing capacity for 20" OLED screens (Tech-on, 2008b), the projected market share is still modest. As shown in Figure 108, even given the industry projected growth in OLED sales, these will represent only about 1% of global television sales by 2013.

Figure 108 • OLED sales forecast, 2006-2013



Source: iSuppli, 2008.

SED

Although SED technology uses the same concept as conventional CRT televisions, and might therefore be expected to have a lower consumption than Plasma and LCD panels, the evidence from mass-produced examples is not yet available.

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Power supplies

Improving the overall efficiency of power provided to the various components within a television – the display and its driver, the video signal processing unit, speakers and other audio equipment – has the potential to reduce consumption by at least 10%. Losses in the power supply unit, and also the subsequent low voltage conversions can be substantially reduced through better design and the use of a more efficient power supply (Fraunhofer, 2007b).

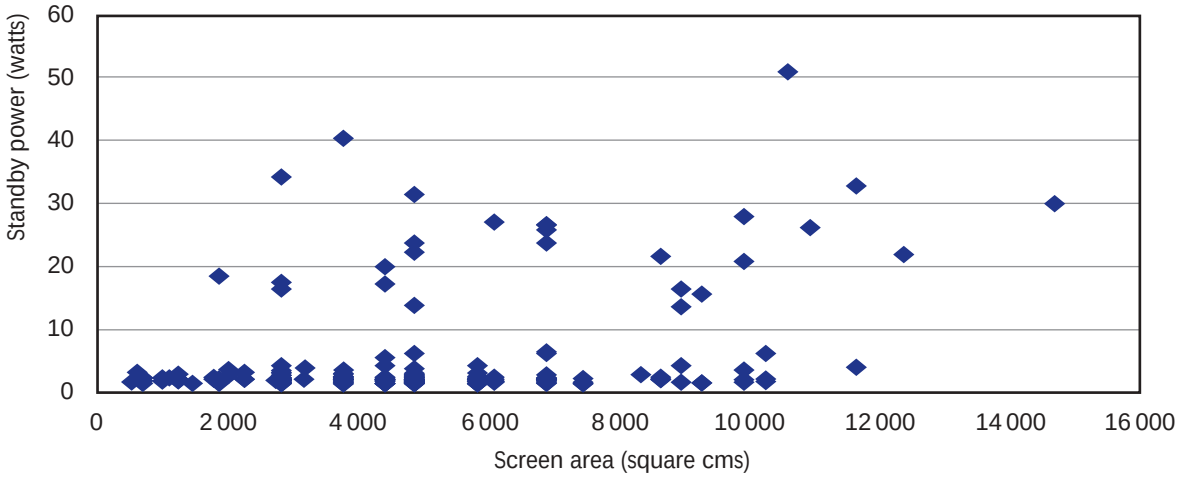
Standby power

Until the arrival of remote control units for televisions, TVs were switched on and off by a manual switch so that no power was consumed when the unit was off. From the late 1980s, when remote controls became increasingly popular, standby power was born; allowing a TV to exist drawing less power than when fully on, but sufficient to enable it to respond to a signals to switch on delivered by the remote control. Nowadays remote controls have become ubiquitous so that the largely redundant on-off switch has been removed completely in many televisions.

Even though the functions provided by televisions in low power modes have increased to allow connected devices such as DVD players and home audio equipment to communicate, standby power has been decreasing and there are numerous models which consume less than 0.5 watts. Televisions with additional integrated components including tuners and hard discs, will have slightly greater power requirements, though products are available now which use only 1.8 watts in standby. Then there are a limited number of products which remain on at higher power level to accept programme materials and software updates (Fraunhofer, 2007b).

Figure 109 and Figure 110 show the results of measurements undertaken in the United States in 2007, illustrating the range of values for low power consumption in a sample of 228 televisions. They show that unlike *on* mode power consumption, there is no correlation between the size of a

Figure 109 • Example of variation in standby power measurements by size



*http://www.energystar.gov/index.cfm?c=revisions.tv_vcr_spec.

Source: Compiled from measurements from CNET 2008; and EnergyStar, Data-set Used to Determine Draft Final Version 3.0 Specification Levels, 17 December 2007.

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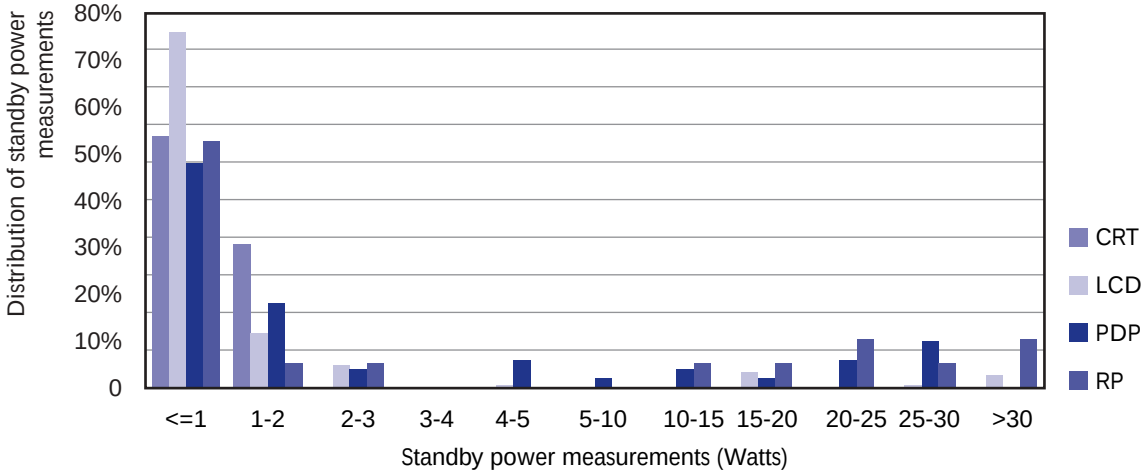
TV set and standby power. Nearly 20% of the sets measured have values over 2 watts. While this suggests the presence of additional functions, there is still a noticeable variation amongst the values, with one product recording 50 W in the low power mode.

Figure 110 • Distribution of standby power measurements



* http://www.energystar.gov/index.cfm?c=revisions.tv_vcr_spec.

Source: Compiled from measurements from CNET 2008; and EnergyStar, Data-set Used to Determine Draft Final Version 3.0 Specification Levels, 17 December 2007.

Assuming that this television was used for 4 hours per day, approximately half its total electricity consumption would be spent when it was in standby state.

Televisions as radios

Most people are not aware that listening to digital radio through the television uses nearly as much energy as watching a normal programme, and for most technologies it makes little difference whether or not the screen is blanked. Tests undertaken in the United Kingdom indicate that compared to a typical digital radio, the energy used by a television performing the same function consumed approximately 10 times the electricity.

Table 58 • Power consumption of televisions receiving digital radio

TV technology	Power consumption (watts)	
	Freeview with picture	Freeview with BBC black screen
28” CRT+STB	110	102
26” IDTV LCD	114	60
32” LCD	105	104
50” Plasma	183	86

Source: EST, 2007.

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Commercial applications

Although this analysis focusses on residential usage of ICT and CE equipment, it is worth noting that electronic displays have an increasing market in the commercial sector. Large LCD and plasma displays are now common in offices, hotels, entertainment centres, retail outlets and conference facilities, with sales totalling over one million in 2007. It is estimated that this market will increase to over 15 million units by 2011 (ID, 2007).

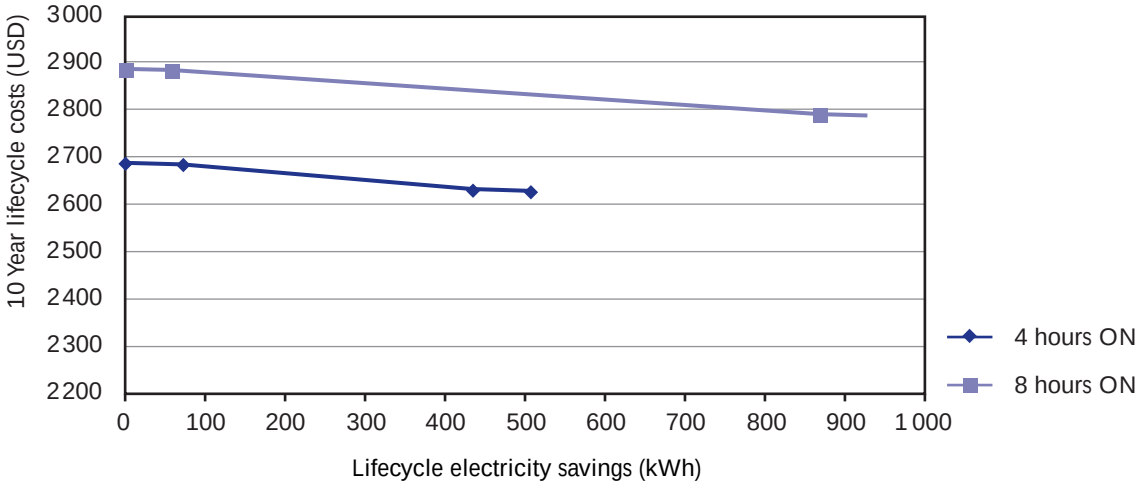
Summary of outlook for TVs

Estimating future trends for products, like TVs, that are undergoing rapid technological transformation is particularly difficult since it is perfectly feasible that some of the television technologies available between 2020 and 2030 are not yet in production, and may still be in R&D phases.

Certainly there are already considerable prospects to improve TV energy efficiency at low cost. For example, an examination of the potential based on currently available technologies undertaken in the EU show that savings of between 20-30% could be made with very little additional capital cost (Fraunhofer, 2007b). In fact, the cost of TV technologies is falling so fast that this report concluded that in this context the cost of the identified measures should be considered negligible.

Examining these conclusions over the lifetime of a television makes interesting reading. The various improvement options outlined above, represented by the marker points in Figure 111 and Figure 112, result in lower energy consumption and lower overall costs. Although further options were not investigated in depth in this report, it is likely that some improvements will

Figure 111 • Potential lifecycle cost and energy efficiency improvements for LCD televisions



Source: adapted from Fraunhofer, 2007b.
The figure shows the results for two usage patterns, one the TV in ON mode for 4 hours per day, and the second with the TV in ON mode for 8 hours per day. A discount rate of 10% has been used to provide the NPV of future electricity cost savings.

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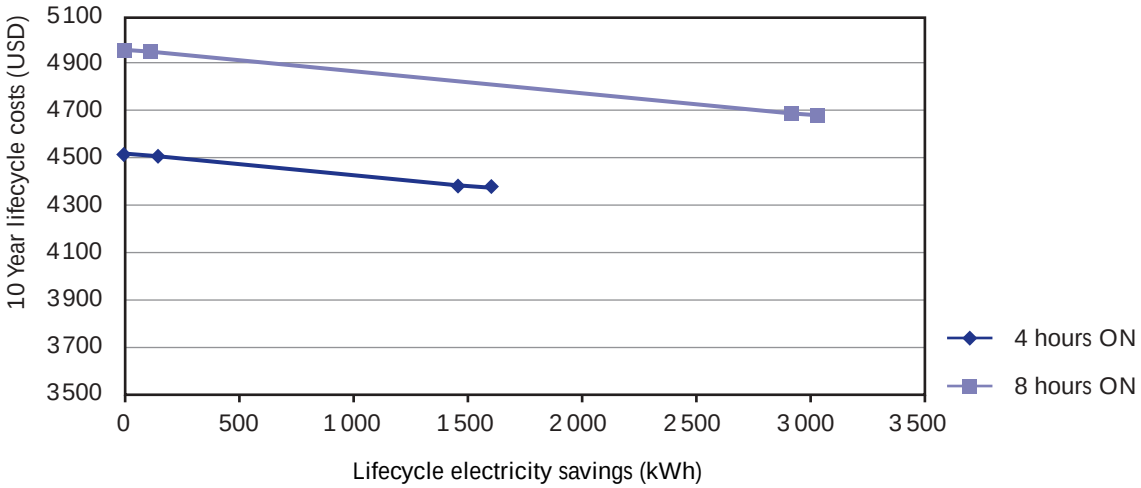
increase the capital cost to the extent that these outweigh the electricity savings. This type of analysis is useful to determine the least life-cycle cost (LLCC), in other words the point at which the product design is optimised to be cheapest to consumers, including the capital and running costs (see OECD/IEA, 2003, pp. 153 for further details). The energy performance of a product when it reaches the point of LLCC is therefore often used as a reasonable level to set as a policy objective. It should be noted that by incorporating a carbon price in the cost of electricity would have the effect of increasing the stringency of policy targets.

Figure 112 • Potential lifecycle cost and energy efficiency improvements for plasma televisions



Source: adapted from Fraunhofer, 2007b.
The figure shows the results for two usage patterns, one the TV in ON mode for 4 hours per day, and the second with the TV in ON mode for 8 hours per day. A discount rate of 10% has been used to provide the NPV of future electricity cost savings.

Other options offer even greater savings potential, such as backlight modulation or dimming for LCD and improved luminance efficiency for plasma TVs in the short term, and the development of OLEDs in the longer term, although there are currently questions about whether these will become technically and commercial viable within the current market.

On the other hand, trends such as the shift towards larger screen sizes, higher definition TV and other picture quality improvements will tend to increase the amount of energy used by new televisions. Proprietary issues such as technology patents will also continue to limit some technology development. While it remains to be seen which of the various competing technologies come out on top in the medium- to long-term, it is unlikely that the aim of achieving increased energy efficiency will become an important industry driver. At the present time and from the viewpoint of manufacturers, consumers appear largely unaffected by the energy implications of their TV purchasing decisions although whether this is because consumers are unaware that larger screens lead to more energy consumption is open to discussion.

Nevertheless to the extent that some technologies offer both improved picture quality and better energy performance, some overall improvements are likely. To go further than towards the levels of efficiency that represent LLCC and at a more rapid pace than would otherwise occur will require new policies which provide the right signals to the television industry.

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Policies for energy efficient televisions

The policy landscape

Most countries with efficiency policies for televisions have focussed only on standby power rather than the more significant area of *on* mode energy consumption. Of these, some voluntary programmes, such as the EICTA Commitment in Europe, have not been renewed due to difficulties in maintaining compliance in a market with a growing number of imported products (EICTA, 2007).

With the arrival of flat panel technologies, the existing energy performance test method, which had been devised for CRT screens, required updating. Work by the International Electrotechnical Committee (IEC) to produce an energy measurement standard for new flat screen technologies (IEC 62087) has now been largely completed and should be published in early 2009. However, for several years, the lack of a credible test method has hindered the development of policies.

A growing number of governments have implemented or are now examining options for policy measures for televisions, which are summarised in Table 59. In most cases, it is too early to determine the impact of these policies.

Table 59 • Summary of current national policies for televisions

Country	Programme type	Television category	Mode	Status
Canada	Endorsement label	All	standby	Current
Japan	Top Runner	CRT, LCD, Plasma	all modes	Current
China	MEPS	CRT	all modes	Current
China	Endorsement label	All	standby	Current
U.S. (Energy Star)	Endorsement label	All	all modes (revision)	November 2008
Brazil	Comparison label		standby	Current
Australasia	MEPS & comparison label	All	all modes	Under consideration
Europe	MEPS	All	all modes	Under consideration
India	Endorsement label	All	standby	Under consideration

Key policy considerations

In view of the huge financial stakes involved, the television industry is perhaps even more highly attuned to the demands of a competitive marketplace than is the case for other electronic products. The industry is dominated by a small number of major brands which make very large investments in research and development into technologies and manufacturing processes in order to gain market share.

While these companies continuously make short- and long-term strategic decisions to compete in this rapidly evolving market, it is clearly not a trivial matter for the industry to cope with new

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drivers beyond those imposed by the current marketplace. For the television industry to adopt a significant and new emphasis on energy performance will require a substantial re-alignment which will take time. On the other hand, it will not happen without clear direction in the form of public policy.

Broad issues relating to public policy aimed at reducing energy consumption by electronic devices are discussed in chapter 4. However, it is recognised that there is considerable scope to improve television efficiency and therefore this aim should be an important component of future policy. To improve television efficiency, effective policies should accommodate the dual objectives of encouraging the uptake of the most energy efficient models currently available in the short term, and stimulating the emergence of new energy efficient technologies in the longer term.

There are several drawbacks to prescriptive policies which are especially relevant to televisions. The prevalence of proprietary technologies inhibits the potential for industry-wide solutions, while picking short-term winners may cut off development paths which could lead to significant future improvements. For these reasons, policy measures that are technology-neutral and allow individual companies the flexibility to make strategic decisions on how to meet energy performance targets are likely to be most effective.

Performance-based measures can also more readily accommodate issues of convergence, such as the decreasing separation between televisions and computer monitors. In this case, a policy measure which targeted displays and other common elements irrespective of whether they were eventually used in a monitor or television would be more realistic (noting that a manufacturer may not actually know the final application of the product).[2] As technology develops, policies should not target any one mode of operation but preferably need to be able to impact on all modes.

These are some of the important issues to be considered by policy-makers. They demand challenging long-term goals or targets for energy performance agreed between both governments and stakeholders in the television industry, preferably on a global scale. These would be supported by specific policies and measures implemented by governments, including agreed interim milestones or steps which can be taken in the short term.

Policy options and projected energy savings

Calculating the costs of improvements in television technologies is particularly difficult in an environment when the capital cost of the dominant flat screen technologies and their components have been falling so quickly in recent years. It is further complicated by the broad range of efficiencies within television categories, indicating that more efficient technologies are currently competitive. As a result, the savings estimate from switching to least life-cycle costs (LLCC) is likely to be conservative. Nevertheless, these policies would cut the estimated electricity consumption in 2030 by over 20%, saving 160 TWh per year.

2. *More detailed consideration of how policies can accommodate convergence and variations in functionality is provided in chapter 4.*

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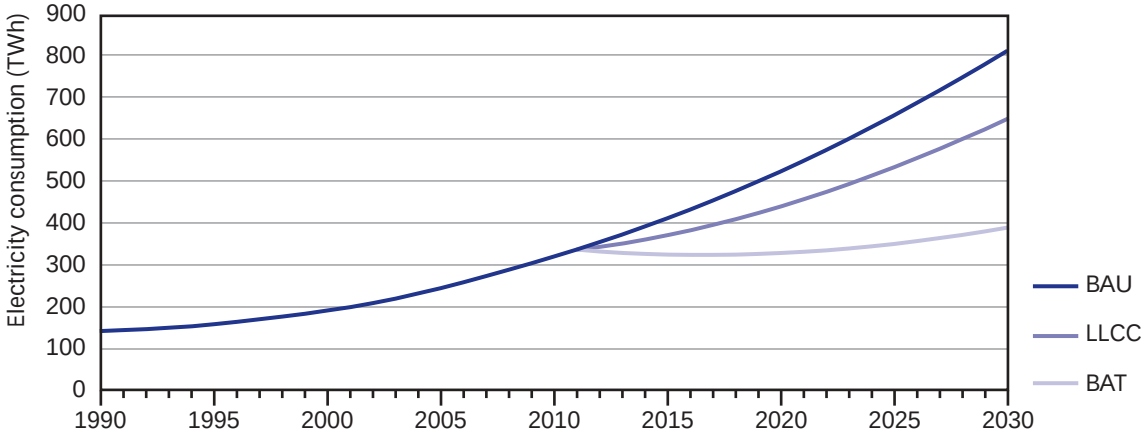
If policies were implemented which led to the uptake of the best currently available technology, then electricity consumption in 2030 could be halved, saving an estimated 420 TWh (see Figure 113).

Figure 113 • Estimated electricity savings from implementation of LLCC and BAT policies



Source: IEA estimates.
The LLCC and BAT scenarios assume policy implementation in 2012.

Recommendations

Televisions have undergone a rapid transformation in recent years as flat screen technology has replaced bulkier traditional screens. Unconstrained by space limitations and encouraged by falling prices, consumers continue to purchase televisions with larger screens for primary use, often keeping, rather than replacing older televisions. Consequently, the number of televisions is growing in most countries. Televisions are also switched on for longer periods of time, although they may not be watched. Increased use of games consoles and programme recording devices have extended viewing hours. These developments are leading to increases in energy use of approximately 5% per annum.

However, current technologies vary in efficiency and therefore savings can be realised through implementing policies to promote the best performing products presently available. In addition, technologies with even higher efficiency levels are on the horizon and require policies which stimulate the market sufficiently to make them commercial.

As part of the package of recommendations on energy efficiency policies made to G8 Summits in 2006, 2007 and 2008, the IEA made the following recommendations regarding policies to encourage more energy-efficient televisions (OECD/IEA, 2008):

> *(3.3c) Governments should implement energy efficiency policy measures for TVs and set-top boxes designed to:*
>
> > *i) Promote the best-performing current TV products and technologies;*
> > *ii) Stimulate the market entry of new television technologies which aim to halve TV energy consumption compared to current performance levels;*

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Analysis in this publication has supported the addition of more detail to these recommendations, as follows:

- Policy measures should be designed to move the market towards the most efficient products currently available, and which provide a market incentive for manufacturers to offer increasingly efficient products. A combination of minimum energy performance standards and appliance labels will achieve these objectives.
- Energy performance labelling in particular should be technology neutral to allow consumers to compare all types of televisions, and include information on the estimated running cost of TVs according to an average duty cycle.
- Energy performance indices used for MEPS and labels should ensure that thresholds better reflect overall energy consumption (not just efficiency) by requiring larger screens to meet more stringent levels compared to smaller screens.
- Policy measures should move towards horizontal measures spanning all display technologies, with allowances for particular functions, such as for tuners, as appropriate.
- Strategies designed to support the commercialisation of new television technologies which offer the potential to halve the unit area consumption of displays should be developed and implemented. There are several candidate technologies which offer potential, including advance backlight modulation of LCDs and OLEDS, but other options may also warrant this support.

These policy recommendations are appropriate for consideration by all governments.

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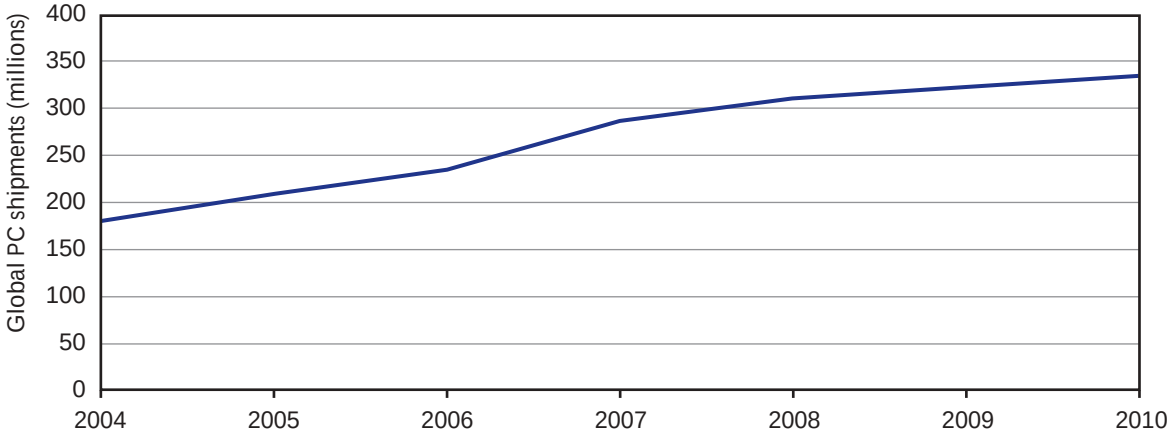
Chapter 6 • COMPUTERS AND MONITORS

Introduction

Sometime between now and 2010 the number of people using a personal computer (PC) will pass the one billion mark (Kanellos, 2008). The chances are that the one-billionth customer will live in a non-OECD country and use the PC to connect to the Internet, like the majority of other residential owners in the world.

Despite predictions since 2000 that PC sales would fall as markets became saturated, demand continues to grow with annual shipments predicted to rise by 15% to 310 million units in 2008 and reach 334 million by 2010 (see Figure 114) (Networkworld, 2008).

Figure 114 • Global PC shipments, actual and estimated, 2004-2010



Sources: Networkworld, 2008; Metric, 2006; Systems, 2006.

Growth in some OECD countries has slowed in recent years, most notably in Japan which is the first major economy to experience falling PC sales over a prolonged period, causing the withdrawal of some manufacturers from that market (AP, 2007). However, the situation is not uniform: PC sales in Western Europe during 2008 were 23% higher than the previous year, and in the UK sales were up by 27% over the same period (PC Retail, 2008). This growth occurred in a market which showed reasonably high penetration rates as shown in Figure 115, indicating that not only is the number of households which own a PC increasing, but also that the number of PCs per household is growing. In the United States and Japan, there are estimated to be over 1.5 computers per household, and such saturation rates may well occur in other OECD countries (Roth *et al.*, 2007; EECJ, 2007).

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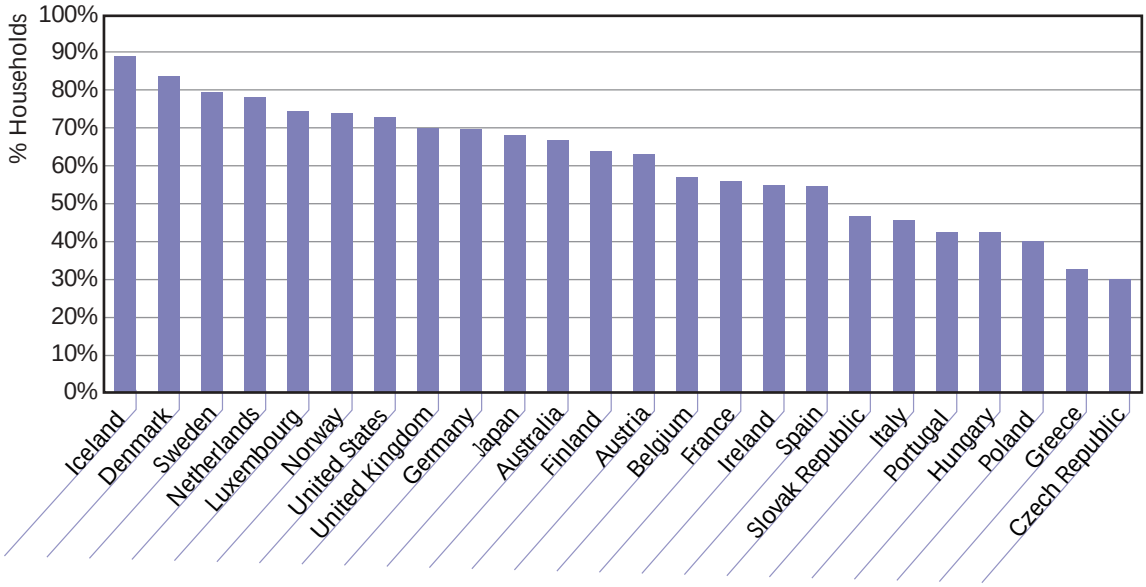
Figure 115 • Household penetration of PCs, 2005



Source: OECD, 2007; TBA, 2007; ECCJ, 2007.

Drivers for PC growth in the OECD

Continual improvement in PC performance, new applications and markets are amongst the factors which are driving growth in OECD countries. The use of computers for gaming and video streaming, for example, requires (for optimal viewing) higher performance hardware than available on many older PCs, creating a vibrant replacement market, often stimulating the retirement of PCs well before the end of their technical lifetime. The general reduction in the price of PCs and periodic discounting also help to stimulate this market. Computers are also being increasingly used in the home by both older and younger age groups than traditionally has been the case, and by students and those that spend some of their time working from home.

These two latter groups are helping to increase the share of portable computers (laptops[1] and notebooks), which have become more price competitive with desktops and are no longer primarily sold for commercial use. As a result of this trend, it is estimated that annual sales of laptops will rise by 35% and comprise over 40% of all PC sales in 2008, many of which are destined for the residential market (Networkworld, 2008).

1. Portable PCs are referred to throughout this book as laptops, although elsewhere they may be referred to as notebooks.

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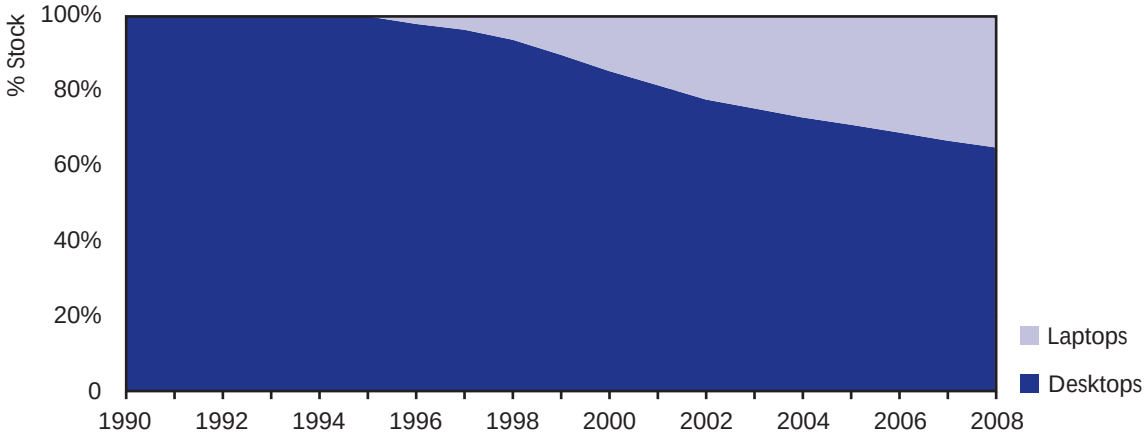
Figure 116 • Estimated share of global PC stock by technology, 1990-2008



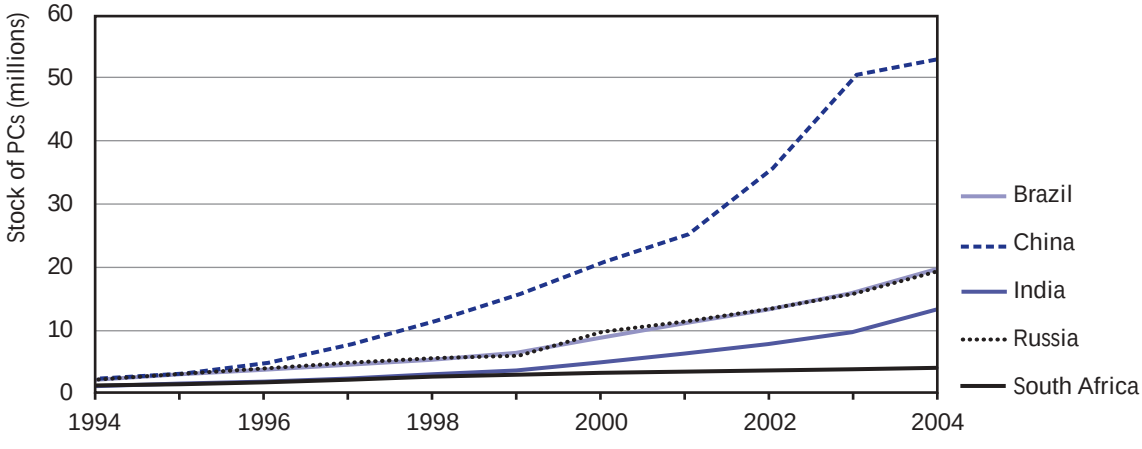
Source: IEA estimates.

Drivers for PC growth in non-OECD countries

Global PC sales are also swelling from demand in non-OECD countries, where the market is growing more rapidly than OECD countries. Between 1994 and 2004, the ownership rate has increased by over 30% per annum in the BRICS[2], with nearly half a billion PCs sold in these five countries over this period (see Figure 117). Recent information suggests that this trend is continuing: for example the market in Russia rose to 6.1 million PCs in 2006 (Gidabyte, 2006).

As in the OECD, laptop PCs are gaining their share of the non-OECD residential market, although at a slower pace.

Figure 117 • Growth in stocks of PCs in BRICS, 1994-2004



Source: OECD, 2007.

2. *BRICS countries include Brazil, Russia, India, China and South Africa.*

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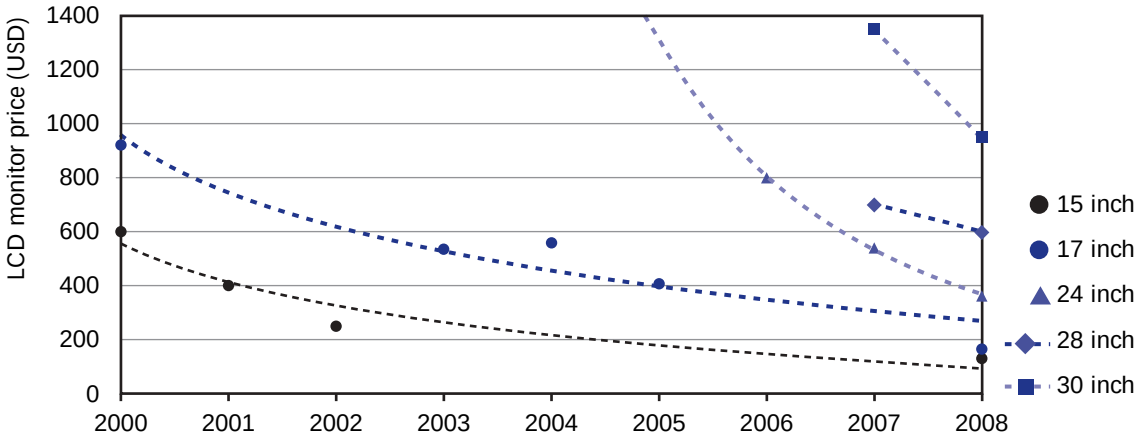
The changing face of computer monitors

With the switch away from desktop PCs, the market for monitors has also decreased, although this has been masked by the emerging market for flat panel monitors. As with TV screens, prices for flat panel LCD monitors have fallen sharply by nearly 20% per annum on average[3] (see Figure 118), fuelling a rapid growth in market share. Although LCD monitors are still more expensive than CRT monitors, the additional benefits of less bulk and aesthetics have great consumer appeal and have caused many householders to prematurely retire their more bulky CRT screens.

Figure 118 • Typical LCD PC monitor costs, 2000-2008



Source: Dealnews, 2007; DisplaySearch, 2002; EE Times, 2006; TG Daily, 2008; TNO, 2008; IVL, 2007.

Initially the majority of consumers opted for screen sizes equivalent to their previous CRT, either 15 or 17 inch, but as prices for larger monitors continue to fall, both in standard format and widescreen, the share of sales for 19 to 30 inch monitors is growing substantially.

Nor is the shift to LCD monitors the preserve of OECD countries. For example, more than 80% of computer monitor sales in Asia non-OECD comprise LCD screens and in India LCD monitors captured more than half of the market in mid-2008 (ZDNET Asia, 2007).

These changes have meant that the presence of CRT monitors is dwindling, representing only 10% of sales in 2006 (Hachman, 2007). Nevertheless, there are some consumers who still prefer CRT monitors, most notably for applications which involve fast moving pictures and the need for high resolution graphics, such as gaming and design work. Despite improvements to LCDs, these niche markets are likely to ensure that there is a small demand for CRT monitors, or an equivalent, for some time to come.

3. *Prices for LCD monitors are quite volatile as a result of mismatches between supply and demand, discounting and competition for raw materials with TV production.*

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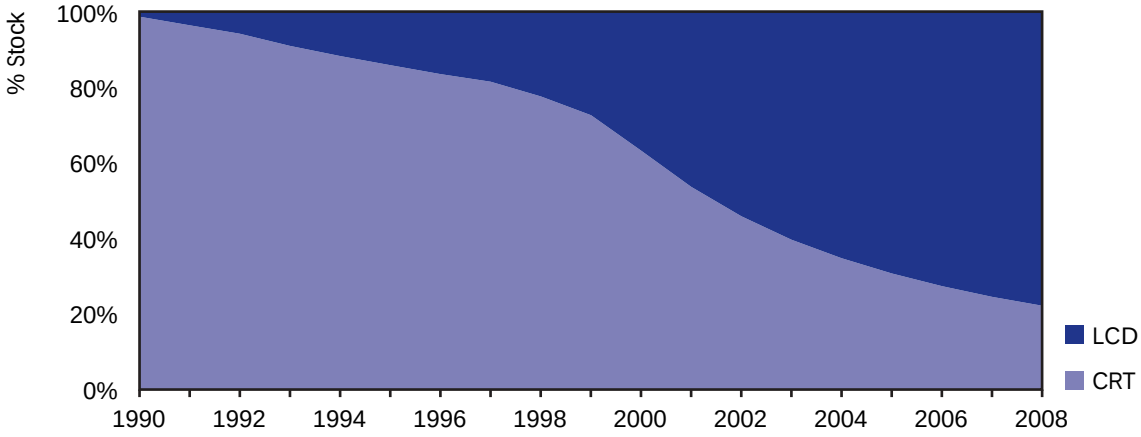
Figure 119 • Estimated share of global PC monitor stock, 1990-2008

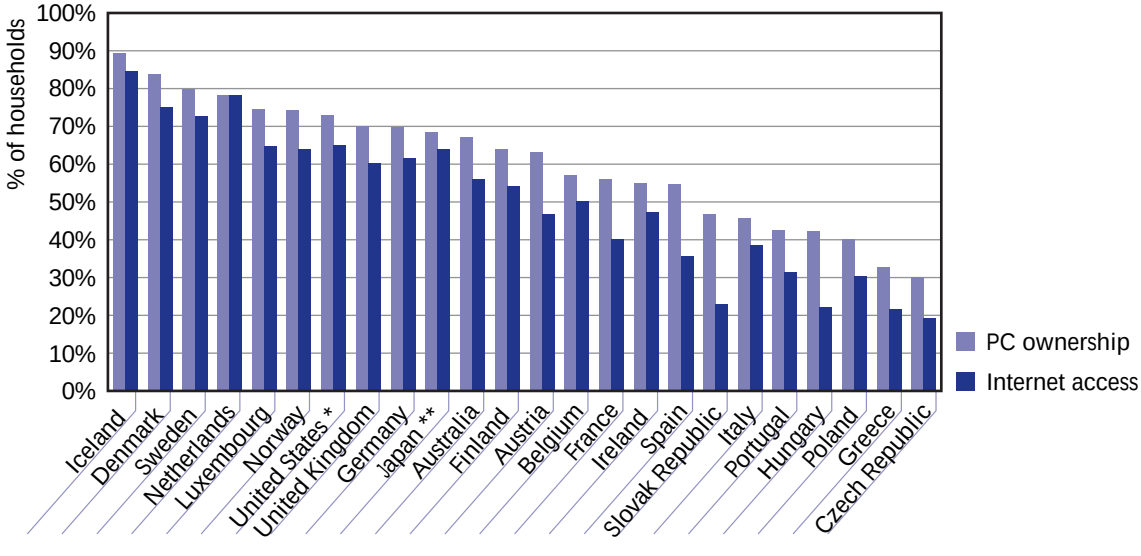


Source: IEA estimates.

The Internet

Overlaying the trends mentioned previously, access to the Internet for a range of functions is now one of the most significant reasons why householders own a PC. The strong correlation between household Internet access and PC penetration is evident in Figure 120.

Figure 120 • PC penetration and Internet access, selected countries, 2005



Source: OECD, 2007; Shibatani, 2007; PEW, 2008.
* Internet access derived from PEW (2008) for 2008. ** Internet access from Shibatani (2007) for 2007.

Access to the Internet, and particularly broadband, is high on the political agenda and seen as an important part of the social infrastructure. All OECD governments and many others have therefore implemented a raft of policies to support the development of the technical infrastructure

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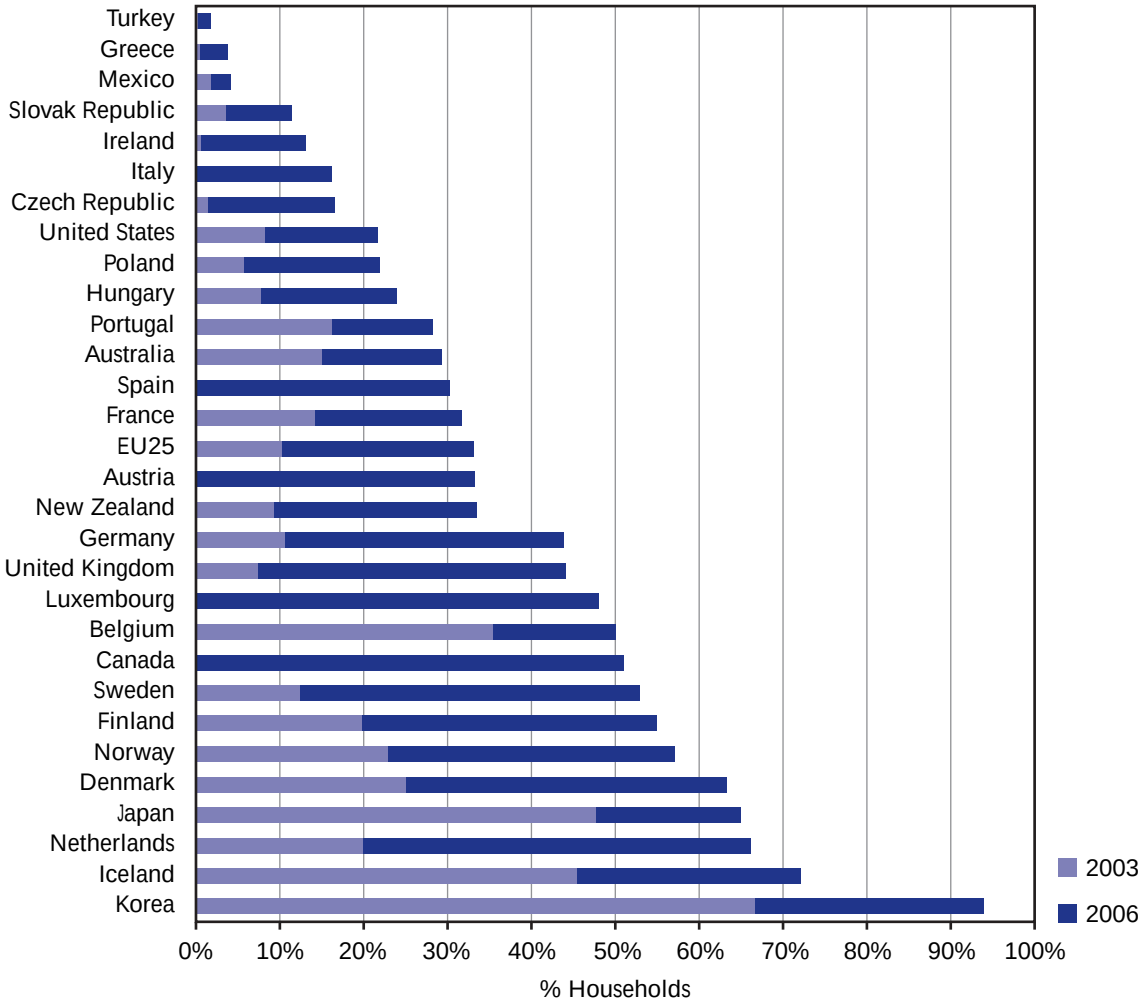
and improve access, with the result that the number of broadband subscribers in the OECD rose from 83 million in 2003 to 221 by June 2007. These broadband subscribers represent 60% of all subscribers to a fixed Internet connection in the OECD (OECD, 2007; OECD, 2008).

Figure 121 • Households use of broadband in selected OECD countries, 2003 and 2006 (or available years)



Source: OECD, 2008; Shibatani, 2007; PEW, 2008.
Where no data is available for 2003 or 2006, data from the nearest years has been substituted.

Changing patterns of use

Despite competition from other potential activities and technologies, householders are spending more time on their PCs than ever before. This is relevant to a consideration of energy issues because it indicates a growth in the time which PCs spend in active use. While this is less important to overall energy consumption of PCs than the proportion of PCs with power

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management[4] (for reasons discussed in more detail in the section below on *Energy Issues*) it is nevertheless significant.

PCs have become more prevalent amongst students, and many educational establishments require students to have access to a PC at home. This not only has an impact on ownership rates, but also indicates that many students are spending more time using a PC at home.

Although PCs are used for an increasingly diverse range of activities, one major growth area over the last decade has been in time spent on the Internet, particularly amongst broadband users. Household access to broadband has been significant because it has allowed simultaneous multiple connections to the Internet: not only making ownership of more than one PC per household more attractive, but effectively removing the limitation on the total number of hours spent on the Internet per household.

Several studies suggest that the average time spent on the Internet has increased by between 10% and 20% per year in most regions, even though there is considerable variation amongst countries, categories of users and individuals (Guardian, 2006; Nielsen, 2008). Increased use of PCs to watch films, communicate via voice-over-Internet protocol (VoIP) and participate in social networking, have all contributed.

Launched in 2003, Skype is the best known voice-over-Internet protocol (VoIP) service, with over 300 million subscribers[5] who made an estimated 16 billion minutes of calls in the first quarter of 2008, a 100% increase from 2006 (Wikipedia, 2008). Social networking is also becoming extremely popular since it emerged in South Korea in 1999. *MySpace* and *Facebook* both have an estimated international subscriber base of 115 million[6], and there are several further regional networks with a growing number of subscribers (IHT, 2008; PPI, 2007).

Another trend leading to an increase in the use of PCs in OECD countries includes a rise in the number of people working from home, or *teleworking*. For example, the number of teleworkers in the United Kingdom has doubled in the eight years between 1997 and 2005, while in the United States an increase of 23% was recorded between 1990 and 2000. An estimated four to six million people in the United States now telework at least one day per week (USC, 2004; EGov, 2005; Roth, 2007). Although such developments will be reflected in an increase in residential PC usage, clearly most of this will merely substitute for PC use in the commercial sector. Furthermore, looking at the bigger picture, teleworking may also yield additional energy savings in the form of reduced travelling.

Energy issues

Energy basics

Computers have a wide variety of different technical specifications, such as type and size of monitor, hard disk capacity, facility to play and record CDs and DVDs, volume of memory, processor type and speed, and graphics capability. As a result the distribution of power required

4. *So that the PC goes into a low power mode, called standby or* sleep, *when not being actively used.*
5. *Note that some users may have multiple accounts.*
6. *No estimates are available on the number of users subscribing to both.*

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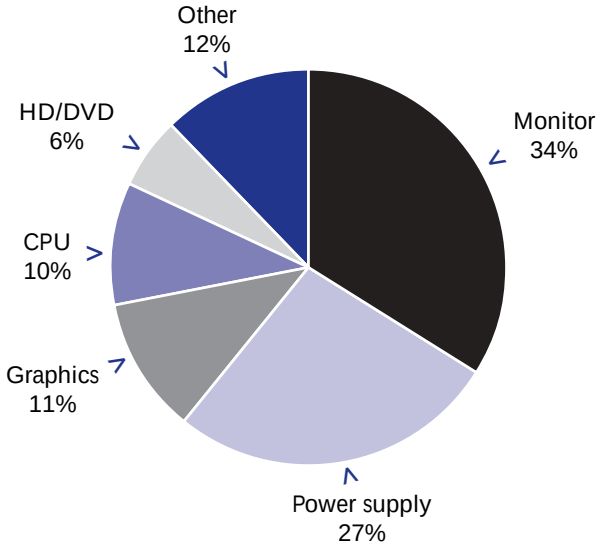
in a PC system varies considerably; however the monitor and power supply usually comprise the largest single loads, as shown in Figure 122.

Figure 122 • Estimated distribution of power amongst components in a typical desktop PC with LCD monitor



Source: IEA estimates.

A typical home PC and monitor draws from zero when switched off, to between 90 and 150 watts when used to its maximum capabilities.

While some PCs have a hard off switch, these are seldom used. Instead most PCs are turned off using a more accessible soft switch, which still uses a small amount of power, in the region of 0.5 to 5 watts.

As a PC is booted up, power is supplied to all the components until it reaches a state in which the operating system and other software have completed loading. This is often referred to as the *idle* mode, since the PC is ready to operate but not actually performing any useful tasks for the user. The most power is drawn by the PC and monitor when being actively used, although the power required will vary according to how heavy the workload is on each of the various components.

In addition, most PCs and monitors have the capacity to go into one or more low power modes, with the main one being *sleep.*[7] These modes are driven by power management software settings which turn off various energy consuming components and activities automatically

7. *Microsoft used the generic term standby for sleep mode prior to the introduction of Vista. Some PCs also have a* hibernate *mode, with similar power levels to* sleep *but resilient to the loss of power.*

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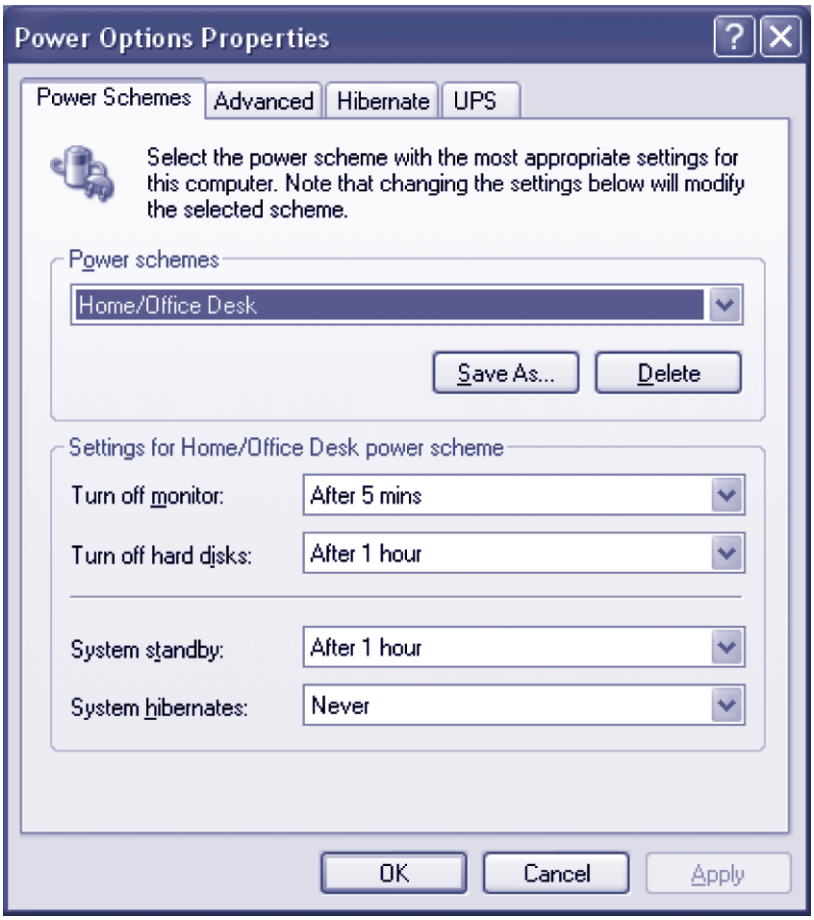
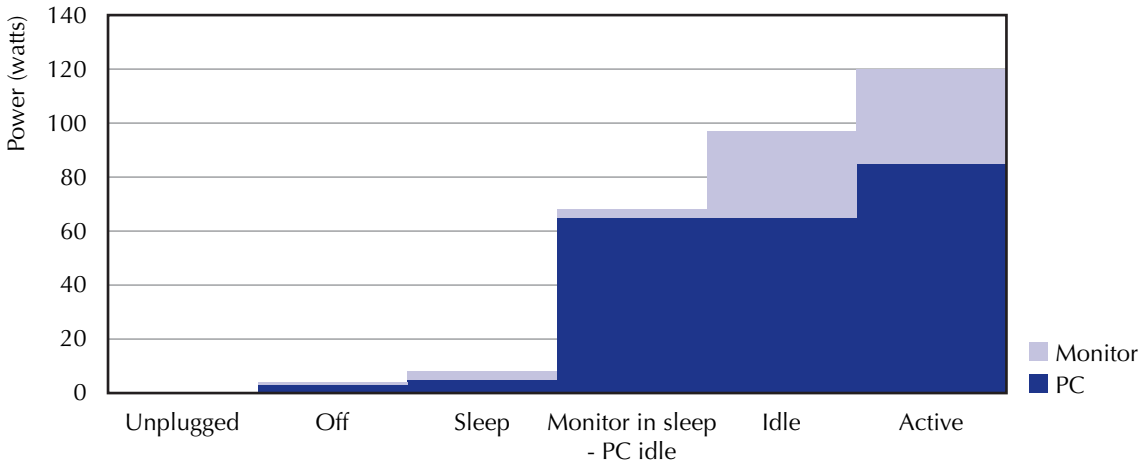


after a prescribed period of inactivity. These can be accessed and altered by the user in most PCs using a drop-down menu. Typical values for the power drawn in these various modes are shown in Figure 123.

Figure 123 • Typical estimated desktop PC energy consumption in different modes



Source: IEA estimates.

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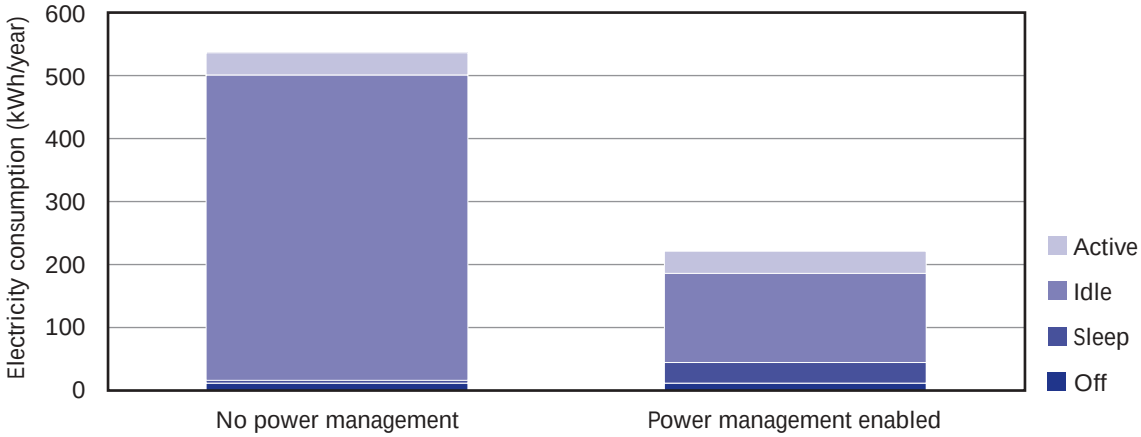
Power management is crucially important in the overall electricity consumption of PCs and monitors, since many PCs are switched on but not actually actively used for long periods of time. Figure 124 demonstrates that for a typical user profile, the ability to automatically enter into a low power mode when the PC is not being actively used can cut electricity consumption in half.

Figure 124 • Estimated annual electricity consumption of desktop PC and monitor with and without power management



Source: IEA estimates.

However, studies have shown that users rarely employ the power management facility to maximise savings. Typically less than 10% of users employ the *hibernate* mode and fewer than 25% of users activate the *sleep* mode on their PC. Power management of monitors is more common, enabled in around 70% of cases (EES, 2006; MTP, 2006).

Although the power settings can be altered with relative ease, in practice the factory settings are often never adjusted by consumers; and not all suppliers ship products with management enabled. Another explanation why power management is not used to its full potential is that some users dislike the time delay taken to reach a functioning state from the low power mode.

In the past, computers joined to others on a local area network, including via the Internet, lost the link when their PC went into sleep mode, with the result that many users on a network (typically in commercial sectors) de-activated the power management function. Despite improvements, such as the development of *Wake-on-LAN* (WOL) to enable PCs to wake up in response to a remote signal, maintaining network connection still frustrates efforts to achieve effective power management (Nordman *et al.*, 2007).[8]

8. Work is ongoing in this area, for examples of potential solutions see: http://www.ethernetalliance.org/

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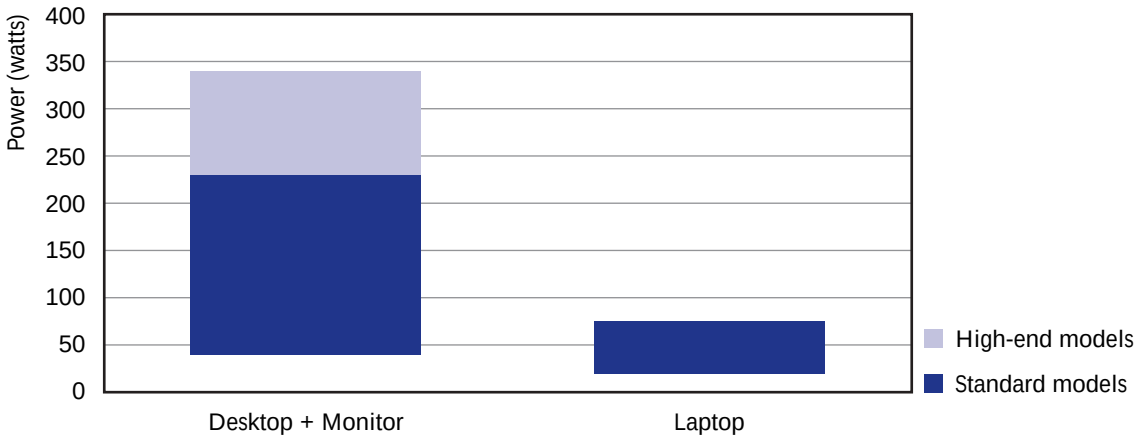
Performance of PCs

There is a wide variation in the amount of energy consumed by the range of desktop models. Although high performance products suitable for gaming and similar applications are located at the high end, and products at the bottom tend to have lower than average performance, the energy consumption of the bulk of products lies within a broad range, even though they all have similar performance attributes.

Laptops almost always consume far less energy than desktop PCs. A typical desktop connected to a 17" LCD display uses approximately three times the energy of an average laptop, and the difference would be even larger if a CRT monitor was used.

These two points are illustrated in Figure 125, which shows the range of power drawn by desktops and monitors, compared to laptops, when all are in idle mode.[9]

Figure 125 • Range of power drawn by PCs in idle mode



Source: IEA estimates.

The explanation is a simple one: in the portable PC market there are dominant commercial incentives to extend both the life and weight of the battery which can be achieved by making the laptop consume less power. Even though laptops may be plugged into the mains power supply for substantial amounts of time, the number of hours that it can operate on batteries only, together with the product weight and dimensions, are key product design criteria and a major part of supplier marketing strategies. As a result, laptop designers have put considerable effort into making products as energy efficient as possible.

How do laptops do it?

Portable computers achieve low energy consumption through optimising the efficiency of the individual components used, improving the way in which they interact, and introducing power

9. *Idle mode is where a PC is fully on and waiting to perform tasks, and is responsible for over 90% of the energy consumed by the PC in typical use.*

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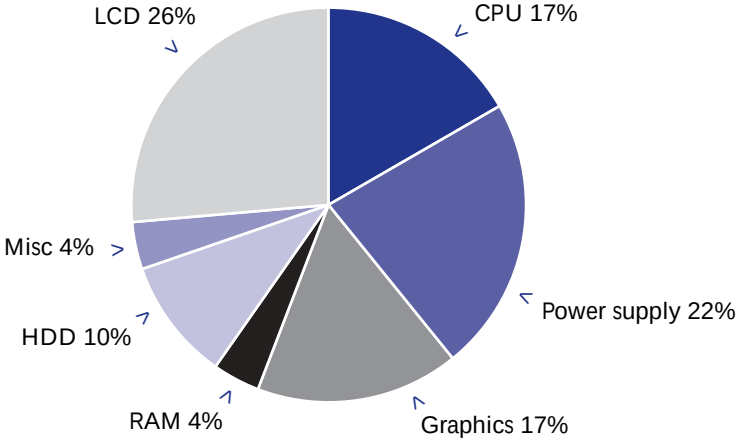
management processes which ensure that energy is only consumed when it is providing a useful function. The close attention to the design of each of these elements has brought about a dramatic reduction in energy consumption.

Clearly, the small size of most laptops compared to typical desktop monitors provides a major advantage. Nevertheless, as the demand for portables with larger screens has increased, laptops have had to minimise energy consumption by screens, leading to technology improvements such as dynamic dimming techniques and LEDs, the benefits of which are described in chapter 5 on televisions. As a result, the screen in a portable PC consumes relatively modest proportions of the overall energy used, as shown in Figure 126.

Figure 126 • Distribution of electricity consumption in a typical portable PC



Source: IVL, 2007.

To reduce size, weight, and minimise the need for internal cooling mechanisms such as fans, portable PCs use external power supplies.[10] These tend to be more closely matched to the power requirements of the laptop and often have efficiencies between 70% and 80%, compared to the internal power supplies in desktops which are often oversized and have efficiencies in the range of 60% to 70% (Ecos, 2008; Intel, 2002; IVL, 2007).

In recent years specific microprocessors (chips) have been designed for mobile applications, which are much more efficient than the products used in standard desktop PCs. In general, the power required by chips in the central processing unit (CPU) has increased considerably as they have become faster and able to undertake a greater number of tasks. This is illustrated by the progression of the maximum power drawn by Intel chips from around 5 watts in 1989 to 75 watts in 2000, as shown in Figure 127.

10. The use of switching power supplies also make laptops easier to charge in countries with a variety of mains electricity voltages/frequencies.

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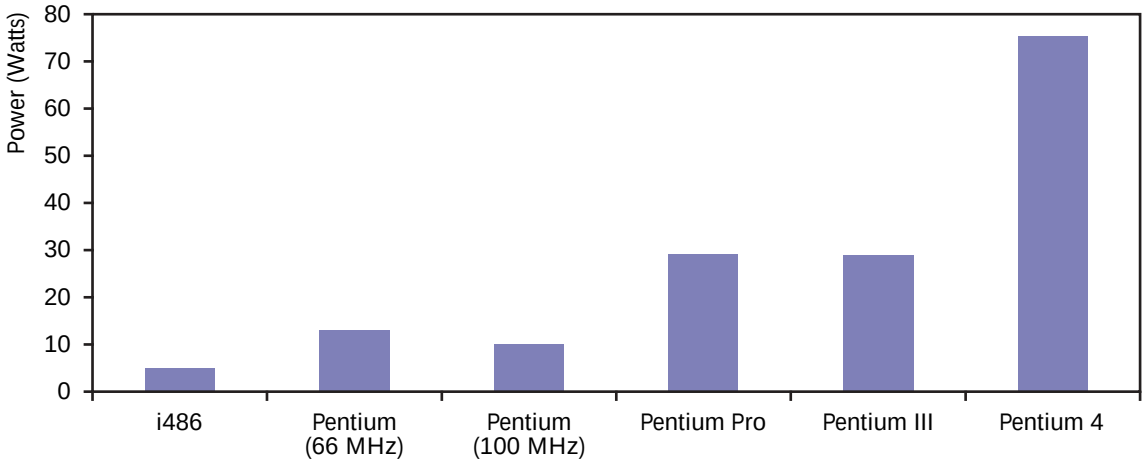
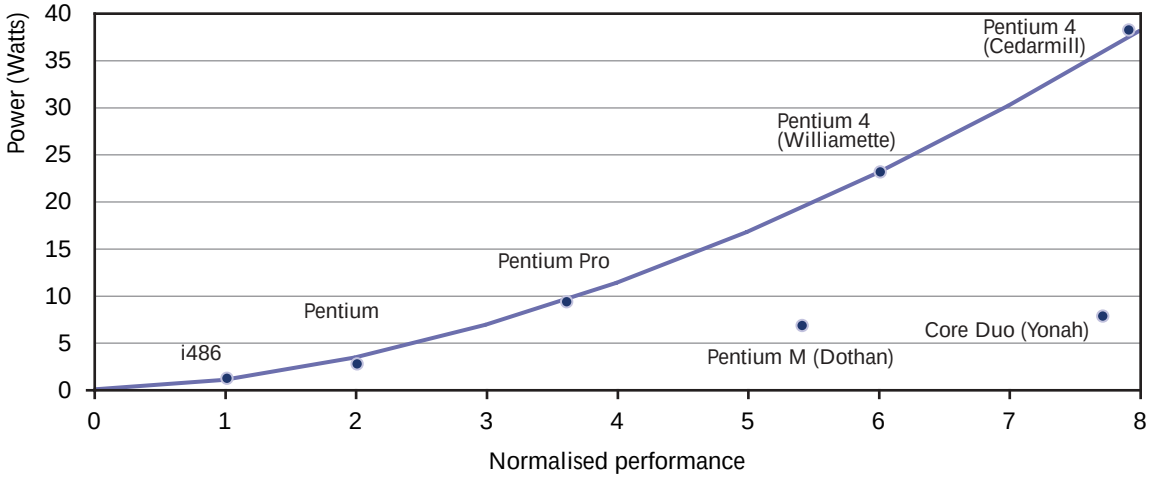
Figure 127 • Maximum power draw of Intel microprocessors



Source: Growchowski *et al.*, 2006.

Figure 128 shows the normalised performance[11] of these chips against their power consumption, corrected for various changes in architecture. It demonstrates that the energy efficiency of these desktop chips has decreased over time such that the Pentium 4 chip consumes 38 times more power, while delivering eight times the performance of the i486 processor (Growchowski *et al.*, 2006). [12]

Figure 128 • Power draw of Intel microprocessors vs. normalised performance



Source: Growchowski *et al.*, 2006.
The trendline in this figure represents performance to the power of 1.75.

11. Performance is measured using SPECint, a computer benchmark specification for CPU's integer processing power, maintained by the Standard Performance Evaluation Corporation (SPEC).

12. Note that this performance measure does not account for the time taken to process an instruction, and is therefore only one measure of performance.

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However, two chips shown above have both high performance and efficiency. Both were developed primarily for mobile applications: the Pentium M (Dorian) in 2003 and the Core Duo (Yonah) in 2006. The latter draws only 20% of the power of a Pentium 4 while having a nearly identical performance rating.

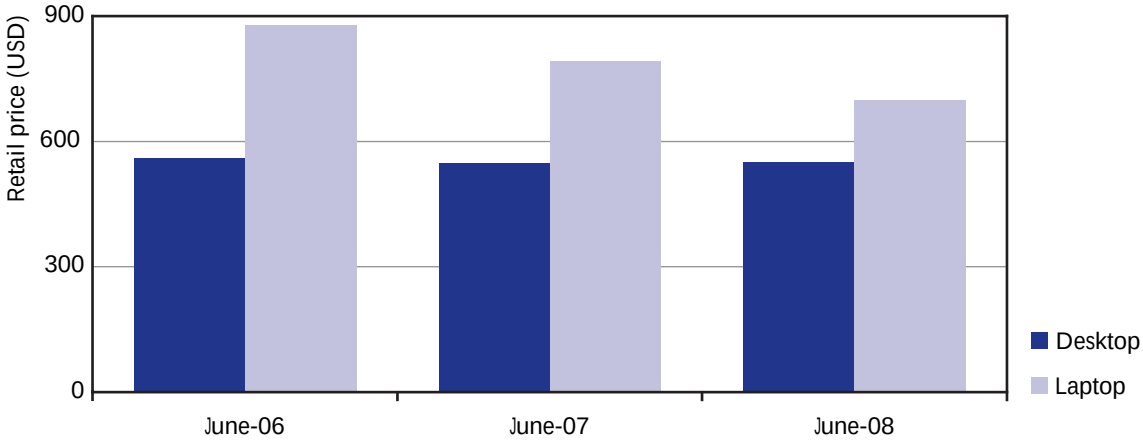
Although Intel chips have been used in these examples, other major manufacturers have similar ranges of microprocessors available, many of which are integrated on the motherboard with graphics and sound processors which have optimised low-energy configurations.

Low power CD and DVD drives/recorders and other components have also been developed for the laptop market in order to push down the overall energy consumption of these devices and extend the battery life. Most recently, hybrid hard drives have become available which use flash memory and save approximately 15% of the energy consumed in a typical desktop model. By using some of these laptop components within a modern desktop PC, the *idle* mode power consumption can be reduced to 20 watts or less (Ecos, 2008).

However it is the ability to power-manage all the components to provide only the energy required for the functions that are being used that contributes a large amount of the savings in laptops. Effective power management covers a range of activities primarily controlled by the software, including throttling down the processor at appropriate times and ensuring power is not supplied to components which are not being used. Laptops also have facilities to dim the screen to reduce power consumption. As a result, laptops minimise energy when they are in idle mode, as well as reducing the time in which they spend in this mode by promptly moving into sleep or hibernation modes. Although all PCs have power management software that can be altered by the consumer, laptops tend to be shipped with more aggressive factory settings and accompanied by obvious warnings about the impact on battery life if these are altered.

What is particularly impressive about these achievements is that they have been made while at the same time the average price of a laptop has fallen relative to desktops in many markets (see Figure 129). This strongly suggests that many of these improvements have resulted in few additional costs, or have enabled costs savings to other components.

Figure 129 • Average retail price of PCs in United States, 2006-2008



Source: Reisinger, 2008.

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Monitors

The switch away from CRT monitors to flat panel screens has occurred extremely swiftly and brought with it a bonus in terms of energy saving. As shown in Table 60, the power consumed by monitors varies by technology, with the typical LCD screen drawing one-half to one-third of the power of an equivalent sized CRT monitor.

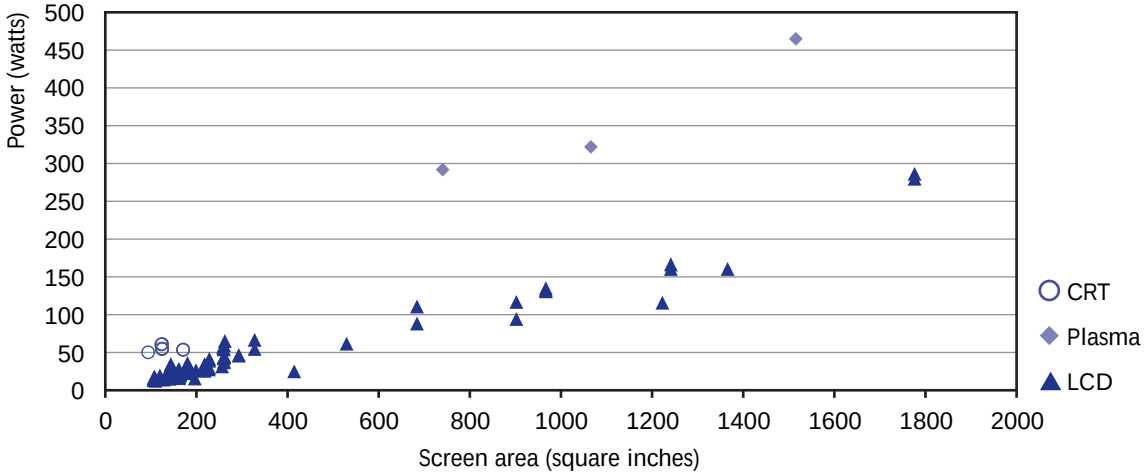
Table 60 • Power consumption of PC monitors by technology

	Power consumption (watts/square inch)		
	Average	High	Low
CRT	0.43	0.53	0.31
Plasma	0.33	0.39	0.30
LCD	0.15	0.25	0.06

Source: Energy Star, 2008.

The power required for most screen technologies increases with larger screen areas, as well as other factors such as the resolution (for LCD and Plasma screens), as illustrated in Figure 130.

Figure 130 • Power draw by PC monitors vs. screen size



Source: Energy Star, 2008.

One of the major drawbacks of CRT monitors is that they are bulky, and so screens tended to be kept small to be easily managed, particularly in the home environment. A benefit of flat screens is that they allow larger screen sizes without needing large amounts of desk space, and as a result the average screen sizes of LCD monitors has increased in recent years. A part of this is due to an additional transition towards the widescreen format, particularly popular in Asia, with the market share growing from 9.1% in 2006 to 37.2% in 2007 (IDC, 2008).

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Therefore, although LCDs use less energy per unit area compared to CRTs, the growth in the average screen size has reduced the impact of the switch to LCD technology on overall energy consumption.

As discussed in Chapter 5 on televisions, the numerous opportunities to make further energy savings in screen technologies also apply to PC monitors. In addition, improvements to external power supplies (EPS) will also impact a share of the monitor market, and the potential for savings in this area are discussed in Chapter 9.

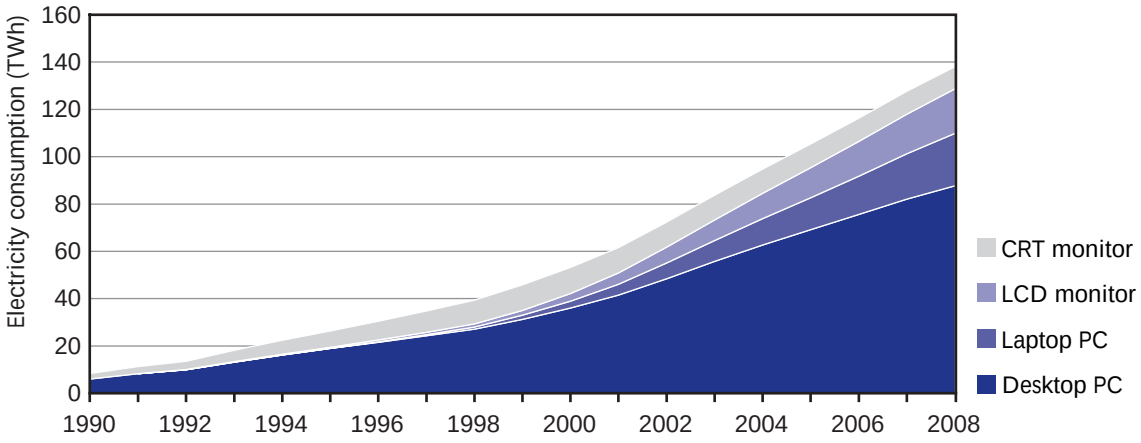
PC and monitor energy consumption

There have been considerable improvements made in many aspects of PC design in recent years, particularly in the efficiency of power supplies and in the reduction of power drawn by products in low-power modes. Many desktops now use twin power supplies in order to maximise the efficiency of power supplied for small loads, as well as at higher loads when the PC is active.

As is typical in ICT, the gradual improvement in energy performance has largely been the result of on-going collaboration and co-operation between many sectors of the industry, including the manufacturers of PCs and components, software producers and chip designers. Many of the leading PC suppliers have made individual commitments to the development of more efficient products, and worked collectively with initiatives such as *80 Plus* and *Climate Savers*.

Nevertheless, the overall consumption of electricity by PCs and monitors has risen by around 17% per annum between 1990 and today, with current usage totalling around 150 TWh (see Figure 131). Growth has primarily been driven by greater penetration rates across a larger number of countries, combined with the impact of more powerful PCs, larger screen sizes and an increase in average hours of use.

Figure 131 • Estimated electricity consumption by all PCs and monitors, 1990-2008, by technology



Source: IEA estimates.

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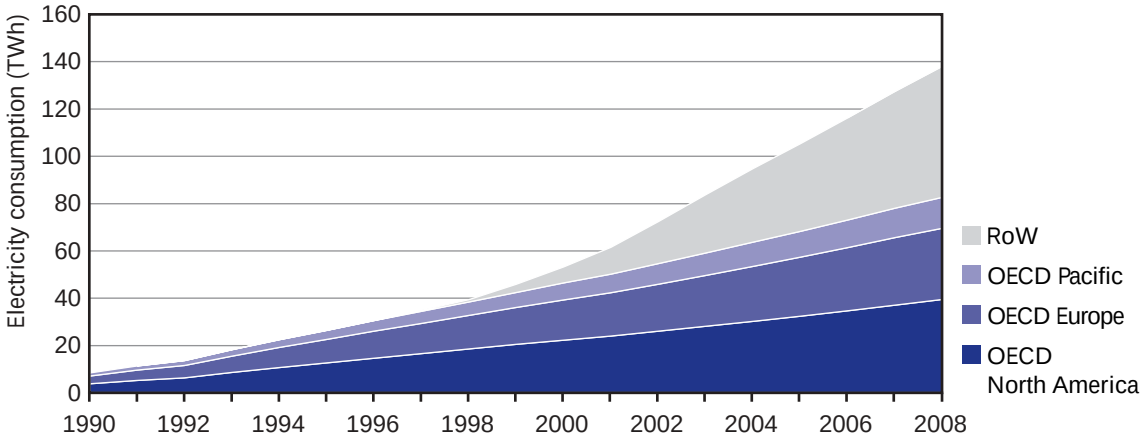
However, without the rapid adoption of laptop PCs and LCD monitors by consumers around the world, the energy consumed by PCs would have been far higher. Conversely, had the energy saving features widely used in portable PCs been integrated into desktop computers then the current level of energy consumption would be even lower.

While growth has been steady in OECD countries, the use of PCs in emerging economies has had a major impact on energy consumption since 2000, as shown in Figure 132.

Figure 132 • Estimated electricity consumption by all PCs and monitors, 1990-2008, by region



Source: IEA estimates.

Looking forward

Most analysts agree that the home computer, or devices which resemble it, will be around for many years to come, even if its role and form may change over time. Starting as a means to produce written text, it has evolved into a major communications hub through the use of email and, most recently, social networking. Householders use computers to store still and moving pictures, download and play a range of media including music, television and film content. The worldwide web is used by students to study, research and participate in distance learning; while householders now depend on it to shop, select their holidays and pay bills.

Internet connection, and particularly broadband, appears the dominant driver for residential computer penetration and usage. With countries committed to broaden access arrangements, there will be a steady demand for devices which can make use of the many services provided via the Internet. The greater mobility provided by portable computers and wireless connectivity has enabled several users within the same dwelling to use PCs simultaneously. These factors combine to continue pushing up the number of hours that computers are used, despite the arrival of personal digital assistants (PDAs), smartphones and portable media players which can replicate some of the functions of conventional PCs.

While additional mobile devices will no doubt enter the market, it is likely that for many applications the traditional PC will remain the most appropriate product for the majority of householders, though it will continue to evolve to meet consumer needs. For example, several

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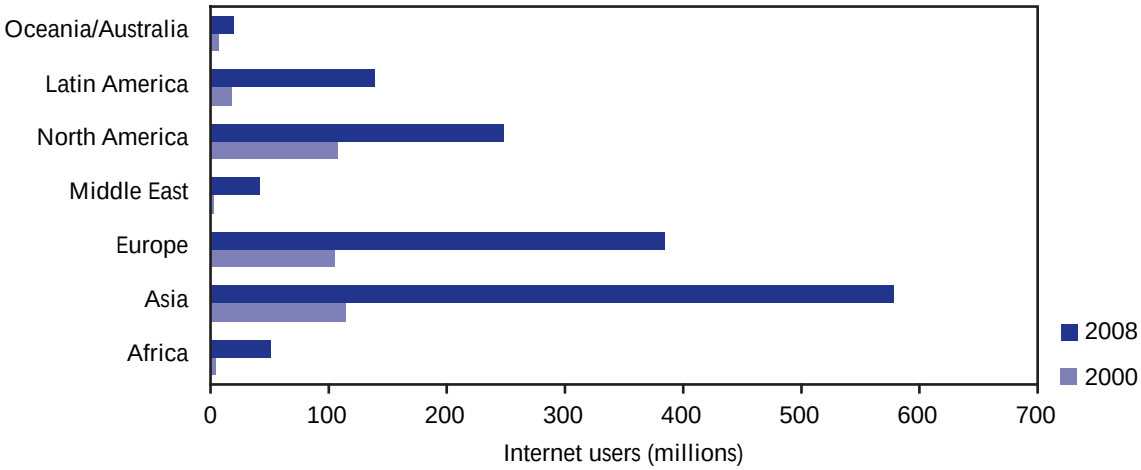
manufacturers are already marketing PCs primarily as music centres, with rapid start-up audio playing capabilities using flash drives. Media centre PCs are also becoming more common, linked to other devices in the home to store and replay a range of content. Versions of PCs are also at the heart of *Smart homes* in which most appliances within a dwelling are managed by a central interface, processing a range of inputs such as internal and external temperature, lighting conditions and energy costs.

The interconnection of digital devices can offer many opportunities for reducing energy consumption through greater control; however the opposite is also possible. There can be considerable energy penalties if connected products have to remain in an active state in order to share signals with other devices, as in the case of PCs connecting to a network, as discussed above. Further elaboration of this complex issue is included in the later chapter on cross-cutting issues (Chapter 9), but it is important to note here that one of the first questions which should always be asked when assessing the impact of connected devices is whether products will spend longer periods of time in a higher power mode as a result.

For the traditional desktop PC, the major growth market will be in non-OECD countries. Already the penetration of PCs in non-OECD countries is rising rapidly, and the growth in Internet users has been rapid, as illustrated in Figure 133. Since 2000, the number of Internet users has grown by over 300%, reaching 1.4 billion people by 2008, equivalent to 22% of the worlds' population. There are now more people accessing the Internet in Asia than any other region in the world, although penetration is still only at 15% of the population. Africa has the lowest penetration rate (5%) but has grown by 35% per annum since 2000 (IWS, 2008).

Figure 133 • Estimated growth in Internet users by region, 2000-2008



Source: IWS, 2008.

Currently the demand for PCs in non-OECD countries is met from a wide range of sources, including a large number of smaller suppliers and PC assemblers, many of which may not have been involved in the energy efficiency policies, programmes and technical development initiatives taking place in the OECD. It is likely that many of these will remain primarily focussed

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on providing low cost products in order to gain a share of this large market. Without the adoption and implementation of local energy efficiency policies, there is no guarantee that the technical advances which have been made in recent years will be adopted throughout the industry.

Of further concern is that at least some of this market appears to be supplied with second-hand PCs from OECD countries. The donation of prematurely retired PCs and monitors from wealthier countries has been promoted for several years as a means of overcoming the *digital divide*. Several charitable organisations specialise in the transfer of refurbished PCs[13] and Gartner estimates that the re-sale market will be 110 million by 2009, much of which will be to non-OECD countries (Gartner, 2005).

In addition to the safe end-of-life disposal issues raised by this growing trade, the implication of meeting some of the demand for PCs in non-OECD countries with second-hand products, most of which do not use the most efficient technology available today, is likely to be rapidly growing energy consumption.

On the other hand, most of the major PC hardware and software suppliers are already involved in pilot projects with non-OECD governments to supply low-cost PCs, most of which are low energy devices. Examples include *50×15* supported by Advanced Micro Devices (AMD), aiming to bring affordable Internet access and computing to 50% of the world's population by 2015, and the *One Laptop per Child* venture.[14] The latter has designed a product which is claimed to require only 15 watts D.C. when in use and currently retails for USD 190. It also has the facility to be re-charged using solar power (ZDNET, 2004).[15]

Another example, decTOP[16], is a basic computing device designed to support Internet access (see http://50x15.amd.com/en-us/sol_tech.aspx for further examples). As with all these solutions, Internet connection is a primary goal. Many of the hardware suppliers have also initiated joint projects to support the development of Internet and other infrastructure, such as the *IT Access for Everyone Initiative* (ITAFE, 2005).[17]

13. *For examples, see http://www.usedcomputer.com/nonprof.html*
14. *Further details available from: http://50x15.amd.com/en-us/about.aspx and http://laptop.org/en/index.shtml*
15. *Image provided courtesy of fuseproject.*
16. *http://www.dataevolution.com/dectop%20info%202.htm*
17. *The* IT Access for Everyone Initiative *is supported by Accenture, AMD, BMC Software, Cisco, Dell, Global Learning Ventures, Ingram Micro, Institute for Connectivity in the Americas, Intel, Philips Electronics, Synopsys and VeriSign.*

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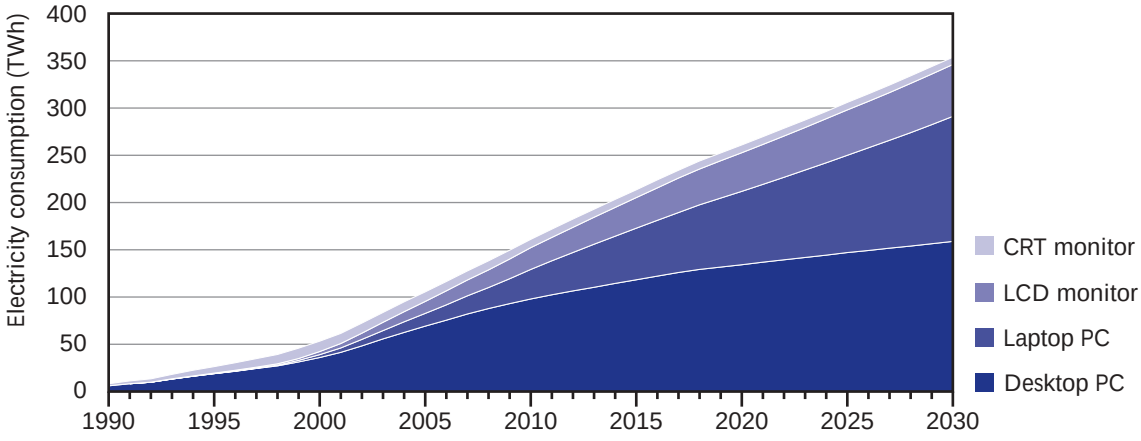
While it is relatively clear the ownership levels of PCs, or similar devices, will continue to grow, particularly in non-OECD countries, there is considerable less certainty regarding the energy performance of the average product in various markets. As costs continue to fall, many consumers are turning to higher specification desktops with advanced graphics capabilities, high processor speed and larger screens, which increase the power load. Where laptops are replacing desktops PCs there is a similar tendency. On the other hand, real advances have been made and there are some PCs available which, if widely adopted, would stabilise and possibly reduce future energy consumption.

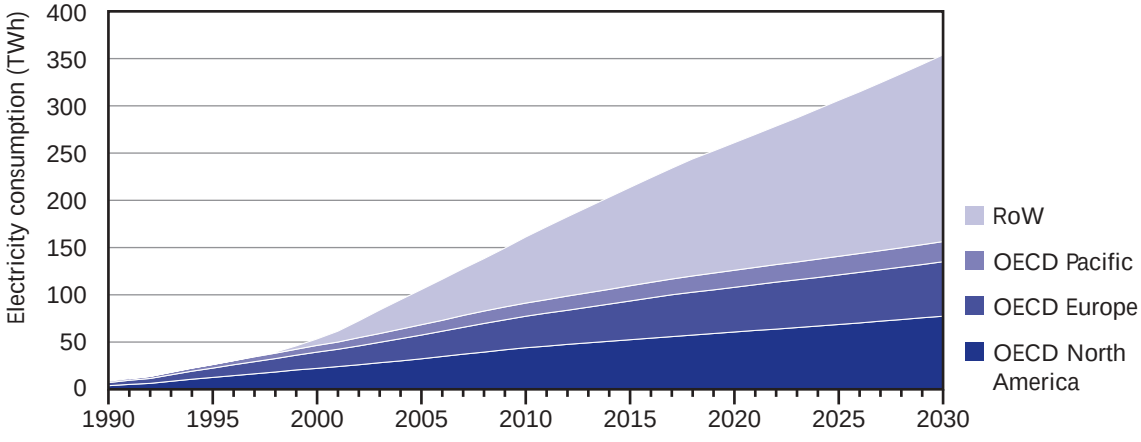
Balancing all these factors, a reasonably optimistic view of the future suggests that global energy consumption by PCs and monitors in the residential sector will double between now and 2030 to around 300 TWh. Nearly half of this consumption is estimated to occur in non-OECD countries by the end of this period.

Figure 134 • Estimated electricity consumption from PCs and monitors, 1990-2030



Source: IEA estimates.

Figure 135 • Estimated electricity consumption from PCs and monitors by region, 1990-2030



Source: IEA estimates.

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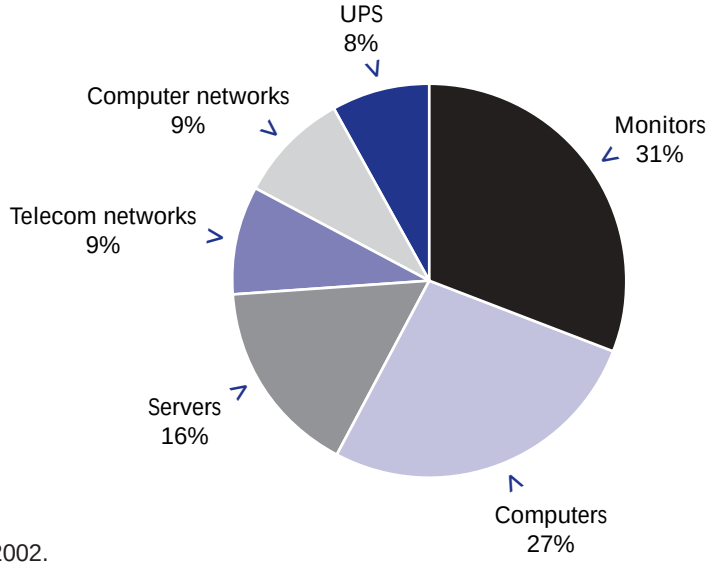
The big picture: putting residential PC energy use in context

This chapter has identified some of the major trends for computers and monitors which relate directly to residential electricity consumption. However, it is also important to note that household PC use creates impacts elsewhere in the economy as well. A key example of this is the use of Internet, which has already been noted as an important driver to the penetration and usage patterns of PCs in today's world. The process of supplying information to the 1.5 billion Internet users in the world today involves a wide range of infrastructure located remotely from the end-user, provided by telecoms, ISP, web hosts and search engine providers, amongst others.

As a result of the rapid expansion in the Internet subscriber base over recent years there has been considerable speculation on the quantity of energy consumed in this field. However, in making assessments in this area it is often difficult to distinguish between customer sectors (residential, commercial, etc) or between services (mobile phone, fixed telephone, TV services, etc), since much of the infrastructure is either shared or in a common location. Nevertheless, a number of studies have been conducted which, although still not definitive or global, provide some indication of the scale of energy consumed in providing Internet and related services.

A United States' study on office ICT in 2002 found that computers and monitors in this sector consumed slightly more energy than the infrastructure used to provide a range of services including Internet applications, as shown in Figure 136 (Roth *et al.*, 2002). Since the majority of infrastructure is also used to service Internet access in the residential sector as well as other applications, the energy consumed by end-use equipment in all sectors is likely to represent a higher proportion than indicated in this figure. As a result, it is clear that the end-use equipment is responsible for a far larger share of electricity consumption than the infrastructure used for a diverse range of applications.

Figure 136 • Estimated share of energy consumed by office computers and related infrastructure in United States, 2002



Source: Roth *et al.*, 2002.

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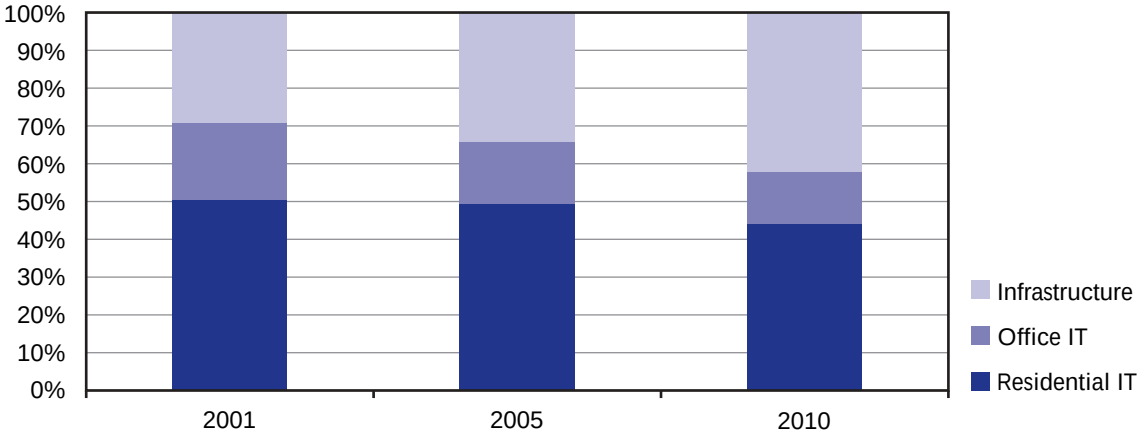
A more recent and thorough study of servers in the United States is consistent with the earlier findings, although it notes that total electricity consumption has grown as a result of an increase in the number of servers installed between the dates of the two studies (Koomey, 2007).

Elsewhere studies appear to show similar results. In Germany, the share of energy consumed by end-use computer equipment in 2001 was estimated to be 71% compared to 29% consumed by the infrastructure, although this ratio was predicted to change over time with improvements to computers and more investment in the infrastructure (see Figure 137) (Cremer *et al.*, 2003).

Figure 137 • Estimated share of energy consumed by computers and related infrastructure in Germany, 2001-2010



Source: Cremer *et al.*, 2003.

A more recent study in France, focussing on the energy used in the residential ICT networks, estimated that these consumed 2.6 TWh in 2006 (Souchon *et al.*, 2007; 2008). Based on data from France Telecom, this study estimated the energy used in providing a range of ICT services to customers, as shown in Table 61.[18] While the energy used by end-use equipment is not known, approximately 2.1 TWh was consumed by servers; suggesting that the networks consume more than servers, which is similar to the findings by Roth in the United States.

Table 61 • Estimated energy consumption of ICT services, France, 2006

Service	Energy per subscriber (kWh/year)
Fixed telephone	19
Mobile	23
VoIP	12
Internet access	31
Audiovisual	157

Source: Souchon *et al.*, 2008.

18. Some care needs to be taken with interpreting this data since some services require combinations of elements. For example VoIP requires Internet access in addition to the specific allocation in this table.

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Cooling and auxiliary equipment adds considerably to the energy consumed for servers: nearly doubling the total in the United States and adding a further 50% in France. In both countries it is estimated that growth in the number of servers has led to an increase in energy consumption by over 10% per annum over recent years.

Despite differences amongst these various studies, they provide a remarkably consistent picture: that the infrastructure used to provide Internet and related services account for less energy consumption than the end-use equipment. Nevertheless, there is a lot more to learn about this issue, particularly with respect to increasing the energy efficiency of these services.

There are considerable opportunities for energy efficiency in the Internet infrastructure. Already there is a range of initiatives working in this area including *Green Grid*[19], *Climate Savers*[20], *The Green IT Promotion Council* (Japan)[21], *The World Semiconductor Council*[22] in addition to the efforts of many individual companies. *Climate Savers*, for example, have the aim of reducing global CO_2 emissions from the operation of computers by 54 million tons per year by 2010.

In addition, governments have become more aware of the need to increase energy efficiency in the ICT area, and the following section highlights major national policies for computers and monitors in the residential sector.

Policies for energy efficient computers and monitors

The policy landscape

Many OECD governments have policies in place which impact PCs and monitors, the majority of which are either endorsement labels or procurement type policies.

Japan is the only country which has regulations in force for PCs (Top Runner), although mandatory minimum energy performance standards and comparison labels are being finalised in Australasia and Europe for both PCs and monitors.

In addition, some countries have policies targeted towards external power supplies (EPS) which have an impact on laptops and some monitors, as discussed in the chapter on external power supplies (Chapter 9).

The most widely applied programme is the Energy Star endorsement label, used in the United States, Canada, Europe, Australasia, Chinese Taipei and Japan for both PCs and monitors. A linked programme is also in operation in China. The main features of these programmes are that they cover *off*, *sleep* and *idle* modes, require products to be shipped with power management enabled, and specify the use of energy efficient external or internal power supplies (typically at least 80% to 84% efficient). No upper bounds of power consumption have been specified for desktop computers when actively computing. The Energy Star power requirements for monitors

19. *For further details see http://www.thegreengrid.org/home*
20. *For further details see http://www.climatesaverscomputing.org/*
21. *http://www.greenit-pc.jp/e/*
22. *http://www.semiconductorcouncil.org/*

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in *on* mode are the same, irrespective of technologies, and are specified on a pixels per watt basis. Revisions underway suggest that energy performance in *on* mode is a function of both resolution and screen size.[23]

As part of the process of programme development, Energy Star has been driving work to devise test methodologies for assessing the energy performance of PCs and related equipment, in association with a variety of other stakeholders. This work has been crucial in advancing policies in this field.

In most countries, government purchases of ICT equipment represent a significant proportion of the hardware market and, recognising their opportunity to influence the market, several governments have adopted procurement policies for efficient computers and monitors. Examples include the United States, China, Korea and most recently, the European Union.

As with many policy areas, energy efficiency policies often are most effective when a number of programmes designed for different target audiences are co-ordinated. A good example of this is in the United States, where government procurement linked to Energy Star has helped to transform the market.

In 1993, an Executive Order in the United States directed all federal agencies to purchase only energy-efficient computers and office equipment that qualified for the Energy Star label. Although federal sales amounted to only 2-3% of the market, this policy caused manufacturers to join the Energy Star programme, with most types of office equipment quickly reaching Energy Star penetration rates of 90% or more (Harris *et al.*, 2005). Subsequent Executive Orders have reinforced the role of Energy Star, as have purchasing and even financial incentive schemes put in place by additional layers of government at a state and local level which are linked to Energy Star products. Through these processes, the Energy Star requirements have a more influential role in the United States than many other endorsement label programmes without such established linkages.

The *80 Plus* programme has added another dimension to programmes in the United States. A partnership between the power supply industry, computer manufacturers and utilities, it was established in 2004 by Ecos Consulting to stimulate the development of more efficient PC power supplies. It works by creating a market for more efficient desktop PCs by taking advantage of U.S. energy utility programmes that pay for energy reductions when they are cheaper than purchasing additional energy supplies. By certifying desktop PCs containing highly efficient power supplies (greater than 80% average efficiency with active power factor correction) the *80 Plus* programme has enabled desktop PC producers to gain access to millions of dollars in utility incentives and considerable marketing support. From one compliant power supply in 2004, today there are more than 600 products which meet the 80 Plus standard, included in desktops sold by many of the leading PC brands. The 80 Plus criteria has been included in the latest Energy Star specification (80 Plus 2008).

The following tables summarise the major national policies and initiatives for computers and monitors.

23. See version 5.0 of Energy Star specifications for Displays.

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Table 62 • Summary of energy efficiency policies for personal computers

Country	Programme title	Products covered	Programme type	Mode(s) covered	Status
Global	TCO label	Desktops, laptops	Endorsement label	Off, sleep	Current
Australia and NZ	S&L	Desktops, laptops, desktop-derived servers	MEPS	Off, sleep, on	Under consideration
	S&L	Desktops, laptops, desktop-derived servers	Comparative label	Off, sleep, on	Under consideration
	Energy Star	Desktops, laptops	Endorsement label	Off, sleep	Current
	Energy Allstars	Desktops, laptops	Procurement	Off, sleep, on	Current
Canada	Energy Star	Desktops, laptops, desktop-derived servers, gaming consoles	Endorsement label	Off, sleep, idle	Current
China	Energy conservation certification	Desktops, laptops	Endorsement label	Off, sleep	Current
	Procurement law	Desktops, laptops	Procurement	Off, sleep	Current
Chinese Taipei	EnergyStar	Desktops, laptops	Endorsement label	Off, sleep	Current
Europe	Ecolabel	Desktops, laptops	Endorsement label	Off, sleep	Current
	EnergyStar	Desktops, laptops, desktop-derived servers, gaming consoles	Endorsement label	Off, sleep, dle	Current
	Eco-design	Desktops, laptops	MEPS	Not known	Under consideration
	Regulation (EC) No 106/2008	Desktops, laptops, desktop-derived servers	Procurement	Off, sleep, idle	Current
Japan	Top Runner	Computers and CPUs	Sales weighted target	All	Current
	Uniform energy saving label	Desktops, laptops	Comparative label	All	Current
	EnergyStar	Desktops, laptops, desktop-derived servers	Endorsement label	Off, sleep, idle	Current
Korea	Energy Boy	Desktops, laptops	Endorsement label	Sleep	Current
	e-standby Program Application Regulation	Desktops, laptops	Procurement	Sleep	Current
United States	EnergyStar	Desktops, laptops, desktop-derived servers, gaming consoles	Endorsement label	Off, sleep, idle	Current
	FEMP	Desktops, laptops, desktop-derived servers	Procurement	Off, sleep	Current
	80 Plus	Desktops, servers	Procurement	All	Current
	Executive Order 13423	Desktops, laptops, desktop-derived servers	Procurement	Off, sleep, dle	Current

Source: IVL, 2007; Collins, 2007; EECJ, 2007; METI, 2008; EU, 2008; 80 Plus, 2008.

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Table 63 • Summary of energy efficiency policies for computer monitors

Country	Programme title	Products covered	Programme type	Mode(s) covered	Status
Global	TCO label	Flat panel	Endorsement label	off, sleep, on	Current
	TCO label	CRT	Endorsement label	off, sleep	Current
Australia and NZ	S&L	All	MEPS	off, sleep, active	Under consideration
	S&L	All	Comparative label	off, sleep, active	Under consideration
	Energy Star				Current
	Energy Allstars				Current
Brazil	S&L	All	Comparative label	off, sleep	Current
Canada	Energy Star	All	Endorsement label	off, sleep, on	Current
China	Energy conservation certification	All	Endorsement label	off, sleep	Current
	Procurement Law	All	Procurement	off, sleep	Current
	National Standards	Flat screen	MEPS	off, sleep	Under consideration
Chinese Taipei	Energy Star	All	Endorsement label	off, sleep	Current
Europe	Ecolabel	All	Endorsement label	off, sleep, active	Current
	Energy Star	All	Endorsement label	off, sleep, active	Current
	Eco-design	All	MEPS	not decided	Under consideration
	Regulation (EC) No 106/2008	All	Procurement	off, sleep, active	Current
Japan	Energy Star	All	Endorsement label	off, sleep, active	Current
Korea	Energy Boy	All	Endorsement label	off, sleep	Current
	e-standby Program Application Regulation	All	Procurement	off, sleep	Current
United States	EnergyStar	All	Endorsement label	off, sleep, active	Current
	FEMP	All	Procurement	off, sleep, active	Current
	Executive Order 13423	All	Procurement	off, sleep, active	Current

Source: IVL, 2007; Collins, 2007; EECJ, 2007; METI, 2008; EU, 2008; 80 Plus, 2008.

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Key policy considerations

The switch by consumers to LCD monitors and portable PCs has helped to cut energy consumption relative to a level which might have been expected if desktops and CRT monitors were still the norm. The energy saving technology and processes which are commonplace in laptops indicate the technical ability which can be harnessed to energy efficiency when there are incentives to cut energy consumption. However, equivalent drivers do not exist for all components and many product lines, leaving substantial opportunities to redress market failures and make further energy reductions.

The energy efficiency policies developed to date in some economies have assisted by providing markets for the better performing products and tools to inform the general public. Many parts of the PC industry have made considerable strides to improve the energy efficiency of their products, while also reducing prices to consumers in a highly competitive environment. These policy examples provide an excellent platform, but they have their limitations. There are considerable challenges to ensure that efficient technologies are used by the broadest range of products available today and in the future. The danger is that, as PC providers offer a diversity of products, energy efficiency will be offered as an option, or within niche markets only. Further, policies need to be able to act on the full range of suppliers in the market, not only the major players. The following section highlights some of the key priorities for future policy development.

Setting policy priorities

Considering that in future years the largest market growth will occur outside the OECD, the adoption and implementation of policies in non-OECD countries should be a major focus. While adjustments may need to be made for local circumstances, the adoption of policies based on criteria currently used in OECD countries will speed up the implementation process and provide benefits in terms of international harmonisation.

Policies also need to have a wider focus than just PC technologies. Power management is already available in most of the PCs used today, not just new products, and provides the opportunity for very substantial savings at no extra cost. Although we know too little about user behaviour – whether they choose not to use power management or are unaware of its existence – it is apparent that this tool is extremely under-utilised. Increasing the use of power management therefore needs to be priority policy objective in this area.

Several endorsement labelling programmes already require that computers ship with power management and specific standby delay periods enabled. However, this only applies to new products sold in the market and to those that wish to participate, whereas mandatory instruments could be used to ensure that all new products were supplied to customers with power management enabled. Additional measures, such as information programmes, would help to reach existing users, which would have an even greater impact on energy consumption.

While endorsement labels have helped to promote the best products in the market in some economies, they have not been used to demonstrate to consumers that desktop PCs (with a monitor) consume more energy than equivalent laptops. Given the significant differences in consumption between these technologies, this is important information for the consumer to be aware of. Enabling the performance of all PC types to be compared on the same scale across

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all PC options may also speed up the process by which energy saving technology and features commonly used in laptops are transferred to desktop PCs. Comparison labels, which have gained credibility with consumers in many markets for whitegoods, would be one way to show consumers the relative performance of all PCs. In assessing the performance of a desktop, some allowance would need to be made for a monitor, perhaps through the addition of a uniform energy or power budget based on a market average or the monitor with the largest market share.

It is also important to understand that manufacturers have the technology to achieve the lower power consumption levels of laptops in desktop PCs if the market demands it, so coordinated procurement efforts could help to draw such technologies (e.g. mobile on desktop CPUs, highly efficient motherboards, and solid state hard drives) into the marketplace in larger numbers.

Many governments have yet to put in place mandatory procurement policies which require the use of the most energy efficient IT equipment, despite the evidence that this can have a considerable impact on the market as well as reduce government costs. The fact that some governments have successfully achieved this also demonstrates that there are sufficient products now available to make such policies feasible.

With the increasing penetration of laptop PCs, policies to increase the uptake of highly efficient external power supplies are a high priority and should cover all modes of operation and be linked to policies directed at PCs and monitors. A range of policy measures are viable, and it is likely that the most effective policy mix will include the use of minimum energy performance standards.

As new computers increase in efficiency, governments need to consider whether measures can be introduced to impact on the second-hand market so that efficiency benefits can flow through to the end-user as quickly as possible. This is becoming more important as regulations for the end-of-life treatment of computers lead to increased costs for safe disposal and make re-sale more attractive. Working with the PC industry, governments could consider measures such as financial incentives in order to withdraw products from the market, or point-of- sale discount arrangements for replacement products.

Additionally, governments need to examine the trade in used PCs and ensure that financial and other assistance packages to developing countries are being used to support appropriate computer technology with very low energy consumption. Possibilities may exist to use carbon finance to support programmes which provide the best technologies.

Policy options and projected energy savings

Many of the policy measures available to governments are highly cost-effective, particularly those relating to the improvement of power management. As a result the least life-cycle cost scenario yields a saving of 46% compared to the business as usual path, equivalent to a reduction of 160 TWh in 2030.

While under the BAT scenario the share of sales and stocks by different technologies is maintained, some technologies and power management practices used in laptops are adopted more widely into desktop computers. As a result it is estimated that savings amount to 250 TWh by 2030, a reduction of 72% compared to the business as usual scenario.

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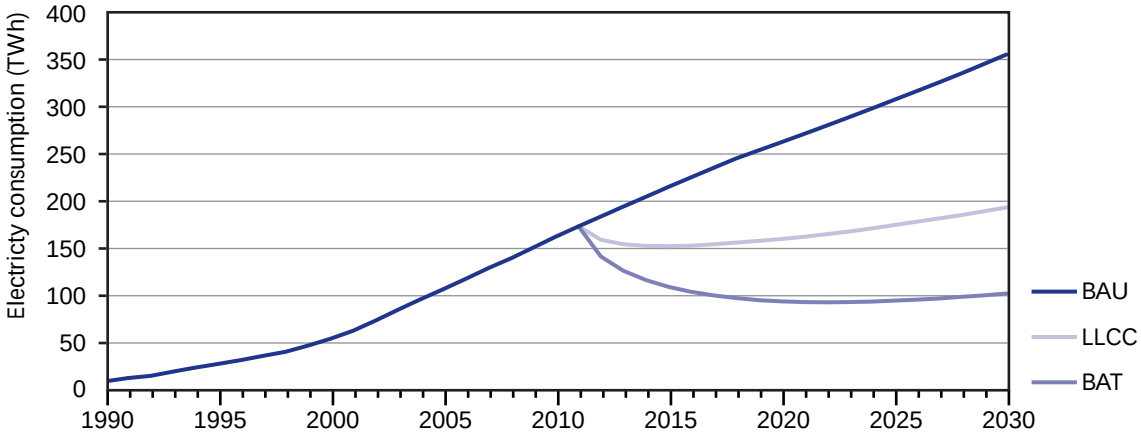
Figure 138 • Estimated electricity savings from implementation of LLCC and BAT policies



Source: IEA estimates. The LLCC and BAT scenarios assume policy implementation in 2012.

Recommendations

The IEA 25 policy recommendations to the G8 (OECD/IEA, 2008) did not address computers and monitors specifically. However, it is now recommended that all governments should consider implementing a range of policy measures for computers and monitors, covering technology and power management issues, in new and existing products. These include:

- Mandatory requirements for all PCs to be supplied with power management enabled at levels should be decided on by governments after consultation with other stakeholders. Governments should also work with industry to design and implement appropriate consumer education programmes with the aim of increasing the implementation rate of power management in existing PCs.
- Procurement policies for all governments and government agencies should be implemented to purchase the best performing PCs and monitors which are fit for purpose. It should be noted that many governments have optional procurement policies which have proven to under-perform and therefore if policies are not mandatory then they need to ensure that non-compliance requires justification.
- A number of policy measures should be considered for improving the performance of all PCs in all modes of operation, including minimum energy performance standards and energy performance labels. Labels for PCs should be technology neutral allowing comparison of PCs and laptops.
- Measures for monitors, such as labelling, should be developed to apply for all display technologies, in line with recommendations for televisions.
- Requirements should be set to improve efficiency of external power supplies (see Chapter 9).
- Governments should work with industry to develop measures to remove older inefficient products from the local or overseas market and ensure their safe disposal.

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Chapter 7 • SET-TOP BOXES

Introduction

The growth in the penetration of pay-TV, the development of new platforms for distributing TV content such as the Internet, and the switch to digital broadcasting is creating a large market for set-top boxes (STB), a device which is new to many consumers around the world.

A set-top box is the generic name for a device used to convert an incoming TV broadcast signal to one that can be seen on a screen, and is therefore sometimes referred to as an integrated receiver decoder.[1] Set-top boxes come in many shapes and sizes depending upon the platform used to send the TV signal (such as aerial, cable, satellite, Internet) and whether the output is designed for an analogue or digital display.

There are many other variations which relate to the ability of a STB to connect to other devices, to produce high definition pictures and record programme material. Many newer set-top boxes have built-in recording devices, such as an internal hard drive or a DVD recorder, and these products and their derivatives will here be referred to as digital video recorders (DVR).

In the past the major task of set-top boxes was to decompress and decode the incoming TV signal, and to ensure secure customer identification in the pay-TV market. Now that many countries are committed to ceasing analogue TV transmissions by 2015 or beforehand (see Figure 101 in Chapter 5), a new market has developed for set-top boxes to translate the digital signal to one which can be displayed on the existing stocks of analogue TVs.

Other important trends are emerging in the set-top box market. *Internet Protocol TV* (IPTV) has the capacity to provide television together with broadband and fixed telecom facilities as bundled services through the Internet. Already established in some markets, such as in France, this type of service is being offered far more widely by telecom companies in competition with other more established TV service providers.

Set-top box variations

The mix of TV delivery platforms varies considerably from country to country, as does the penetration of pay-TV services and high definition 'ready' televisions. In addition, TV signal and decoding standards differ between regions and, as a result, there are a wide range of set-top box types available today.

Typical types of set-top boxes include:

- Terrestrial, Cable or Satellite converter (analogue or digital);
- Digital to Analogue TV converter;
- Pay-TV box (any platform);
- Internet Protocol decoder; and
- Any of the above with permanent recording capabilities.

1. *Some of the functions of a set-top box may be integrated within the television itself, although this has tended to be a regional variation which is less common now that the international trade of televisions is widespread.*

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While some boxes provide a basic conversion/decoding function only, there are many additional features offered by the more sophisticated boxes, which might include any or all of the following:

- Additional tuners for a further media source;
- Processing of advanced video formats such as H.264/MPEG 4;
- Integrated digital recorder (either DVD or hard disc);
- High definition video output (> 480 i/p);
- Integrated modem; and
- Home network interface.

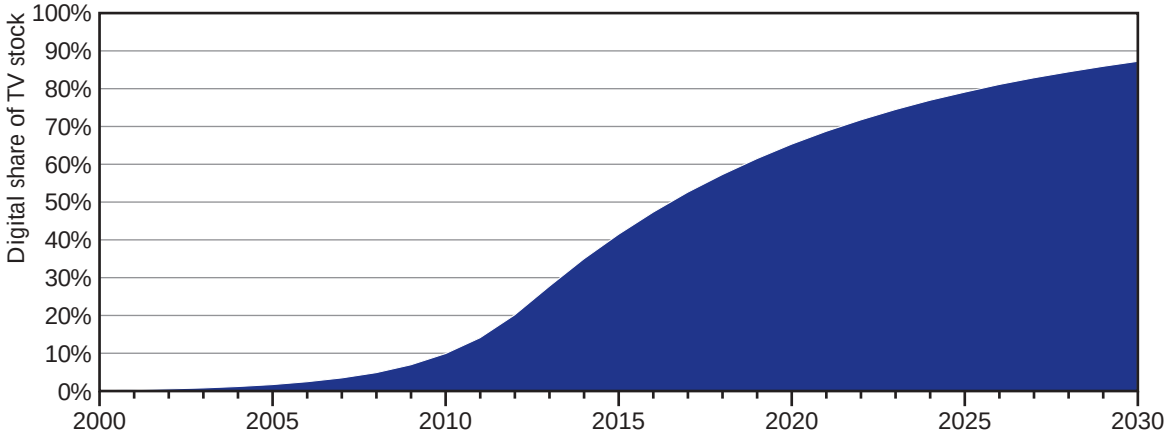
An important distinction between types of set-top boxes is also whether two-way communication between the service provider and the box is supported. Typically, two-way communication is used in association with a conditional access system, such as a smartcard, to ensure that the customer is authorised to receive the service that they have paid for. Conditional access systems provide up-to-date information on how to unscramble programme content and were developed to protect the commercial interests of TV providers, particularly for pay-TV applications.

TV service providers (TVSP) may also use the link to individual set-top boxes to provide electronic programme guides (EPG) and other programme information, in some cases tailored to a customer's specific preferences, and to periodically update the box's software.

Market development

Of the 1.8 billion TVs in the world today, around 95% are analogue (see Figure 139). While sales of digital TVs are now increasing, the majority of sets will still be analogue by the time that major economies switch off their analogue broadcasting service. As a result most regional estimates show a considerable surge in sales of digital to analogue STBs up to 2015. Increasingly, consumers are purchasing boxes with additional features such as recording devices and high definition output.

Figure 139 • Estimated digital TV share of total TV stock, 2000-2030



Source: IEA estimates.

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However, the demand for converter boxes will diminish considerably once most householders in digital broadcasting areas with existing analogue TVs have purchased a STB; and sales of simple converter boxes are likely to be negligible once digital TVs reach full penetration.

Meanwhile, there will continue to be a large and growing market for other types of set-top boxes, particularly associated with the pay-TV market. The introduction of digital broadcasting, high definition formats and IPTV are leading to evolution in all markets, including those which have been in existence for many years and were considered mature. In most markets, traditional providers of TV content and telecoms are vying to offer a wider selection of bundled home entertainment and communication options, many of which will require switching to new types of set-top boxes. For example, access to high definition TV, a feature particularly relevant for the popular larger TV screens, is being strongly marketed by many pay-TV services in order to boost subscriptions. Similarly digital TV allows for a far greater number of TV programmes to be transmitted, opening up the opportunity for pay-TV services to market specialised content to viewers.

Increased TV penetrations in non-OECD countries, where satellite and cable platforms already have a major presence and where IPTV is likely to have a growing influence, will also continue to drive up sales of set-top boxes. China and Russia have both announced their intention to switch off their analogue transmission service in 2015, which will create an additional demand for converter boxes for the large stock of analogue TVs that remains in these countries (OECD, 2007).

While there are several trends running in parallel and these vary by region, it is clear that the medium-term market for set-top boxes comprises both the replacement of existing products with boxes which offer more functionality and a growing customer base.

Looking further ahead, there are several possible innovations. Conditional access functions are beginning to be introduced into televisions in North America,[2] negating the need for separate STBs for pay-TV subscribers (BIOS 2008a). The impact of this development is dependent on the availability of this technology and will be limited by the speed at which the stock of televisions is replaced, since the technology currently is only integrated in new televisions.

There is already considerable convergence in the industry, for example through the combination of DVD players and recorders with STBs, and instances like this will only increase. The potential to further integrate much of the functionality provided by STBs, games consoles and audio components into home media centres, is considerable. Already some such products are available at the premium end of the IPTV market, however it is unclear whether this type of product will be universally popular or within the price range of many consumers (E3, 2007; BIOS 2008a).

Despite some uncertainty about the longer term, there will be substantial growth in the market for STBs up to 2015, driven by the switch to digital TV broadcasting and increased use of pay-TV. As shown in Figure 140, this growth will occur in all regions, particularly in the OECD. Thereafter it is likely that the non-OECD countries will be responsible for most of the market growth.

2. Called CableCARD in the United States.

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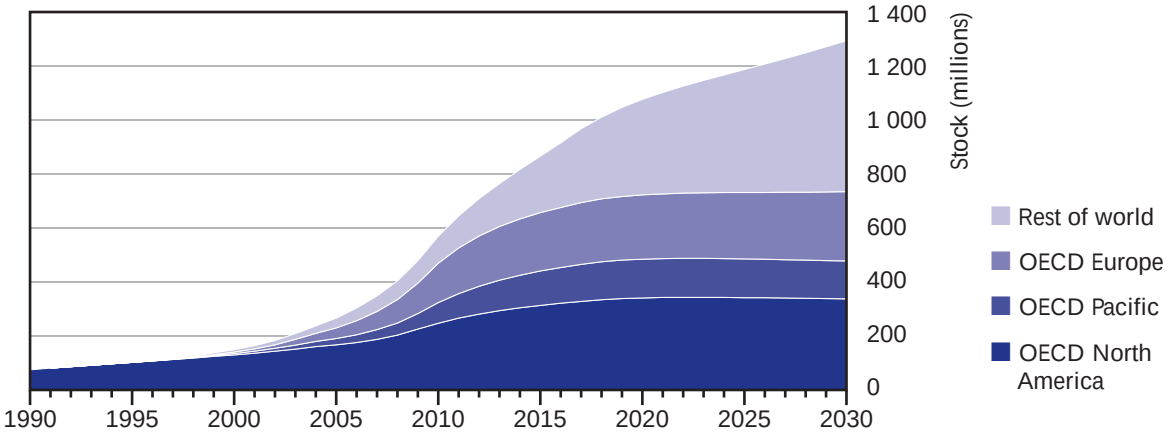
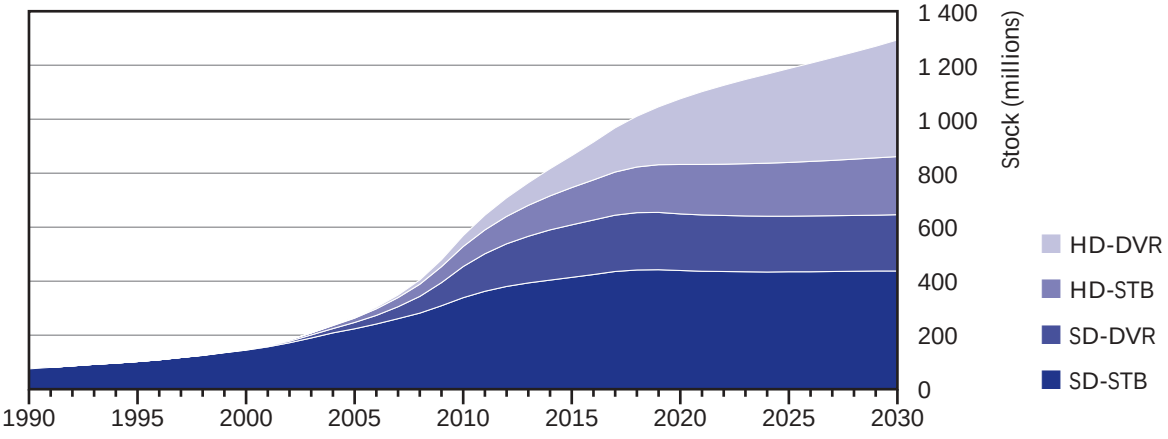
Figure 140 • Estimated stock of set-top boxes by region, 1990-2030



Source: IEA estimates.

While demand for simple, standard definition boxes will continue, particularly in cost-sensitive markets, there will be increasing penetration of boxes with integrated recording and high definition capabilities, in addition to other functionality, many of which will use the IPTV platform (E3, 2007).

Figure 141 • Estimated stock of set-top boxes by type, 1995-2030



Source: IEA estimates.

Key: SD-STB = Standard Definition STB; SD-DVR = Standard Definition DVR; HD-STB = High Definition STB; HD-DVR = High Definition STB.

Market structure and barriers to energy efficiency

A large proportion of set-top boxes used in households is provided as part of a contract for TV content made with a TV service provider (TVSP). In most cases a TVSP will offer a range of products which have been selected as compatible with their broadcast and access/security

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systems, or which may have been designed to meet a specification provided by the TVSP.[3] In these circumstances it is typical for the cost of the box to be included in the fees charged for ongoing connection and receipt of TV services.

This is important because the cost to the householder of receiving a TV service includes not only the service fee (including a component to cover the capital cost of the box) but also the cost of electricity for running the set-top box and associated television display. Therefore, although consumers have an incentive to minimise the total coast of all of these elements, they generally do not determine what box they use, in which case they have no say in the energy performance of that box.

On the other hand, the TVSP does have an incentive to minimise the first costs of the boxes it selects and thereby provide a more competitive service to its customers. The TVSP does not pay the running costs associated with set-top boxes and therefore is not concerned about the energy performance of the set-top box (E3, 2007).

This situation, where one party is in a position to invest in energy efficiency but will see no benefit, is known as the 'principal agent' problem and is an important barrier to energy efficiency, described in detail in a previous IEA publication, *Mind the Gap* (OECD/IEA, 2007).

This barrier is most evident when TVSPs include the provision of STBs with the rental agreement; however where consumers are free to select models, there is a lack of information at the point of sale for consumers to make informed decisions. Some of the policies identified below are aimed at overcoming this issue by introducing endorsement labels for the better performing products; however such programmes are currently far from universal.

The reduction of component failures due to overheating is one direct economic driver which might encourage TVSPs to improve the energy efficiency of STBs, as was noted at a recent IEA workshop with industry on the subject (IEA, 2007). At the same time, it was said that the addition of power management, such as a product going into standby, can cause confusion for consumers and an increase in technical enquiries, which are extremely costly.

Like many electronic devices, STBs combine several hardware components together with software to produce a final product with the desired functionality. As the layers of functionality become more complex, so the task of co-ordinating all these aspects becomes increasingly onerous. In this very competitive environment,[4] non-standard components or those with a risk of failure, or features like energy efficiency which are difficult to market, are often quickly discarded, particularly if they reduce the time a product takes to get to market (IEA, 2007).

While these represent substantial hurdles, public relations benefits associated with the reduced emissions of greenhouse gases have provided a sufficient incentive for at least one major TVSP to pursue energy efficiency, as described in Box 1.

3. Usually in the case of larger TVSPs.

4. Recently a leading retailer in the United Kingdom began selling STBs for GBP 10, which illustrates how tight the margins have become (Guardian, 2008).

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While this example is unusual, it does demonstrate the central role that TVSPs play in determining not only the efficiency of STBS themselves, but also the energy efficiency of the complete service provided. The role of TVSPs is only likely to become more influential as broadcast and telecommunication services are increasingly offered to consumers as bundled packages.

Box 1 • The Sky's the limit

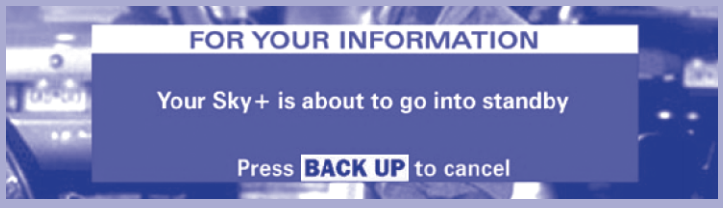
British Sky Broadcasting (Sky), which provides TV content to around 30% of households across the United Kingdom and Ireland, has shown just how much a motivated TVSP can do to do cut the energy consumption of set-top boxes for the benefit of its customers.

Not only has Sky made a commitment that all new set top boxes will not use more than 3 Watts of electricity in standby mode by 2010, but the company uses advertisements and other promotions to encourage customers to switch their set top box to standby when it's not in use.

But the real innovation occurred in March 2007 when Sky introduced an '***auto standby***' feature to 4 million boxes, cutting some £12m a year from customer electricity bills and saving an estimated 52 000 tonnes CO_2.

'***Auto standby***' works by monitoring whether people are using their set-top box. If the box hasn't been used for a period of two hours after 11pm, an 'Auto Standby' message will show on screen for three minutes. If there's no response the box will go into Standby mode automatically, until the customer turns it back on.

It is expected that this feature will be extended to cover a further 9 million set top boxes.



Source: Sky, 2008.

Energy considerations

Set-top boxes can operate in several energy consuming modes, in addition to the *on* mode. Although many current set-top boxes have a hard *off* switch, it is rarely used since it is usually located on the rear panel and therefore inconvenient to use (MVV, 2007). Furthermore, TVSPs

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tend to discourage consumers from turning off their boxes either because of the delay in the time taken to receive an image from start-up, considered to be unpopular with consumers, or to avoid problems with maintaining security for pay-tv customers.

So, normally set-top boxes are put into their lowest power mode by use of the power button on a dedicated remote. The extent to which this is used by householders is unknown, but it is likely that at least some householders are unaware that the set-top box must be switched off, as well as the television, when no picture is being watched.

The energy consumed by set-top boxes in *on* mode is related to the platform and the number of functions performed, and so the large number of different types of boxes gives rise to a substantial variation in energy consumption. For example, different TV transmission formats, high definition output, and the presence of a hard disk may all lead to additional power loads. As an illustration, Table 64 shows typical annual energy consumption values for a range of platforms and common additional features in STBs, included as allowances in the U.S. Energy Star programme (ES, 2008a). It is evident from this that the energy consumption of additional features can be considerable, and that a fully-featured STB may use double the energy or more of a basic STB.

Table 64 • Typical annual energy consumption values for common STB types and features

	Item	Annual energy allowance (kWh/year)
Platform	Cable – basic STB	70
	Satellite – basic STB	88
	IPTV – basic STB	45
	Terrestrial – basic STB	27
Additional functions	Additional tuners	53
	Advanced video processing	18
	DVR	60
	High definition	35
	Removable media player	12
	Removable media player/recorder	23
	Home network interface	20

Source: ES, 2008a.

However, while many STBs have low power modes available for use when products are not in *on* mode, in fact an increasing number of STBs do not use this facility. For boxes which have conditional access procedures, and which have two-way communication with the TVSP, it is usual for the power consumed in the low power setting to be equal or very similar to the *on* mode consumption of the set-top box. Figure 142 shows the power drawn by 87 connected STBs tested in *on* and *standby* modes, demonstrating that in the majority of cases the differences recorded are minimal.

The reason why these boxes remain in a high power mode is so that TVSPs are able to send materials to the box at any time without having to wake it up. This might include the EPG, security updates, software updates, programme promotional materials and other related information.

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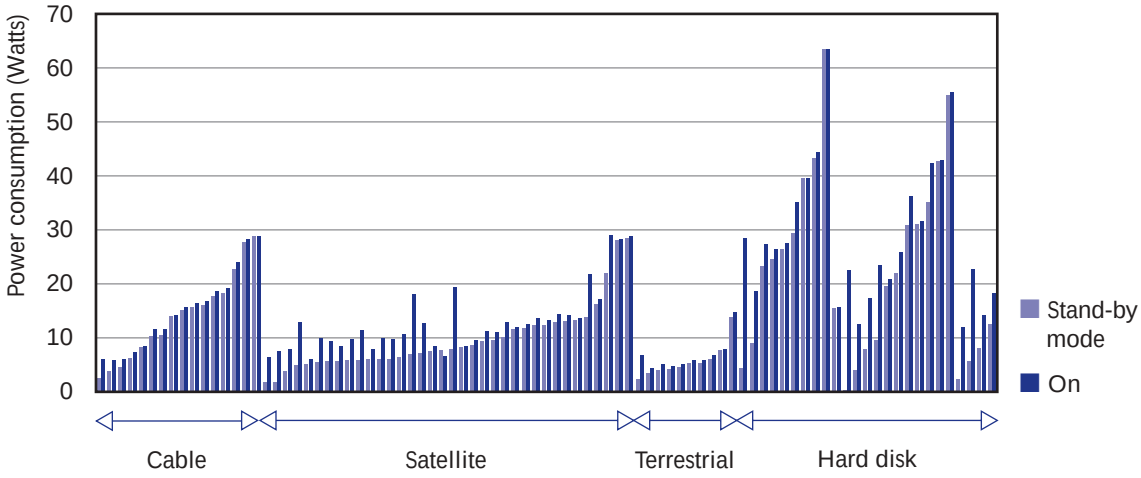
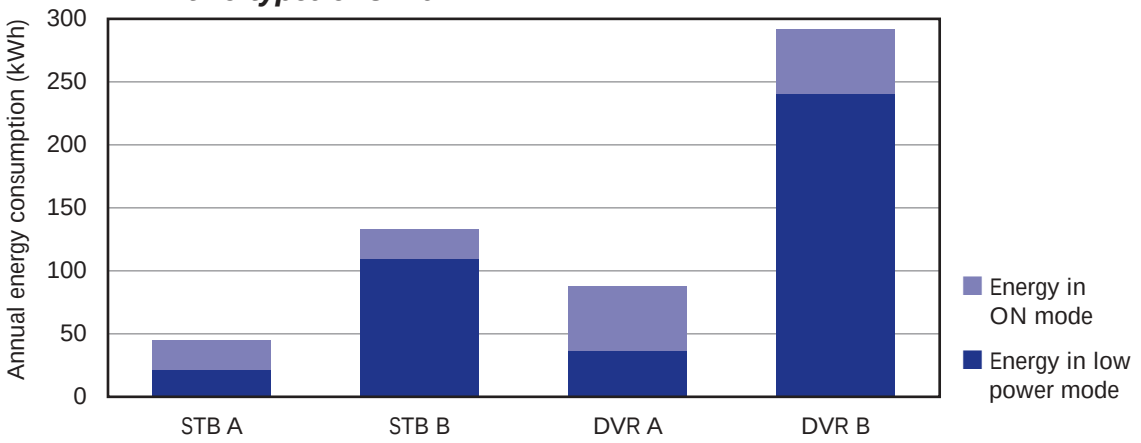
Figure 142 • Combined results from the measurement of 87 STBs in Europe and United States



Source: SFOE, 2007; NRDC, 2006.

Clearly this has significant energy and cost ramifications of which many consumers remain completely unaware. Figure 143 shows the effect on two average set-top boxes: one a basic pay-tv box and the other a DVR, both of which are actively used for four hours per day. In both cases, option A is able to enter into a low power mode for 20 hours per day (when not being used), while option B remains effectively on all the time. As can be seen by this figure, the boxes which cannot enter into a low power consume more than double the amount of energy over a year compared to STBs where power management is effective.

Figure 143 • Impact of effective power management on the energy consumed by two types of STBs



Source: IEA estimates

It is also important to note that not only do DVRs tend to draw more power than many basic set-top boxes when on, but they also tend to be on for a longer time. This is because DVRs are used for both recording and viewing most programme content, effectively doubling the length of time when they are in use.

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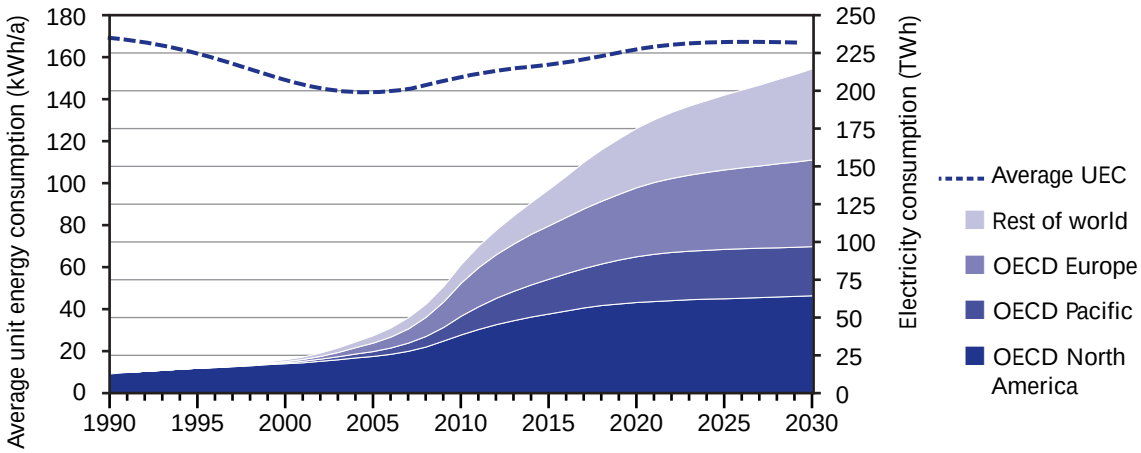
Looking forward

Set-top boxes currently installed around the world use between 50-60 TWh of electricity each year. However, this is estimated to double by 2013, and by 2020 reach 175 TWh, representing an annual growth rate of over 9% (see Figure 144).

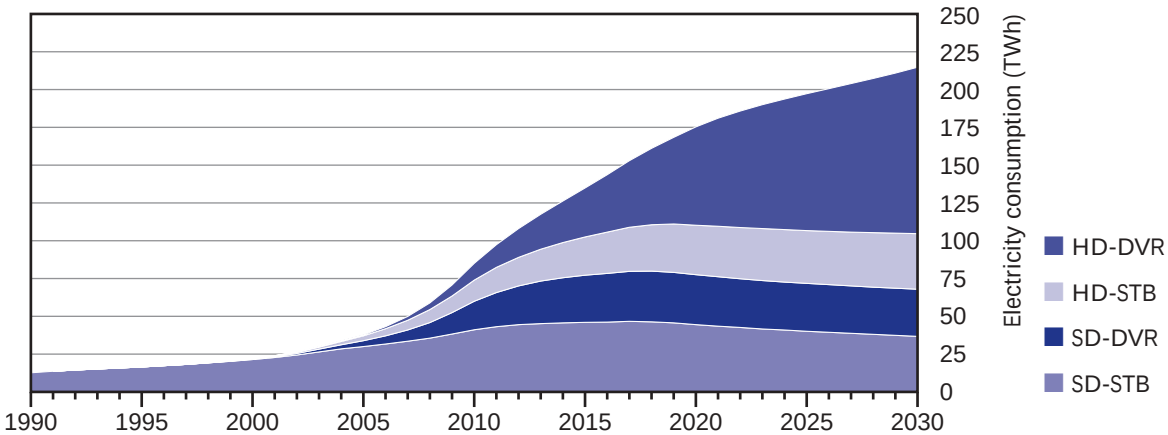
Figure 144 • Estimated electricity consumption by STBs by region, and average unit energy consumption, 1990-2030



Source: IEA estimates.

The major cause of this growth is the increased penetration of appliances; although STBs have increased in functionality, they have also become more efficient, as indicated by the average unit energy consumption line in Figure 144. Some of this efficiency trend is reduced as a result of the growing number of more energy intensive DVRs and high definition STBs, as shown in Figure 145.

Figure 145 • Estimated electricity consumption by STBs type, 1990-2030



Source: IEA estimates.

Amongst the many ways to improve the energy efficiency of STBs, most are common with other electronic devices. They include:

- More efficient external or internal power supplies;

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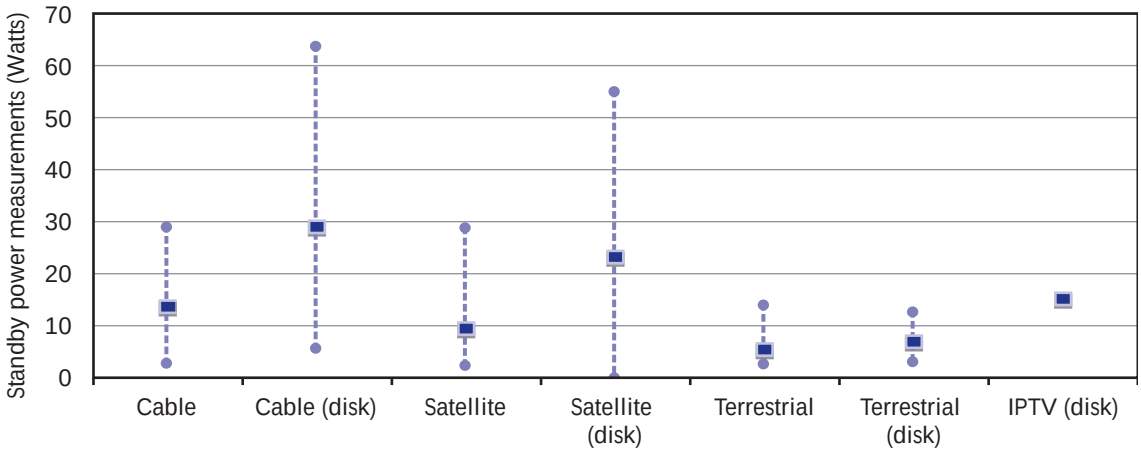
- Better power management so that individual components can be switched off when not in use, such as hard-drives, or the speed of the CPU scaled to match requirements;
- More efficient individual hardware components, chips and circuit design (BIOS, 2008b; EC, 2007).

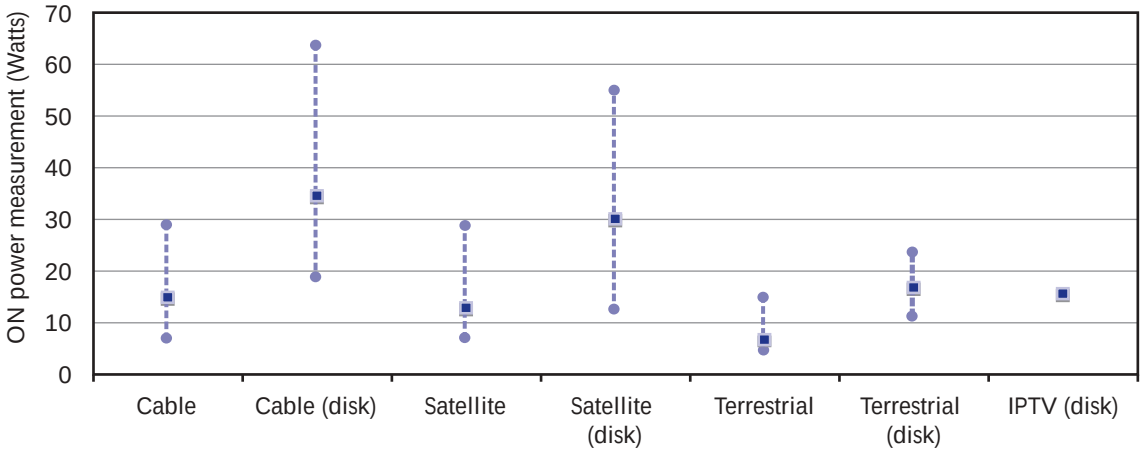
In fact, there are many STBs which have some of these features, as indicated by the wide range of energy performances amongst currently available models. Figure 146 and Figure 147 show the range of values in *standby* and *on* mode for 87 measured STBs in the United States and Europe, according to their platform. While some of these differences do reflect different specifications, most of the models have similar functionality.

Figure 146 • Standby power measurements, 87 samples from United States and Europe



Source: SFOE, 2007; NRDC, 2006.
Note: The range of standby power measurements in the sample is indicated by the round markers and adotted line in the above figure, while the average standby measurement is shown in this figure by the square markers. (disk) denotes an internal hard disk.

Figure 147 • On mode power measurements consumption 87 samples from United States and Europe



Source: SFOE, 2007; NRDC, 2006.
Note: The range of standby power measurements in the sample is indicated by the round markers and adotted line in the above figure, while the average standby measurement is shown in this figure by the square markers. (disk) denotes an internal hard disk.

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The example in Box 2 also highlights a further issue which is the time taken for a product to wake up. This is a key issue since the more components that are switched off when a product goes into standby; the longer it takes to wake up. Therefore consumer expectations, whether real or perceived, about the need for minimal wake up periods currently hinder the development of STBs with very low standby power values.

Box 2 • Efficient boxes made in China

Skyworth is one of China's leading manufacturers of set-top boxes, with about 17.5% of the Chinese market in 2006.

Through the use of low power components and an efficient power supply, their current cable set-top boxes use fewer than 8 Watts when they are in use. They also include a hard off-switch on the front of their models since it is common for Chinese householders to turn off the TV and set-top box when they are not being watched.

Skyworth has also developed technologies to reduce standby power to under 1 watt, which adds in the region of USD 1 to the cost of each box. The wake up time from this low level of standby is approximately 15 seconds, while security is processed (Chiao, 2007).

In products such as laptop PCs, power management interfaces provide consumers with the opportunity to change low power settings, for example to prolong battery life. Similar options could be incorporated into STB designs so that consumers who wished to trade lower energy consumption for longer wake up times could do so.

As indicated previously, enabling STBs to actually utilise their low power modes for the long periods when they are not being used to provide viewing content is at least as critical as improving STB designs. The example of BSkyB demonstrates that the requirements of a TVSP to have access to their fleet of boxes in order to download content can be limited in such a way as to allow boxes to remain in a low power mode for substantial periods.

Policies for energy efficient set-top boxes

Several different approaches have been used by policy-makers to address the need to develop types of programmes and sets of specifications which reflect the many variations in products and platforms, all of which have an impact on energy consumption.

The lack of a standard product and the proliferation of functionalities is becoming a feature of many electronic devices, so this is not unique to set-top boxes. However, STBs are possibly the first major product example where policies have had to tackle these issues.

The policy landscape

Table 65 presents the major national programmes targeted at the products which provide STB functions, which are either current in operation or are likely to be in the near term.

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Table 65 • Summary of current policies for set-top boxes

Country	Programme type	STB category	Mode	Status
China	Endorsement label	All	all modes	Current
Europe (Code of Conduct)	Voluntary agreement	All	all modes	Current
Japan	Top Runner	DVD recorders with digital tuners	all modes	Current
Korea	Endorsement label	All	all modes	Current
Taiwan	Voluntary agreement	All	standby	Current
United States (NTIA)	Financial	DTA	standby	Current
United States (Energy Star)	Endorsement label	All	all modes	Current
Australia	MEPS	All without recording function	all modes	Under consideration
Canada	MEPS		standby	Under consideration
Europe	MEPS	All	all modes	Under consideration
India	Endorsement label	All	standby	Under consideration

Source: ACNRE, 2007; E3, 2008, Dube, 2008, Hu, 2006, EC, 2008; NTIA, 2007; Li, Aizhen, 2008; Li, Tienan, 2006.

In addition to Table 65, it is also worth noting that the Energy Saving Trust in the United Kingdom operates an endorsement label programme for set-top boxes and integrated televisions.[5] Switzerland is in the process of introducing minimum energy performance standards for STBs to be effective from January 2010. The performance requirements will be based on the EU Code of Conduct (V4) specifications (Bruniger, 2008).

Policies to encourage efficient STBs

The most straightforward types of programmes are those that establish power thresholds for one or more applicable modes. As could be expected these tend to be established to cover products with a small number of features and limited functions, such as simple converter boxes. The 2007 Energy Star programme for Digital TV Adaptors (DTAs) is a good example of this, providing an endorsement label for products with an auto-power down facility and which require fewer than 8 watts in *on* mode and 1 watt in *sleep*.

A further example is the national subsidy scheme for converter boxes operated in the United States by the National Telecommunications and Information Administration which includes *standby* power requirements in its eligibility criteria (see Box 3 for further details).

5. For further details, see:
http://www.energysavingtrust.org.uk/energy_saving_products/types_of_energy_saving_recommended_products

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Some programmes are designed to cover a wider range of products. The approach pioneered by the European Code of Conduct and followed by the Korean e-standby (Energy Boy) programme and others, works by relating power thresholds to the features of a box (EC, 2008; MOCIE, 2005). As well as providing power thresholds for standard STBs (for each platform), these programmes give additional power allowances for the presence of common extra functions, such as recording capabilities, types of interfaces, etc. This means of setting power limits allows sufficient flexibility to cover a range of products, while establishing requirements appropriate to their functionality.

A variation on this way of setting specifications involves combining power thresholds for each mode into a daily or annual duty cycle, using specified values for the time spent in each mode. The resulting performance measure is a single energy consumption figure, the total energy consumption (TEC), which easily allows one product to be compared with another.

The Top Runner programme in Japan and Energy Star programme both use this approach (ES 2008a; ACNRE 2007). This approach also differs from other forms of specification when auto-power down is an extra requirement. With the duty cycle approach the presence of auto-power down can be reflected in the time allocation given to devices in *on* mode, which results in a lower TEC value. Table 66 shows that the allowance used by the Energy Star specification for products with an auto-power down facility assumes that the time spent in *on* mode for such devices is reduced by seven hours out of every 24 hours, compared to a STB without auto-power down.

Table 66 • Allocation of hours in Energy Star duty cycle

	Hours per day per mode	
Mode	**STB without auto-power down**	**STB with auto-power down**
On	14	7
Sleep	10	10
Auto-power down	0	7

Source: ES, 2008a.

The Top Runner programme currently does not include any incentive for auto-power down facilities, and, apart from the time taken to download EPG, assumes that the DVD recorder is in *sleep* mode when not actively being used, as shown in Table 67.

Table 67 • Assumed daily operating times used in Top Runner programme for DVD recorders

	Hours per day per mode
Mode	**DVD recorders with hard disk drive (HDD)**
HDD recording time	2.0
HDD playing time	1.0
DVD operating time	0.5
Standby (sleep)	20.5

Source: ACNRE 2007.

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The criteria for Energy Star are also very specific about how the auto-power down function must operate in order to qualify. For example boxes must power down after a maximum of four hours of inactivity. The STB may exit the *sleep* state in order to download content and scan for programme and system information, scheduling information, or any other maintenance activity, but once this is completed, the STB must return to the *sleep* state within a period of time of not more than 15 minutes. The box may wake from *sleep* mode for these purposes up to a maximum time of 2 hours in any 24 hour period, although this limit does not include activities that an end user schedules (*e.g.*, video recording of a daily show). Video downloads that are not user-requested (*e.g.*, "speculative recording" or "push") are to be counted as part of the two hour average per day requirement (ES, 2008a).

Policies to encourage energy efficient service providers

During 2008 Energy Star also launched a new programme designed to encourage TVSPs to give their subscribers access to more efficient set-top boxes which are not only more efficient but which contain auto-power down features. The partnership requirements are that Service Providers must ensure at least 50% of all new set-top boxes they *purchase* in a calendar year (*e.g.*, 2009 and 2010) are Energy Star qualified.[6] Alternatively, at least 10% of all STBs in the Service Providers stock in 2009 (or 25% of all stock in 2010) must be Energy Star qualified (EPA 2008a, 2008b; Kaplan, 2008).

Another potential policy approach raised at the 2007 IEA workshop is to acknowledge that customers have little influence over the running costs of their set-top box by obligating the service provider to meet most of these costs, thereby providing a strong incentive to the service provider to implement energy-saving measures (IEA, 2007).

Key policy considerations

In view of the forecasted rapid increase in electricity consumption by STBs over the next few years, there is an urgent need for governments to implement policy to support the most efficient technologies. Already there are some good examples of programmes implemented in a few countries which can provide valuable lessons.

For the most part, these programmes are designed to improve the efficiency of set-top boxes themselves, which although important, is not the only area where government policy needs to focus. Because TV service providers play a central role in the specification of boxes and in determining whether they can enter standby power modes, policies need to be designed which encourage them to pursue energy efficiency practices. The Energy Star programme for service providers is an encouraging step in the right direction, however its overall impact relies upon attracting sufficient voluntary partners.

6. *Energy Star qualified means that the boxes meet all the relevant requirements in the Energy Star specification for set-top boxes.*

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Box 3 • Subsidies for efficient STBs in the United States

In the lead-in to full digital TV transmission, the United States has provided over USD 640 million in subsidies to encourage the purchase of more energy efficient digital-to-analogue converter boxes (NTIA,2007).

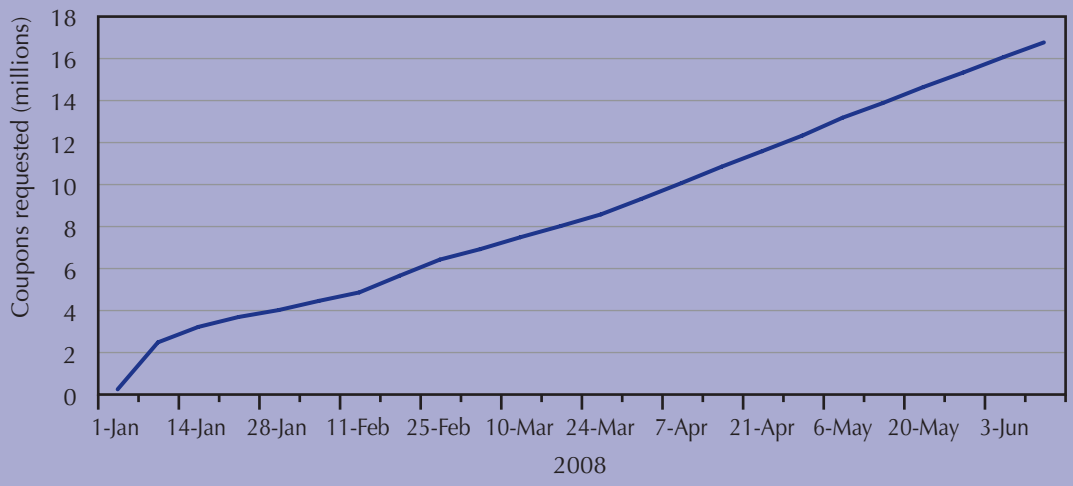
On 17 February 2009, all full-power television stations in the United States will stop broadcasting in analogue and switch to 100% digital broadcasting. Recognising that this may leave many of the most vulnerable consumers without access to TV, the National Telecommunications and Information Administration (NTIA) launched a coupon programme to subsidise digital converter boxes.

Consumers who use *rabbit ears* or a rooftop antenna with an analogue television can claim up to two, USD 40 coupons to help pay for the cost of certified TV converter boxes. Approximately 13.5 million households in the United States rely solely on over-the-air (OTA) television broadcasts.

Certified boxes, of which there are currently 91, can use no more than 2 watts of electricity in the *sleep* mode and must have an auto-power down facility. Eligible set-top boxes must automatically switch from the *on* mode to the *sleep* mode after not more than four hours, which shall be the factory default setting for the device.

The initial funding for this programme was USD 890 million, of which 72% has already been committed on 16.7 million requested coupons (see Figure 148).

Figure 148 • Number of USD 40 coupons for set-top boxes claimed by U.S. consumers in 2008



Source: NTIA, 2007.

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Governments have other policy tools available. Some countries are providing subsidies in the lead-up to switching off analogue TV broadcasts, or are considering doing so. In the current environment, where public funds are used they should be limited to products with the lowest carbon footprint. This would have the additional benefit of reducing consumer energy expenditure.

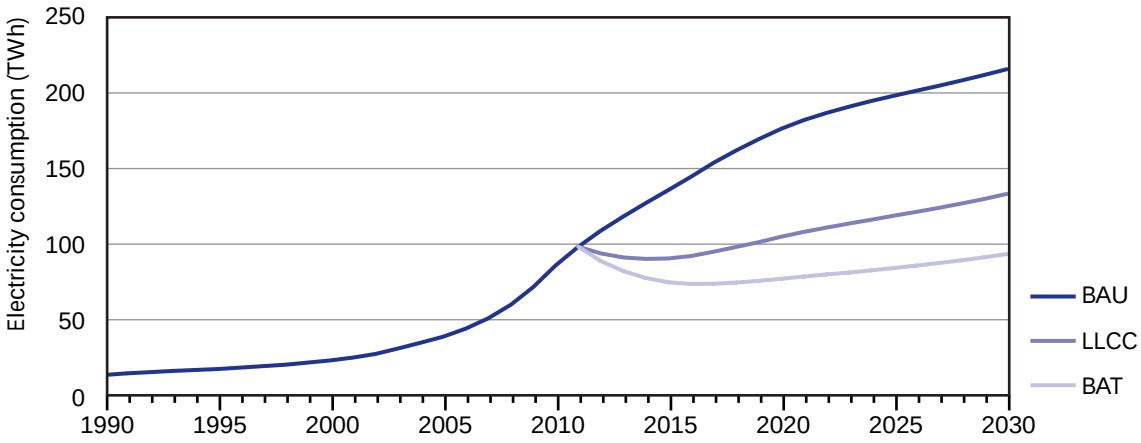
The majority of TVSPs operate under licence from governments, or their agencies, which lay out a range of conditions relating to the franchise. This contract could require TVSPs to ensure that customers were offered energy efficient services, possibly structured in a similar way to the Energy Star Service Providers specification. The adoption of these types of mandatory measures would have the advantage of certainty and speed, both of which are needed in order to impact on the very large numbers of STBs which will be sold in the next decade.

For these reasons, several countries are in the process of introducing minimum energy performance standards, in some cases alongside labelling programmes. Until now, energy efficiency regulations for STBs, and other small electronic devices, have been difficult to implement because of the diversity of products and features. However the development of new flexible approaches which allow extra allowances for features on top of requirements for basic boxes offers a workable solution.

The impact of these types of policies can be highly significant. Implementing policies which offer the lowest life-cycle costs (LLCC) would cut the estimated electricity consumption in 2030 by over 35%, saving 80 TWh per year.

If policies were implemented based on the best currently available technology (and services), then electricity consumption in 2030 could be halved, saving an estimated 120 TWh (see Figure 149).

Figure 149 • Estimated impact on electricity consumption of energy efficiency policies based on least life-cycle cost (LLCC) and best available technology (BAT), 1990-2030



Source: IEA estimates.
LLCC scenario uses a 10% discount over 5 years. The LLCC and BAT scenarios assume policy implementation in 2012.

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Recommendations

As part of the package of recommendations on energy efficiency policies made to G8 Summits in 2006, 2007 and 2008, the IEA included several policies focussed on set-top boxes (IEA, 2008). These policy recommendations are applicable to all governments and remain relevant:

> *(3.2 a) Governments should adopt the same "horizontal" 1-Watt limit and apply it to all products covered by an International Electrotechnical Commission definition of standby power with limited exceptions.*
> *(3.2 b) Governments should adopt policies which require electronic devices to enter low power modes automatically after a reasonable period when not being used.*
> *(3.3 a) The IEA concludes that international best practice, with respect to energy efficient set-top boxes, are policies that establish a minimum efficiency standard for Digital Television Adaptors. These regulations should:*
>
> > *i) Specify the maximum power levels while "on" and "off"; and*
> > *ii) Ensure that the consumer can easily switch the unit to the lower power level.*
>
> *(3.3 b) A second aspect of best practice is to ensure that government-subsidised units meet higher efficiency requirements.*
> *(3.3 c) Governments should implement energy efficiency policy measures for set-top boxes designed to minimise the energy used by TVSP customers in receiving TV services by ensuring that such requirements are included in relevant franchise or licensing agreements that allow TVSPs to operate.*

In view of the changing markets for STBs, in particular the increasing penetration of products with conditional access, recording and high definition capabilities, together with a pressing need for action, the following additional measures are required:

- Policies should be implemented which span the full range of products which provide STB functionality, with sufficient flexibility to encompass products which may emerge in the foreseeable future. Such policies should aim to minimise energy consumption by including all modes of operation and auto-power down requirements.
- Governments are encouraged to use a range of policy instruments, including but not limited to minimum energy performance standards, comparative and endorsement labelling to achieve long-term market transformation. There are strong arguments for using mandatory measures to remove the worst performing products, combined with endorsement labelling in markets where consumers have choice.
- In addition to including requirements for TVSPs in franchise or licensing agreements, governments should work with TVSPs to assist them to fulfil their obligations, such as by setting targets, providing endorsement facilities and other means of support.
- Governments should encourage industry to develop simple power management interfaces for STBs which enable consumers to choose appropriate settings in order to minimise energy consumption. Alongside this, there is also a role for governments, also in collaboration with industry, to educate consumers about actions they can take to minimise consumption.

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Chapter 8 • MISCELLANEOUS ICT AND CE EQUIPMENT

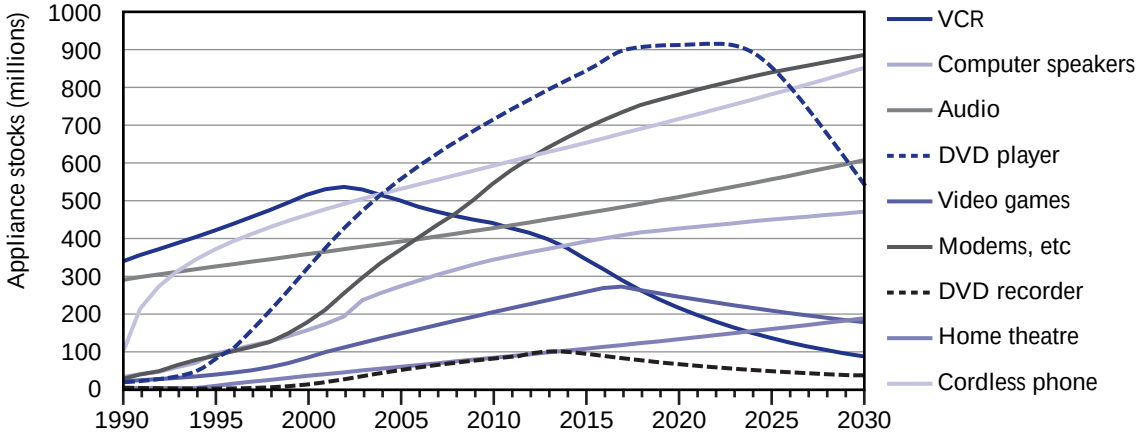
In addition to the major items identified previously, there are between 20 and 40 types of small ICT and CE appliances which appear in houses. Some of these, like mobile phone chargers, use only quite small amounts of power individually but because of their extremely high penetration rates, are responsible for significant quantities of electricity consumption. Others, such as DVD players and recorders are likely to be largely replaced by technologies such as set-top boxes with hard disks and computers.[1]

Printers, faxes, scanners and copiers have changed considerably over the past 15 years, with different technologies coming into homes and then being substituted by multi-function devices and Internet communications. More recently, the arrival of digital cameras has led to a growing market for small inkjet colour printers.

Digital still and video cameras are amongst the many new portable devices that are now common in the home. MP3 players are even more abundant, although mobile phones now offer music storage and playback which will appeal to some groups. Portable video players are also becoming increasingly popular. All of these mobile technologies require electricity for recharging, and while battery storage capacity is improving, the added functionality of most portable devices means that their power requirements are also increasing.

To date technology convergence has helped to reduce the number of appliances in a few cases, however it is probable that there will be a higher degree of convergence over the next decade. Most items have relatively low capital costs and their ownership is not restricted to one per household; so that many households can have multiple numbers of the same small appliances. These factors, together with the growing markets outside the OECD continue to increase sales and ownership levels. Although it is not possible to show the trends in all of these types of appliances here, the estimated stock of some are shown in Figure 150.

Figure 150 • Estimated stock of selected miscellaneous ICT and CE equipment, 1990-2030



Source: IEA estimates.

1. *Where technologies like these converge it is factored into analysis provided in previous chapters.*

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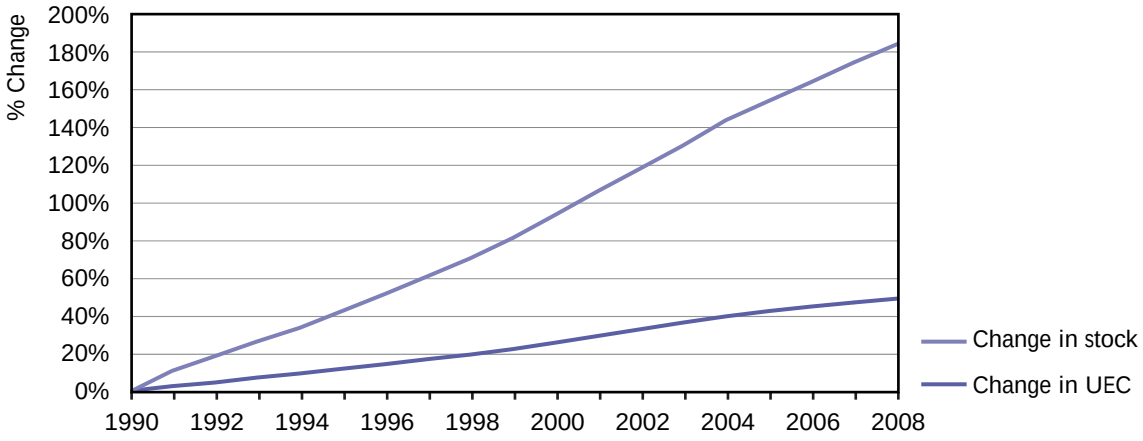
Electricity consumption by these miscellaneous items has been growing by over 8% per annum since 1990, to an estimated total of nearly 200 TWh in 2008. As shown in Figure 151, the unit energy consumption (UEC) of all appliances has increased by nearly 50% during this period, while the stock has grown by over 180%. In fact, the influence of the stock will be greater than shown here since it does not include the very large growth that has occurred in mobile phones and external power supplies.

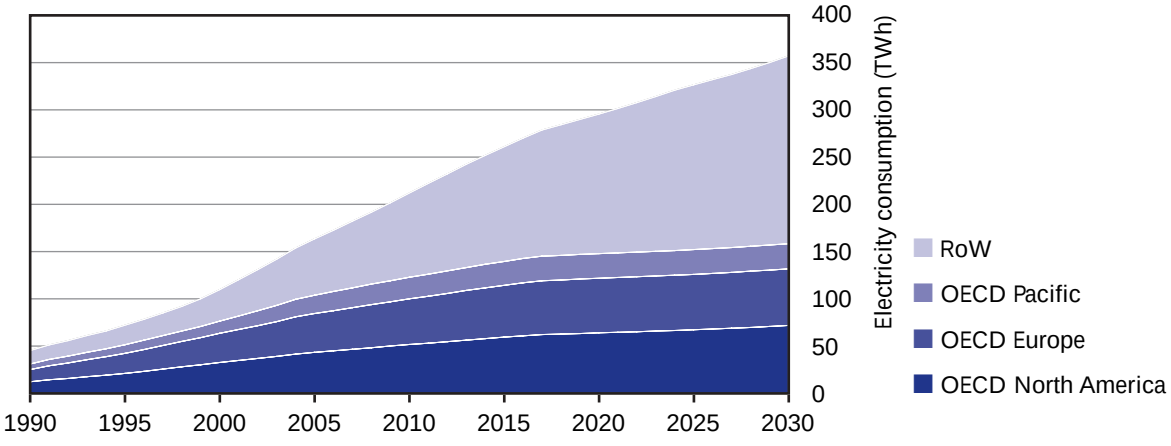
Figure 151 • Estimated change in unit energy consumption (UEC) and stock of miscellaneous ICT and CE equipment, 1990-2008



Source: IEA estimates. The stock figures above do not include external power supplies or mobile phone chargers.

Total electricity consumption is estimated to continue to grow up to 2015, particularly in non-OECD countries, before stabilising due to more product convergence and increased market saturation.

Figure 152 • Estimated electricity consumption by miscellaneous ICT and CE equipment, 1990-2030



Source: IEA estimates.

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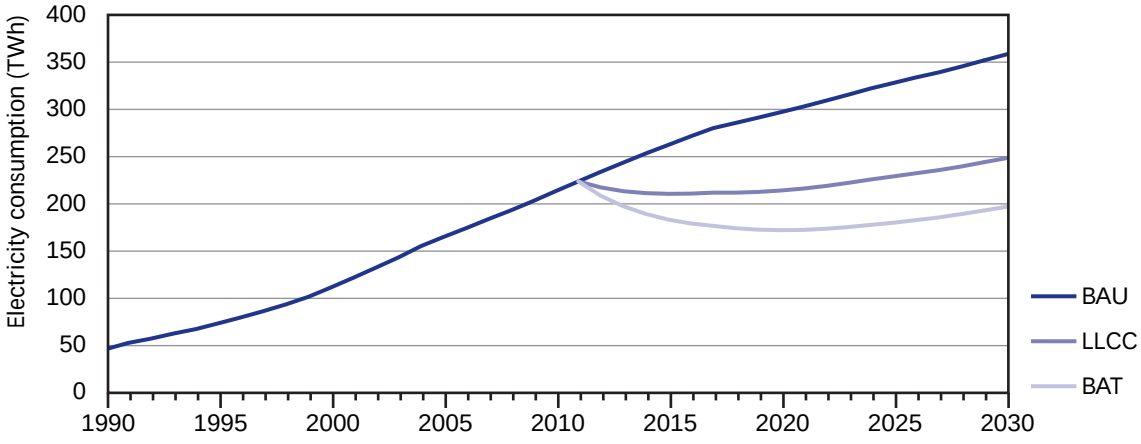
The opportunities for saving energy in these appliances are significant. Cost-effective savings under the LCCC scenario would reduce electricity consumption by an estimated 30% in 2030, or 110 TWh. This would increase to 160 TWh under the BAT scenario; a saving of 45%.

Figure 153 • Estimated impact on electricity consumption of energy efficiency policies in miscellaneous ICT and CE equipment, based on least life-cycle cost (LLCC) and best available technology (BAT), 1990-2030



Source: IEA estimates. The LLCC and BAT scenarios assume policy implementation in 2012.

Recommendations

The IEA 25 policy recommendations to the G8 (OECD/IEA, 2008) address some of the issues facing miscellaneous ICT and CE equipment, however further detailed recommendations are provided below.

Since many of these miscellaneous products are particularly difficult to define and are subject to convergence, they are particularly suitable to horizontal policy measures. As a result the majority of savings in this category result from the following policy measures described elsewhere:

- Implementation of power management requirements for all products;
- 1-Watt horizontal standby policy measures;
- Requirements for external power supplies.

Additional policy measures for specific technologies may also be warranted in some markets, for example for imaging equipment, DVD players and recorders, video games consoles and modems. There are many good examples of effective policies for these types of products, such as those developed by Energy Star and Top Runner, which provide a useful basis for voluntary or mandatory programmes.

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Chapter 9 • CROSS-CUTTING ISSUES

The previous four chapters have examined the electricity consumption of individual types of ICT and CE appliances. While there are many common components and themes across all of these categories, three areas warrant more detailed attention because of their current or potential impact on energy consumption, currently in excess of 450 TWh per annum. The three issues singled out for consideration in this chapter include external power supplies (EPS), *standby* power and digital networks (and appliances connected to these networks).

External power supplies

There are now over 3.3 billion mobile telephone subscribers in the world; equivalent to half the global population (GMSA, 2007). Nearly all of these phones will be charged using a device called an external power supply (EPS) which plugs into the household electricity supply. These small boxes have become ubiquitous over recent years and on average most households in OECD countries regularly use between five and ten different EPS.

Also known as 'plug packs', 'converter boxes', 'transformers' and 'chargers', the function of an EPS is to supply power to another appliance at the required voltage and current. Typically, an EPS will take the household alternating current (AC) mains supply at between 100 and 250 volts and convert it to direct current (DC) at a lower voltage. This conversion is never 100% efficient and so energy is consumed in the process, indicated by the heat given off from EPS in use. In fact losses from EPS often comprise more than 30% of the total electricity used by many appliances which are powered in this way, contributing an estimated 50 TWh to global residential electricity consumption. These losses are generally considered as part of the overall consumption of end-use equipment, such as laptops or set-top boxes, but because EPS are so widespread, similar in design and functionality, and due to the amount of energy used by them, EPS warrant closer examination.

The changing market for EPS

Of the 5.5 billion EPS in use today which are associated with a wide variety of appliances, mobile phone chargers comprise the largest single application. While a small number of EPS are sold individually to consumers, the large majority are supplied bundled with the end-use appliance by the supplier. Most EPS manufacturing occurs either in China or Chinese Taipei, although a significant amount of product design and development occurs in other regions, particularly the United States and Europe.

Broadly there are two types of residential appliances which use EPS: firstly those that source all the power they need to operate through an EPS, and secondly there are mobile devices which have a battery that is periodically charged using an EPS. Some tend to mix both approaches

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and laptop computers are the most common example, being used sometimes as a desktop personal computer connected to the mains supply, and sometimes as a mobile device powered by battery.

A distinct EPS category is used to charge batteries removed for charging purposes, such as in the case of power tools, some digital camera batteries and AA or AAA batteries. In these EPS the charging circuitry is embedded within the EPS product rather than in the end-use appliance and therefore they are technically quite different from most other EPS.

Similarly, some fixtures for extra low voltage (ELV) halogen lamps use a particular type of external power supply, often simply called a 'transformer', providing AC current at either 12 or 24 volts and a frequency of between 10kHz and 100 kHz.[1]

As could be expected, the residential EPS market has closely tracked the dramatic growth in mobile phone subscriptions, the wider use of laptop computers, and the increasing ownership of smaller electronic devices from the late 1980s.

An indication of the rate of growth is that the number of mobile phones subscribers hit the 1 billion mark in 2002 and by September 2005 this figure had doubled. The 3 billion mark was reached in 2007, and reports indicate that growth in the subscriber base during 2008 was the fastest that it had been in five years. Figure 154 shows the market penetration, growth rates and subscriber base for a number of major markets (GMSA, 2007; ME, 2008).

In non-OECD countries, the mobile phone network has expanded faster than the fixed telephone infrastructure, often making mobile phones the only means of telephone communication. As a result, 64% of mobile phone users are in developing markets. In Africa for example, only 3% of people have access to a landline, whereas in 2006 one in nine people owned a mobile phone. With 100 million mobile subscribers, the number of mobiles in use in the African continent is growing nearly twice as quickly as in Asia (Times, 2006).

The penetration of MP3 players has also increased rapidly from the early 2000s and approximately 35% are supplied with their own charger unit. While convergence in technology has allowed consumers to purchase mobile phones with integral music players, emerging markets for other portable devices such as video players (PMP) have provided new growth. Global PMP/MP3 player unit shipments are expected to reach nearly 270 million units by 2011, expanding by 13% per annum from 2005 (iSuppli, 2007).

There are similar fluctuations in many of the market sectors for residential appliances that use EPS. For example, a reduction in the cost of laser printers, and the popularity of multifunction devices, has led to a downturn in the use of inkjet printers and scanners. Answering machines now tend to be integrated within other telephony products, such as base units for cordless phones which still comprise a significant part of the EPS stock in OECD countries. Once, a major proportion of computer monitors used an EPS, however this is now less common. The use of low voltage halogen downlights have become extremely popular in homes in certain parts of the world, the United Kingdom and Australia in particular, but are almost

1. Compared to main electricity frequencies of around 50-60Hz.

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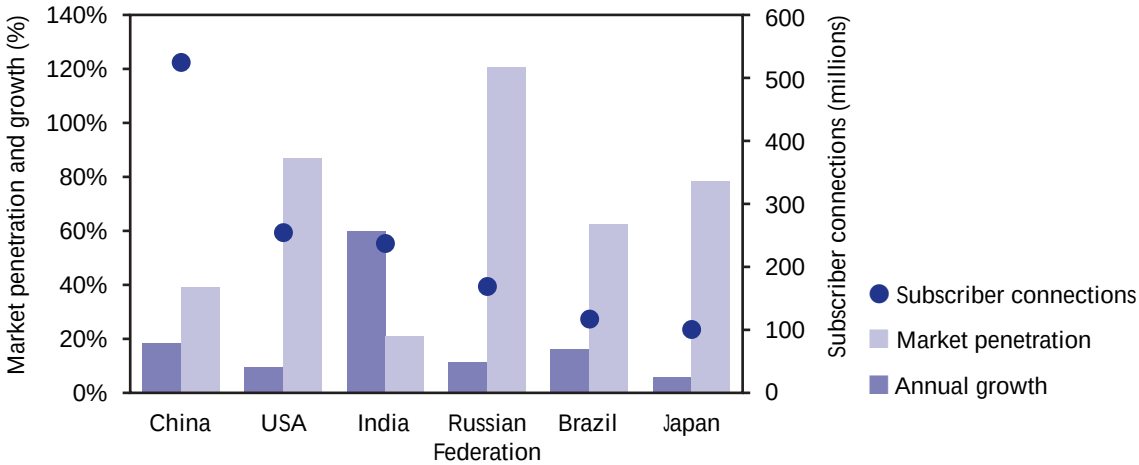
non-existent in other regions. On the other hand, task lighting has been growing and there is a significant market for stand-alone light fittings using low voltage halogen lamps.

Figure 154 • Mobile phone subscribers, annual growth and penetration rates in selected economies, 2007



Source: GMSA, 2007.

Also growing fast in recent years has been the market for EPS used with laptop computers and equipment such as computer speakers, modems, routers and set-top boxes. With 135 million laptops and notebooks expected to be sold in 2008, demand for portable computers is rising by around 25% per annum, and will soon outstrip desktop models (ITBE, 2008; BBC 2008). Once the preserve of the business sector, their mobility, small size and falling cost, together with their improved performance, have made laptops increasingly attractive to consumers, including students.

While the main reasons that laptops use an EPS are to save weight and size, and to remove heat from inside the laptop casing, international trade also plays a role. Since the voltage and frequency of mains electricity varies from region to region around the world, if a device uses an EPS then identical or similar products can be sold anywhere in the world by using an EPS suitable to that region or country. Reducing the product variation between countries can allow suppliers to reduce model ranges and consequently save on compliance and stocking costs, which may be considerable. This explains why EPS are used frequently with small electronic appliances.

Many of the existing markets are close to saturation in OECD countries, so that replacement products comprise a sizeable proportion of the continued demand for EPS. This is one reason for the slowed growth in the estimated stock of EPS in the residential sector in recent years, as shown in Figure 155. However, there is substantial growth for many products which use EPS in developing countries and this is expanding the overall stock. Globally, there are approximately 5.5 billion EPS in active use today, equivalent to 3.8 products in every home with access to electricity. Approximately 30% of the EPS stock now exists in Non-OECD countries, and this proportion is likely to increase in future years (see Figure 156).

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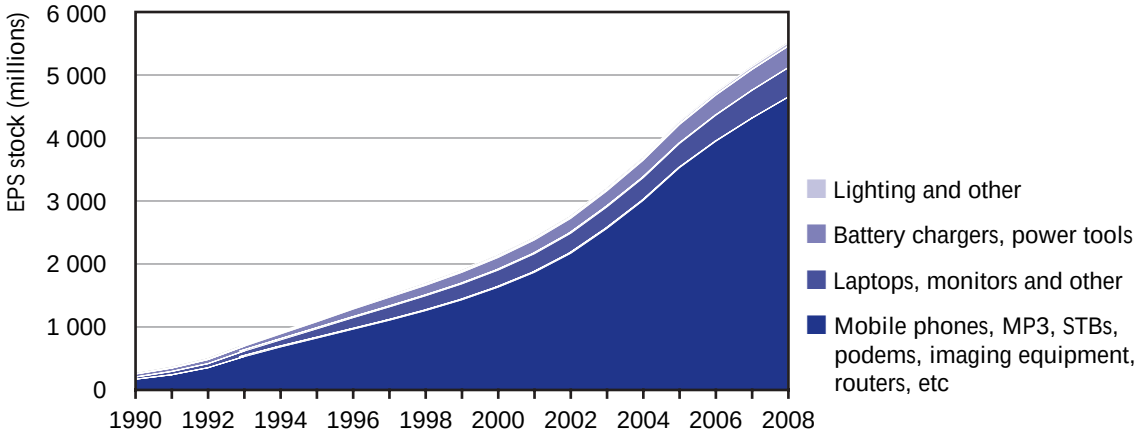
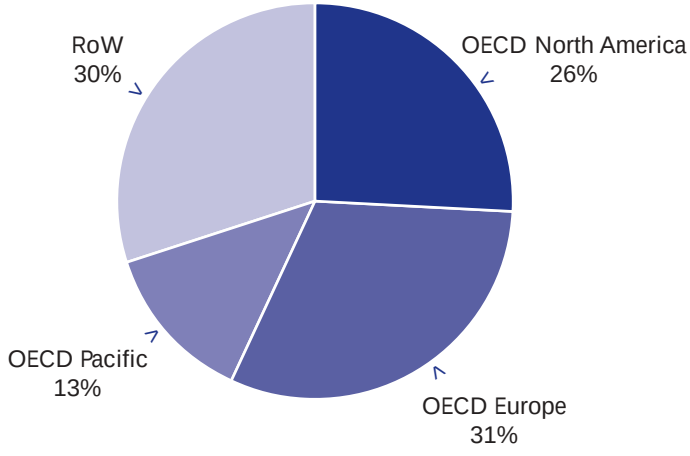
Figure 155 • Estimated stock of EPS by major market sector, 2008



Source: IEA estimates.

Figure 156 • Estimated distribution of EPS stock by region, 2008



Source: IEA estimates.

Energy consumption

Most EPS are rated according to their maximum nameplate output power (P_{no}), however when they are plugged into an end-use appliance the power required may be well below this rated value, depending on what the appliance is doing at the time. Figure 157 shows how the power provided by a laptop computer EPS (as a percentage of its rated output) varies according to what the laptop's functionality.

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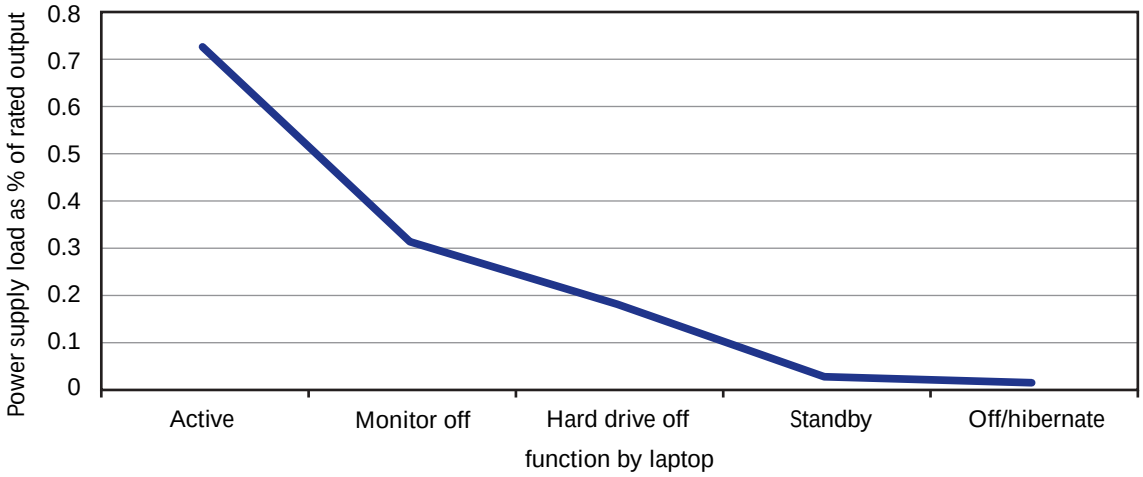
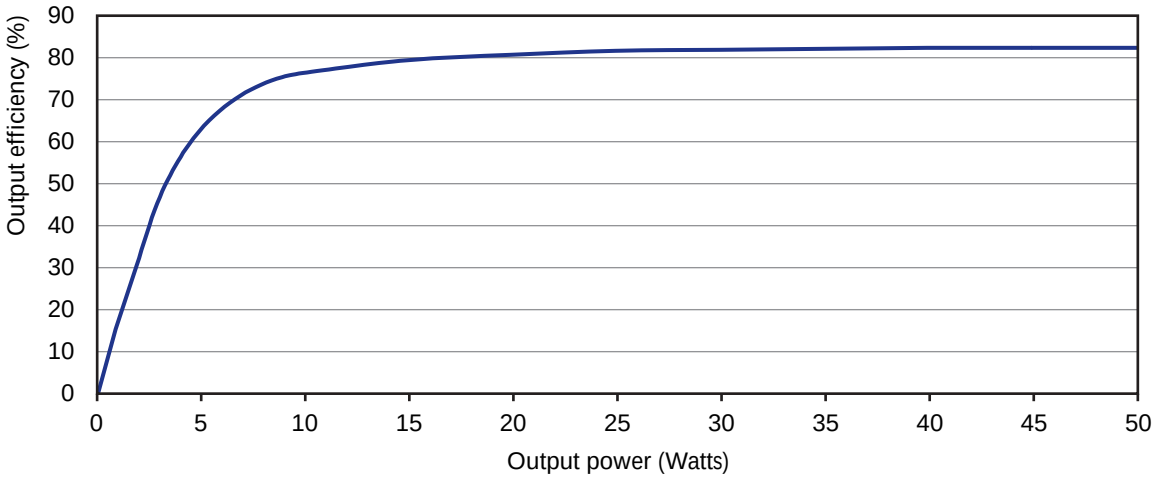
Figure 157 • Variation in power supply load in sample laptop computer



Source: Punchline, 2007.

This is important since the efficiency, and therefore amount of power used by the EPS, changes according to whether the EPS is lightly or heavily loaded. Although dependent on design issues, EPS are less efficient at light loads and get more efficient as the load increases towards their maximum rated output, as shown in a typical performance curve in Figure 158.

Figure 158 • Variation in power supply efficiency with load



Since EPS generally have no power switch, when plugged into the mains power supply EPS consume energy even when the appliance they power is switched off, or when the EPS is disconnected from the end-use appliance. This *no-load* power consumption varies between models but there is little correlation between this and the power rating of the EPS, as shown in Figure 159 for over 650 measurements taken in three countries during 2003.

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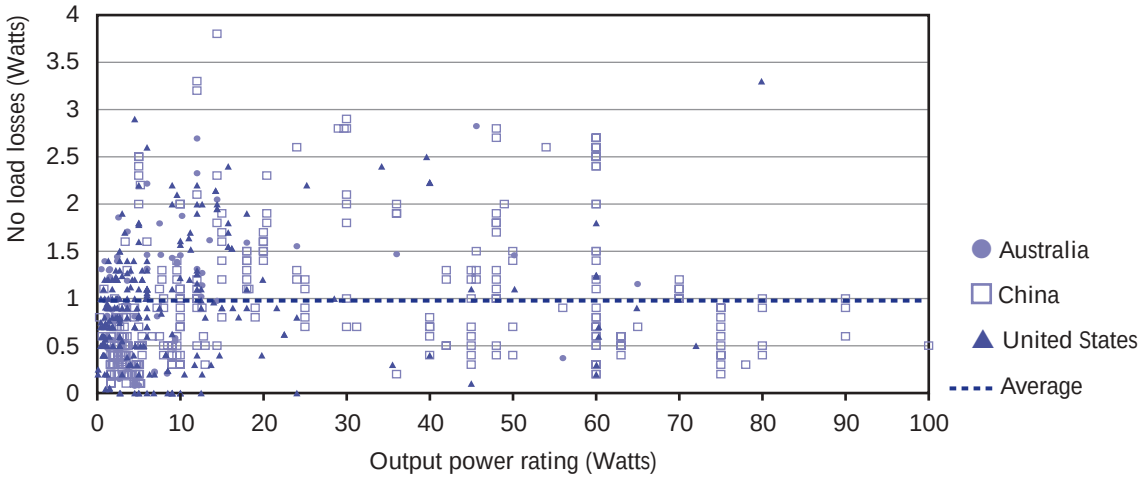
Figure 159 • Measured no-load losses for 650 sample external power supplies



Source: MEA, 2005.

The total losses from EPS are technology related, since the two dominant types of EPS have different characteristics. The simplest type of power supply is linear, which uses a step-down magnetic transformer to reduce voltage, and often a diode rectifier and filter capacitor to convert AC to DC. The other form of power supply is the 'switch mode' or 'switching' type. Here the mains AC is rectified directly to produce high-voltage DC, which is then used to power an efficient high frequency DC-DC converter and uses a smaller and lighter step down transformer than used in linear power supplies.

Linear EPS are easily recognised by their larger size and/or weight compared to switching types. This feature, together with their resistance to power surges, gives them a robustness that tends to make them attractive in situations where electricity supplies are prone to large fluctuations and long-life is valued.

In the past, basic linear EPS have tended to be cheaper than switching power supplies, although less efficient and with higher no-load losses.[2] A study in 2004 suggested that linear power supplies typically operated at between 25% to 60% efficiency, while switching power supplies ranged in operating efficiency from 50% to 90% (MEA, 2004). The smaller size of switching power supplies is also an advantage in packaging and shipping products, making them more suitable for mobile end-use appliances. Switching power supplies can readily adapt to different input voltages and frequencies, for example as used in different global regions, which is important for mobility and trade (MEA, 2004).

Since the late 1990s, policy-makers have become aware of the potential to reduce energy wastage by improvements to external power supplies. In 2001, the IEA publication *Things That Go Blip In The Night* highlighted the issue and noted a new European Commission voluntary agreement process which targeted external power supplies, known as the Code of Conduct (OECD/IEA, 2001). Since then there have been a range of initiatives developed by governments, based on

2. More efficient linear models are available but they tend to be expensive.

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a better understanding of the markets and technologies involved (see *Policies for Efficient EPS* below). As a result of improved data collecting associated with these initiatives, there is evidence that the average performance of most EPS has improved during the 2000s.

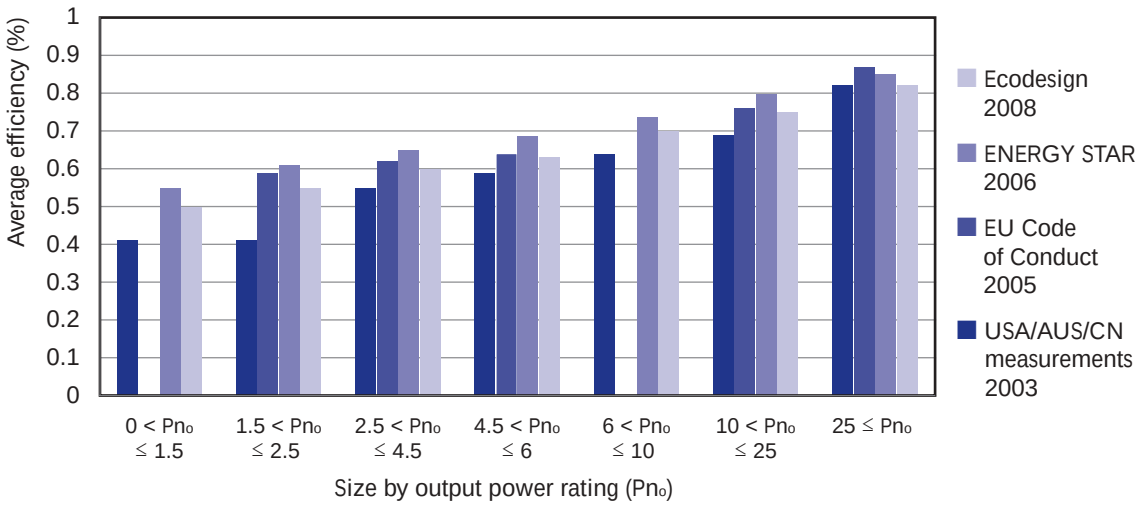
Table 68 and Figure 160 show various estimates of the average efficiency[3] from data collected between 2003 and 2007. While the 2003 data reflects a broad cross-section of over 650 models in three regions, the 2005 and 2006 samples illustrate the better performing products in the market,

Table 68 • Average EPS efficiency data from studies 2003 to 2007

Rated output power (Pn_O) (watts)	USA/AUS/CN measurement campaign 2003	EU Code of Conduct compliant EPS, 2005	ENERGY STAR compliant EPS, 2006	Assumption for EuP preparatory study, 2007
$0 < Pn_o \leq 1.5$	41.0 %	–	55.0 %	50 %
$1.5 < Pn_o \leq 2.5$		59.0 %	60.9 %	55 %
$2.5 < Pn_o \leq 4.5$	55.0 %	62.0 %	65.0 %	60 %
$4.5 < Pn_o \leq 6$	59.0 %	64.0 %	68.6 %	63 %
$6 < Pn_o \leq 10$	64.0 %	–	73.7%	70 %
$10 < Pn_o \leq 25$	69.0 %	76.0 %	79.7 %	75 %
$25 \leq Pn_o$	82.0 %	87.0 %	85.1 %	82%

Source: MEA, 2005; BIOIS, 2007.

Figure 160 • Average EPS efficiency data from studies 2003 to 2007



Source: MEA, 2005; BIO IS, 2007.

3. *The average efficiency is calculated from measuring the efficiencies at 25%, 50%, 75% and 100% of the rated load.*

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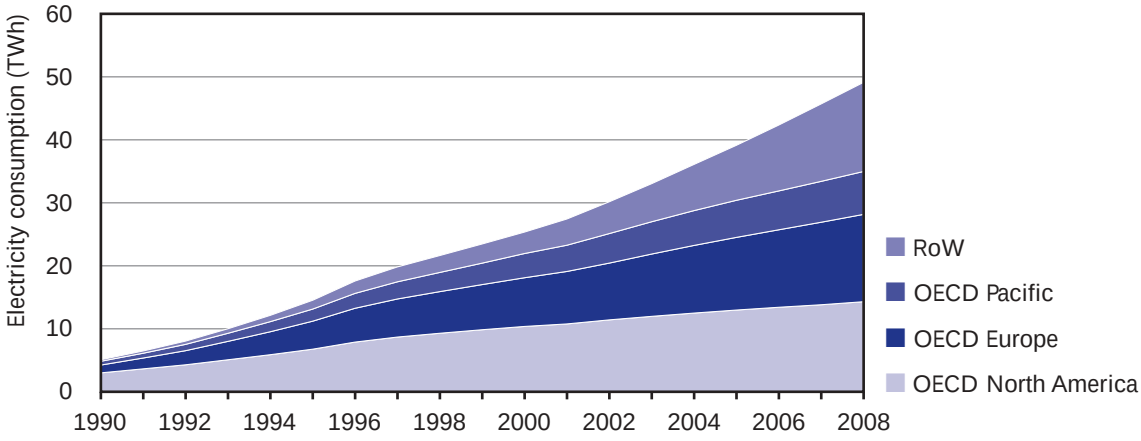
and therefore the Ecodesign study in 2007 has chosen slightly lower figures as representative of the market in general. Nevertheless, this data does suggest a drift towards higher efficiencies in the market.

Contributing towards improved efficiencies in the stock has been a move away from the use of linear EPS towards switching type models, more suitable to internationally traded mobile devices. Nevertheless, linear type models still comprise a substantial part of the market for low output EPS, for example they account for an estimated 25% of shipments in the United States (DOE, 2006). Battery technology has also been improving considerably, enabling products with integral batteries to run for longer between charging cycles; a factor which is balanced by the growing functionality in devices that demand more power input.

Analysis of total electrical energy losses from EPS in the residential sector show that these overall efficiency improvements have been outweighed by the growth in the number of EPS in use today. While the mix of products and their usage patterns vary from region to region, it is estimated that total electricity consumption has increased by approximately 13% per annum between 1990 and 2008, reaching nearly 50 TWh today, as shown in Figure 161. This is equivalent to 1% of global residential electricity consumption, although in some regions this share amounts to 1.5%.

Figure 161 • Estimated electricity consumption from external power supplies, 1990-2008



Source: IEA estimates.

While products such as mobile phones and MP3 players comprise the majority of the stock, their low energy consumption means that this sector uses only about 18% of the energy consumed by EPS. As shown in Figure 162, laptops, set-top boxes, ICT equipment account for the largest proportion of energy losses in EPS. Although many EPS remain connected to the main electricity supply for long periods, the no-load consumption accounts for only 20% of the total losses.

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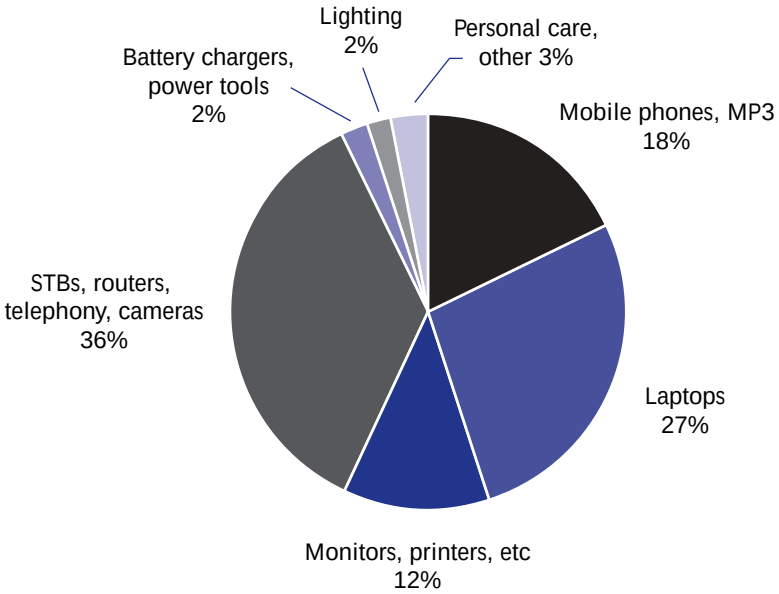
Figure 162 • Estimated distribution of electricity consumption by end-use sector, 2008



Source: IEA estimates.

Future trends

As over the past few years, the likelihood is that the outlook for EPS energy use will be influenced by a composite of conflicting trends. While stocks of EPS in OECD countries look close to saturation in some sectors, there still exist major new markets in many developing regions for the end-use appliances that use EPS. In most regions, stocks of set-top boxes will dramatically increase to cater for the roll-out of digital TV and penetration of pay-TV, many of which will require an EPS.

Less certain is what will happen to computer monitors in the future. Although the recent trend appears to be away from the use of EPS, design issues may dictate that these products favour EPS in the future. This would have a significant impact on the market; however a far larger impact would be if flat panel TV sets were to switch from internal power supplies to EPS. The advantages of using an EPS are that thinner and lighter screens could be provided, with less damaging heat build-up inside the casing. The same benefits would come from separating the data processing and tuning functions, together with the power supply, from the display and some industry analysts believe that this is more likely than just switching to an EPS (BIO IS, 2007). In either case, the total losses would be similar, resulting in little change to overall residential energy consumption.

In a move which reduces the use of EPS, recent versions of Apple's iPod rely upon a USB connection to provide charging power, typically via a computer. While this appears to represent a minor change in terms of energy consumption, in fact if this occurs when the computer would otherwise be in *sleep* mode it is likely to increase energy use since many of the computer circuits are required to be 'on' just to charge the connected end equipment.

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Some markets for EPS are likely to diminish due to convergence of separate devices. To some extent we are already seeing this happen with purchases of a single product which combines a mobile phone with a camera and an MP3 player. Improvements to battery technology have made it possible for products like these to converge and combine while meeting the increased power demand through more effective energy storage. With miniaturisation as an important factor in the market for mobile devices, there is always a balance between the functionality (and therefore power demand of a device), and the size and weight of the energy storage technology. However, this tension has resulted in an extremely positive market driver for improved energy efficiency in mobile technologies.

Unfortunately, outside this market for mobile devices, the more efficient EPS have faced a number of barriers in gaining market penetration. Amongst these is the low consumer involvement in purchasing decisions, since the EPS is almost always bundled with an end-use appliance which is the primary focus of the customer's concern. It is unheard of for a customer to be offered a device such as router or modem and asked whether they wish the basic or premium EPS to go with it; or for a customer to enquire about the efficiency of the EPS bundled with another product! As in other markets where there are principal-agent issues, the selection of the EPS is made by the supplier of the end-use appliance, who has little interest in the life-cycle energy consumption, but does have a strong concern to minimise first costs (see OECD/IEA, 2007, for further discussion of the principal-agent issue).

In fact, although this was the case a few years ago, it is no longer clear that more efficient EPS necessarily command a higher capital cost. It has been claimed that, in general, high efficiency switching EPS are not more costly to manufacture than the standard product, but they do involve more design attention (PI, 2008). The increased penetration of higher efficiency EPS in many very price sensitive market sectors appears to support this view, suggesting that once volumes of production increase the price differences are small to minimal (BIO IS, 2007).

A further example exists in the linear EPS market. The Ecodesign study in Europe reports that the cost of raw material is a significant component of final production costs, and that rising resource costs have now made switching EPS in the lower power sector cheaper than linear power supplies (BIO IS, 2007).

However, it should be noted that some additional business costs are added when a supplier changes a bundled EPS, in terms of time sourcing product, gaining necessary approvals, and perhaps in re-packaging. Without considerable incentive to do so, these additional burdens are unlikely to be shouldered willingly by the majority of the industry.

Additional barriers also exist. In the lighting sector, while switching EPS are becoming more prevalent, many electricians stick with tried and tested products and suppliers for ELV lighting, despite converging costs with linear EPS. This makes life easier for the electrician but is not necessarily in the best interest of the consumer. Figure 163 shows the life-cycle costs for three EPS options supplying an ELV halogen lamp over an operational life of 22 500 hours, illustrating how the most efficient option also delivers the least life-cycle costs.

Although many products offer very high energy efficiency performance, well above the current average, availability of such products remains a limiting factor in some sectors, as noted in the Ecodesign report:

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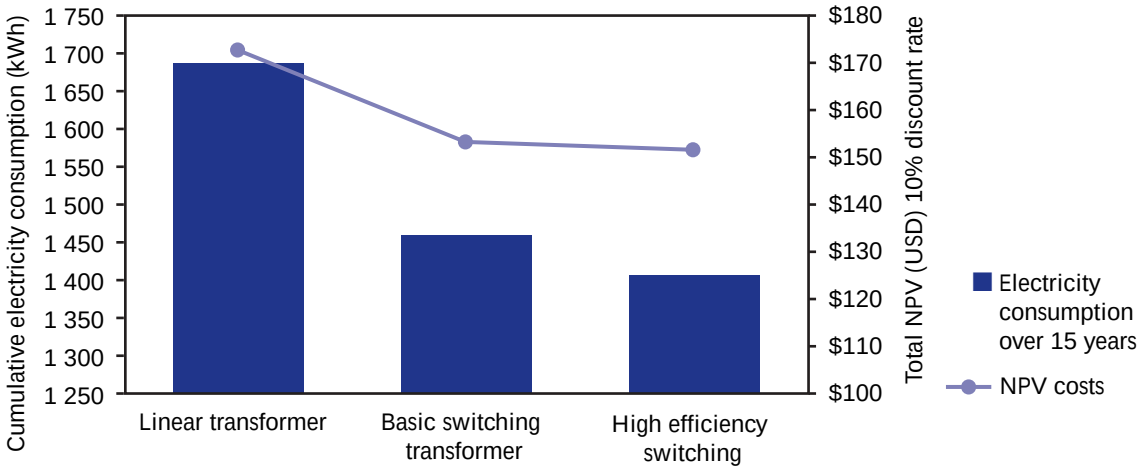
"Outstanding individual EPS, in terms of average active efficiency, (are) already available on the market in different output power ranges (this data is retrieved from the latest ENERGY STAR list). However, this does not mean that all kind of power requirement specifications can be met with such highly efficient EPS.

Even in the power output range of 3.5-10 W, there are EPS achieving average efficiencies above 80% and in the output power below 3.5 W more than 65% average efficiency is achieved by several EPS. The best performing EPS achieve efficiencies 10% and 6% higher than the assumed market average in the range up to 6 W and above 6 W respectively.

Quite a few highly efficient EPS in the low power range have very low no-load losses (not exceeding 0.2 W), and some even below 0.1 W. In the high power range too, no-load losses below 0.5 W are achieved by many EPS." (BIO IS, 2007)

Figure 163 • Least life-cycle analysis of alternative ELV transformer technologies



Source: Based on data from BIO IS, 2007.

Considering the issue of product availability and the development cycle for new EPS products, the recent regulatory impact study in Australia and New Zealand reported that the lead time from specification to market ranges from 5 to 17 months, following discussions with industry supplying products bundled with EPS. In some cases this can further be reduced through undertaking some of the processes shown in Table 69 in parallel (Punchline, 2007).

Table 69 • Development cycle for new EPS product

Activity	Minimum time (months)	Maximum time (months)
Design	2	9
Safety	2	2
C tick	0.5	0.5
Components	1	6
Total	**5.5**	**17.5**

Source: Punchline, 2007.

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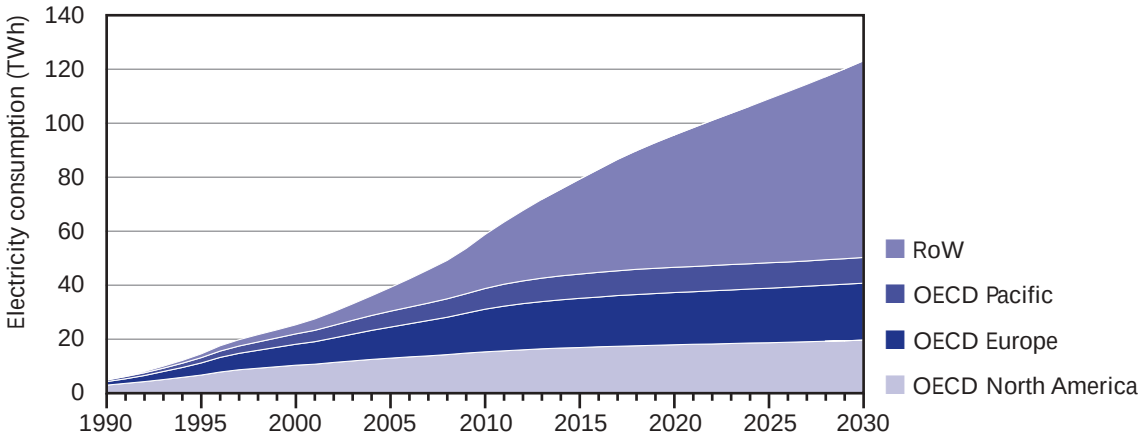
Without policy measures to increase the uptake of more efficient EPS, and to encourage industry to develop and market new products, major improvements in the existing stock appear unlikely. Despite further efficiency improvements in mobile devices, expanding markets for higher powered ICT and home entertainment products and the growth in developing countries are likely to continue driving the overall electricity consumed by EPS upwards. While the drivers for growth are different in each region, the result is that the losses from EPS are expected to increase in all major regions, as shown in Figure 164, reaching over 120 TWh by 2030. The cost of this electricity consumption is estimated to be USD 12 billion in 2030.

Figure 164 • Estimated electricity consumption from external power supplies, 1990-2030



Source: IEA estimates.

Policies for efficient EPS

The policy landscape

Following the lead provided by the EU Code of Conduct, and in response to analysis identifying opportunities for substantial improvements, a number of leading economies have moved to introduce policy measures designed to increase the efficiency of EPS in their countries. Although there are some differences in the scope of these measures, particularly with respect to whether they include battery chargers and ELV lighting transformers, there is a high degree of harmonisation for the majority of EPS products in terms of performance requirements and methods of test. Table 70 summarises the type and status of these policies.

It is interesting to note that the size and lack of consumer visibility of most EPS prohibit the use of a label on the EPS itself. Programmes based on an endorsement label, such as Energy Star, have therefore tended to focus on the wholesale market, and to ensure that where end-use appliances are normally supplied with a bundled EPS, the Energy Star specification for such appliances includes a requirement for compliant EPS.

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It should be noted that there are a number of additional policy measures which indirectly impact EPS by acting on the end-use appliance. For example, the Top Runner programme in Japan specifies performance requirements for appliances including computers (including laptops), imaging equipment and routers, on the understanding that improving the EPS provides one option for suppliers to achieve the performance thresholds. There are numerous such policy measures, both mandatory and, more commonly, voluntary, which are identified in earlier chapters dealing with policies in individual countries and regions; and for this reason they are not identified below.

Table 70 • Summary of major policy measures for EPS (excluding ELV halogen lighting transformers)

Country/Region	Type	Status	Implemented	Threshold**
Australia/New Zealand	Mandatory MEPS	Pending	Aus: December 2008 NZ: April 2009	III
Australia/New Zealand	Voluntary high efficiency specification	Pending	As above	IV
Canada	MEPS	Pending		
China	Voluntary endorsement label	Current	2005	IV
China	Mandatory MEPS	Current	Tier 1: 2007 Tier 2: 2009	II IV
European Union (Code of Conduct)	Voluntary agreement	Current	1999	IV
European Union	Mandatory MEPS			Tbd
Korea	Voluntary endorsement label	Current	2005	0.8 W no-load only
Korea	Mandatory MEPS	Pending	2009	III*
United States (ENERGY STAR)	Voluntary endorsement label	Current	Tier 1: 2005 Tier 2: 2008	III V
United States (Federal Govt)	Mandatory MEPS	Current	2008	IV

* MEPS will apply to no-load and active modes for EPS except chargers, where only no-load requirements will be required.

** See below (International Efficiency Marking Protocol) for an explanation of these threshold levels.

The ELV lighting market is highly regionalised and therefore policies for extra low voltage tungsten halogen lighting transformers have not been widely considered. In Australia/New Zealand a new test method has been developed and approved by Standards Australia (AS/NZS 4879.1:2008) and MEPS will be introduced by 2010 at the levels shown in Table 71 (SA, 2008a; SA, 2008b).

In the EU, policy measures for ELV lighting transformers are being considered under the Ecodesign Directive (BIO IS, 2008).

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Table 71 • Proposed MEPS for halogen lighting transformers in Australia and New Zealand

Rated transformer power	MEPS level (% efficiency)	High efficiency level (% efficiency)*
≤ 200 VA	≥ 86%	≥ 92.5%
> 200 VA	≥ 91%	≥ 92.5%

Source: SA, 2008b.
* The high efficiency level indicated is not mandatory, but products wishing to be marketed as 'high efficiency' must meet or exceed this threshold. In addition, it serves as an indication of future mandatory efficiency levels.

International harmonisation

The development of policy measures for EPS has been a unique collaborative venture amongst energy efficiency agencies in the United States, Europe, China and Australia, which serves as an example for further harmonisation and policy development processes.

Beginning in 2003, interested parties including United States Energy Star, the Californian Energy Commission, CECP in China, JRC in Europe and the Australian Greenhouse Office agreed to share the work needed to provide the basis for policy development and implementation. The major aims of this coalition include:

- The development of a robust energy performance test methodology for EPS, suitable for the support of policy measures;
- Co-ordination in the setting of performance thresholds in national policy measures, in order to maximise opportunities for harmonisation and alignment;
- The exploration of initiatives leading to enhanced compliance; and
- To encourage other national energy efficiency agencies to adopt similar measures. (Ellis *et al.* 2006)

Having produced a draft test method, over 650 EPS were measured in the United States, China and Australia, including a ring test of products amongst these countries. This experience not only enabled refinements to be made to the methodology but the large quantity of data gathered allowed detailed analysis of the current performance of products in most major markets, something that would have been out of the reach of any single country.

Early on in the process it became clear that one performance requirement would not suit the needs of the various agencies involved. For example, endorsement labelling programmes such as Energy Star try to promote the best performing products, whereas other partners wished to establish MEPS levels in order to remove the worst products from the marketplace. Therefore, a system was devised which contains a limited number of performance requirements which, like rungs on a ladder, increase in stringency. The key features of this system include:

- Countries can still select which 'level' to set their requirements; however, the number of different specifications is agreed and limited;
- Countries may elect to adopt requirements 'up the ladder' at some future date, for example after 3-4 years when technology improves;
- Manufacturers have clear performance targets set for many years in advance.

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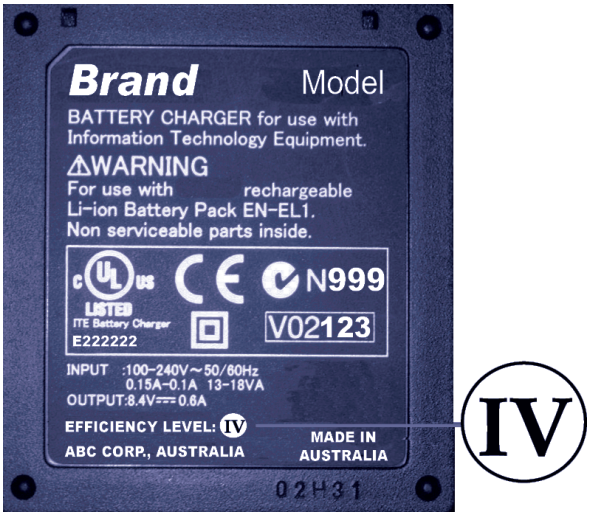
One further element to this project is the development of a special 'marking' system as an aid to compliance monitoring. Comprising a roman numeral (I – VII) that corresponds to each performance level, this 'efficiency mark' is placed on the product nameplate, alongside safety and other compliance information (EPS IEMP, 2005).[4] "I" is the least stringent *i.e.* least efficient level and "VII" is the most efficient level. To date, levels I – V have been set, with higher levels reserved for future use as more stringent levels are established.

The mark is not a label for consumers, but to indicate to those involved in enforcement that the product has been tested according to the unified test method, and claims to meet a certain performance level. This gives regulators in any country the chance to make a first assessment of compliance, and provide a claim to check against (Ellis *et al.*, 2006).

Figure 165 • Illustration of energy performance mark



Source: Ellis *et al.*, 2006.

All the current national programmes for EPS (not including battery chargers) now use technically identical test methods, based on the one originally developed collaboratively. Australia and New Zealand have published this as a national standard in 2005 (AS/NZS 4665.1:2005). Most programmes require or encourage the use of the marking system.

Key policy considerations

While the benefits of improving the efficiency of most EPS are evident, there are two different policy approaches currently used. One group of policy measures apply to individual end-use appliance categories that use EPS for at least some models (computers, imaging equipment, etc), and encourage efficiency improvements in EPS bundled with those appliances by setting overall performance thresholds. The second group applies measures targeted directly at specific categories of EPS.

4. Each level corresponding to the efficiency mark has requirements for both no-load and average efficiency requirements.

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The merit of the former approach is that it provides suppliers with a high degree of flexibility in selecting the energy efficiency options which best suit their marketing and cost strategies, while delivering the desired energy performance. It is not certain that this will necessarily result in improvements to the EPS.

A disadvantage is that it only applies to EPS which are bundled with appliances which can be identified and targeted with policy measures. In fact, EPS are used with a large number of end-use appliances, many of which have too minor a share of electricity use to warrant particular attention; or rather the administrative burden of implementing programmes which target these appear beyond the capacity of most national schemes. Without a proliferation of policy measures, the potential for cost-effective energy savings from EPS will not be realised through this approach.

As noted above, there can be no guarantee that measures which apply generally to the end-use appliance will necessarily lead to improvements in the performance of bundled EPS, and therefore such measures will provide a weaker market signal to EPS suppliers. Given that the availability of more energy efficient EPS across the broad spectrum of the market is an issue, maximising the market opportunities is an important policy objective. Although it is recognised that the range of products available at the current time can create problems, this should be viewed as a transitional issue which can be overcome through reasonable lead-times for policy measures; noting that the time to bring new EPS to market is typically less than two years.

While programmes which target EPS explicitly are favoured for these reasons, the opportunities to reduce losses in EPS through minimising the demand of end-use appliances (supplied via an EPS) also need to be considered. It is the combination of policy measures directed at both major appliances and EPS that will make the most of the considerable energy efficiency potential, while providing industry with both flexibility and market opportunities.

As is currently the case, policy measures do need to recognise the different technologies used for some battery chargers and for ELV lighting fixtures and reflect these in the performance thresholds and test methodologies used in specifications for these different products.

Policy recommendations

The energy losses in the current stock of EPS are significant and projected to continue growing over the near future, while the technology to improve efficiency is well-known. The list of efficient products already available is expanding quickly, as policies measures designed to enable them to access market share are implemented and production volumes increase sufficiently to reduce costs.

A considerable amount of work has been done to design a range of different types of programmes able to meet the major policy objectives of most regions, while maintaining a framework of global alignment. These circumstances lend themselves to the speedy and wide-scale adoption of S&L type programmes specifically for EPS, based on the current examples of policy measures.

It is estimated that implementation of these programmes could save between 30% and 50% of energy consumption by 2030, as shown in Figure 166.

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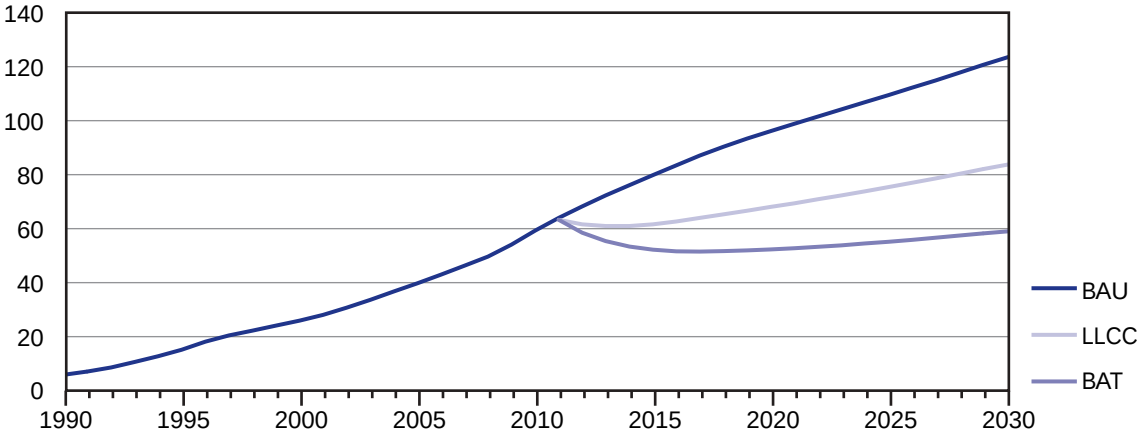
Figure 166 • Estimated impact on electricity consumption of energy efficiency policies in external power supplies, based on least life-cycle cost (LLCC) and best available technology (BAT), 1990-2030



Source: IEA estimates. The LLCC and BAT scenarios assume policy implementation in 2012.

- The IEA 25 policy recommendations to the G8 (OECD/IEA, 2008) did not address external power supplies specifically. However, it is now recommended that all governments should consider implementing the following policy measures for external power supplies:
- Governments should consider the adoption of mandatory minimum energy performance standards for the majority of external power supply categories, using the current range of programmes as a basis for development. Governments should also consider implementing labelling programmes for end-use equipment supplied with EPS, to encourage the bundling of the most efficient EPS.

Standby power

The IEA has estimated that standby power in electrical appliances and equipment around the world accounts for between 200 TWh and 400 TWh each year, based on extrapolations for surveys undertaken by a growing number of countries (OECD/IEA, 2001; E3, 2006).

Standby power has risen to prominence on the energy policy agenda not only because of the significant quantity of energy involved, but also because much of it is considered to not serve any useful purpose. Many people, politicians included, have been shocked to learn that appliances that they thought were switched off still consum electricity. As a result the issue of standby power has received a high degree of attention over the past 15 years from policy-makers and other stakeholders.

In 1999, the IEA advised governments to introduce policies with the aim of limiting standby power in most electrical appliances to 1 watt by 2010. A book, *Things That Go Blip In The Night* was later published by the IEA to provide further background information and a summary of policy options (OECD/IEA, 2001). Since then the number of countries that have policies

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addressing standby power has been growing steadily and an internationally adopted method for testing standby power has been published.[5] In 2005, G8 leaders endorsed the IEA 1-Watt target in the 2005 Gleneagles Plan of Action (G8, 2005), however interest in standby power is not confined to OECD countries. Thailand has also announced that they will require products to meet a 1 watt *standby* limit by 2011, and the most recent in a series of international conferences on the subject took place in Mexico[6] and India[7] (BP, 2008).

While the term standby power is now far more widely used than fifteen years ago, the issue of how to reduce standby power poses some unique challenges for policy-makers. This chapter looks at what has been achieved to date and what are the key issues that policies need to address in the future if they are to be effective.

What is standby power?

At one time appliances all had hard on-off switches or could be unplugged, but with the introduction of devices with remote controls and timeclocks on products such as televisions and VCRs, more appliances needed to remain energised. This allowed them to respond to start-up signals, or keep clocks running. However, most of these functions require only small quantities of power, and so to avoid unnecessary energy consumption, manufacturers began designing products so that they could go into a lower power level while performing these background tasks.

The generic term for this state is called standby, and standby power is typically defined as the power required by a product when that device is not performing its primary function.[8] In fact, as products have become more complex, many have a hierarchy of low-power levels, rather than a single one, depending upon what they are doing at the time.[9]

Generally, products in a standby mode are actually performing some functions; whether it is waiting for some sort of command, or collecting information, or maintaining a steady of readiness so that they can provide user services in a reasonable time after being woken-up/re-started.

But appliances only save energy once they enter standby, and their ability to do so is dependent upon a combination of several factors. An appliance needs to have the technical ability to run the desired functions at a low power level, for example through the use of integrated circuits (chips) which switch off unused components. It also needs appropriate software to provide commands which drive the chips. Last, but not least, it needs a trigger for these commands which can either be in the form of human intervention, such as the push of a button, or an automated process, like a timeclock. This whole process of interactions is called *power management*.

In the simple case of a VCR or DVD player this usually requires the user to signal the appliance to switch off. If the householder fails to do so, the appliance remains in a higher power state until

5. *IEC 62301.*
6. *See http://www.conae.gob.mx/work/sites/CONAE/resources/LocalContent/4967/3/Standagendaingles20agosto.pd for further details.*
7. *See http://www.energymanagertraining.com/StandbyPower/main.htm_for further details.*
8. *In this report, the energy used when a product is in standby is referred to as standby energy.*
9. *These low-power levels are referred to variously as sleep, hibernate, network standby, passive standby or active standby, for different products and in different countries. For simplicity the term standby is used in this chapter to refer to encompass all of these low-power levels.*

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next used. But some appliances can be programmed to perform this task automatically after a period of dormancy, such as when there has been no action by the user for a prolonged period of time. Computers, many printers, mobile phones and other devices often have this facility, as described previously in the chapter on computers and monitors (chapter 6). Automating the process whereby products power down into standby can save considerable amounts of energy, particular for those appliances where it is not obvious to the consumer that they are switched on, such as in the case of many home entertainment and office appliances. Auto-power down features can be applied to almost all appliances to ensure that the ability of products to enter standby is actually used, without causing inconvenience, but in a far more effective way than could be achieved by trying to educate all consumers. It is therefore critical that policies need to address not just the power levels required by products to perform their functions, but whether products move to the lowest appropriate power level as quickly as possible.

While most people associate standby power with devices such as televisions and computers, in fact there are well over 100 types of appliances in the residential sector which use power when apparently not performing their primary function. As well as the large number of electronic devices around most households, some space heaters and water heaters fuelled by gas or oil in fact use power to run their timers and ignition systems. Alarm systems, doorbells, intercoms, many smoke alarms and sensor lights also use standby power. While most appliances with a standby load are connected to main electricity through a plug and socket, some appliances are hardwired. Extractor fans, garage door openers and air-conditioners are all good examples of appliances which often have a permanent electrical connection.

Although on an individual appliance level, the quantities of energy used are often quite small, it is the integration of standby across such a wide range of appliance types that not only leads to the large amounts of energy consumed but also presents challenges to policy-makers.

National standby energy consumption trends

In order to answer questions about energy policy priorities, many countries have undertaken studies into the overall contribution made by standby power demand. The scope of these has varied, as shown by OECD/IEA 2001 (Annex II); however they typically comprise the following elements:

- In-situ power measurements of individual appliances in low-power modes, to provide data on average power requirements by appliance type for each relevant mode; and
- A survey (telephone or face-to-face questionnaire), or desktop study, to determine the ownership level of each appliance type, and typical usage hours for each appliance and low-power level.

Data from these sources are then used to make an assessment of total average energy consumption by appliances in standby mode. Where studies have attempted to forecast future standby energy consumption, data on the standby power of new products may also be included.

During 2005, national assessments were undertaken in Australia and Japan which follow from previous surveys and hence provide an opportunity to analyse trends. As shown in Figure 158, the results indicated that electricity consumption due to standby in Japanese households

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decreased between 2002 and 2005, while the opposite occurred in Australia between 2000 and 2005 (EES, 2006a; ANRE, 2006).

In Japan, there was a noticeable decrease in the number of hours spent by some products in standby between 2002 and 2005, which contributed to the reduction in energy consumption. One possible explanation for this is that more users unplugged appliances not in use as a result of promotional activities by the government, although another possibility is that these appliances spent longer periods in *on* mode.[10] These issues are to be investigated further in a new study in Japan during 2008 (Ohkuni, 2006, 2008).

It is also noteworthy that compared to Australia, the Japanese samples had less than half the number of products per household, although both studies indicated that the number of appliances per household had increased from the previous studies, growing at more than 5% per annum (EES 2006b).

Table 72 • Comparison between standby power surveys in Japan and Australia

Item	Japan (2002)	Japan (2005)	Australia (2000)	Australia (2005)
Houses measured (number)	86	100	64	120
Products measured (number)	1 760	2 751	3 296	8 000
Average number of appliance per house	21	28	52	67
Average standby power per house	n.a.	n.a	86.8 W (74.2 W)*	92.2 W (82.9W)*
Standby electricity consumption	437 kWh	308 kWh	760 kWh	807 KWh
Standby as % of total residential electricity consumption	9.7%	7.3%	11.6%	10.7%

* Note the values in brackets have been adjusted for purposes of comparison.

Source: ANRE, 2006; EES, 2001, 2006a; Ohkuni, 2006.

Two other major studies are also noteworthy. In 2004, the Lawrence Berkeley National Laboratory conducted field studies of 280 products at eight houses in order to develop protocols for similar standby studies at the product and household level. In doing so, the authors identified over 100 household products which have a low-power mode. As part of this project, it was estimated that in California standby power accounts for 108 watts per household on average, of which hardwired devices account for 14 watts. Standby electricity consumption is estimated at nearly 1 000 kWh/year per household, or over 15% of statewide residential electricity consumption (PIER, 2004).

In Europe, all mains-connected household appliances are estimated to consume 40 W per household in standby, equivalent to 406 kWh per household or 10.1% of household electricity (Fraunhofer, 2007). As with the study referenced above, the Ecodesign study identified a growing

10. If appliances are spending less time in standby and more in active mode, the net result is likely to be an increase in total energy consumption, which would not be a desirable outcome.

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number of functions currently or potentially provided by a product in standby; particularly a range of network connections involving telephone and computer products at relatively low speeds and up to full broadcast capability.

These surveys illustrate the difficulties in making accurate comparisons across countries, and in analysing the reasons why some countries may have higher or lower standby power consumption. The surveys undertaken to date have primarily, and understandably, been to satisfy domestic policy requirements, and while there are numerous similarities, there are also small differences in scope and methodology.

The development of a consistent methodology with regard to all the components of such surveys in order to provide the framework for future national standby surveys would greatly facilitate cross-country comparisons and analysis. This could build upon the methodologies used in most of the recent national surveys. The availability of a well-designed template may have the additional benefit of encouraging more national surveys to be undertaken.

One of the major uncertainties in standby studies results from the data collected on usage patterns, particularly when this is sourced from consumer surveys. For many appliance types it is unlikely that most consumers can make an accurate judgement about which mode an appliance is in, and the length of time in which it spends in each mode. Data-logging of individual appliances provides a far more accurate assessment; however this greatly increases the cost of any survey, depending on the number of households monitored. Techniques to minimise uncertainties in regard to the collection of data on usage patterns could also form part of the framework discussed above.

New product trends

While the previous type of study examines the average standby energy consumption of the appliance stock, tracking consumption by new products over a period of time provides an indication of future trends. For countries which have already implemented policies, monitoring standby in new appliances can be an effective means of evaluating progress. As a result, several countries have collected data on new appliances, either through manufacturers directly, or where available, from catalogues, or from direct appliance measurements.

Figure 167 shows four examples of this type of time-series from Australia, where almost 14 000 standby power readings have been collected since 2001 by taking six monthly measurements of products in retail stores. While not all products show an identical trend, the data suggests that the power used in standby for most new individual appliances has fallen over the past five years.

Combined with the previous national study in 2005, this data provides a fairly clear indication that the rise in overall standby energy of 2.5% per annum per household is not due to increasing standby power levels in individual appliances. The chief driver for growth appears to be the increasing ownership rates of appliances which use energy in standby (EES, 2006a; 2006b).

Building on this experience, the Asia Pacific Partnership (APP) has initiated a project to allow comparison of standby power in 14 common appliances across a number of countries (see Box 4).

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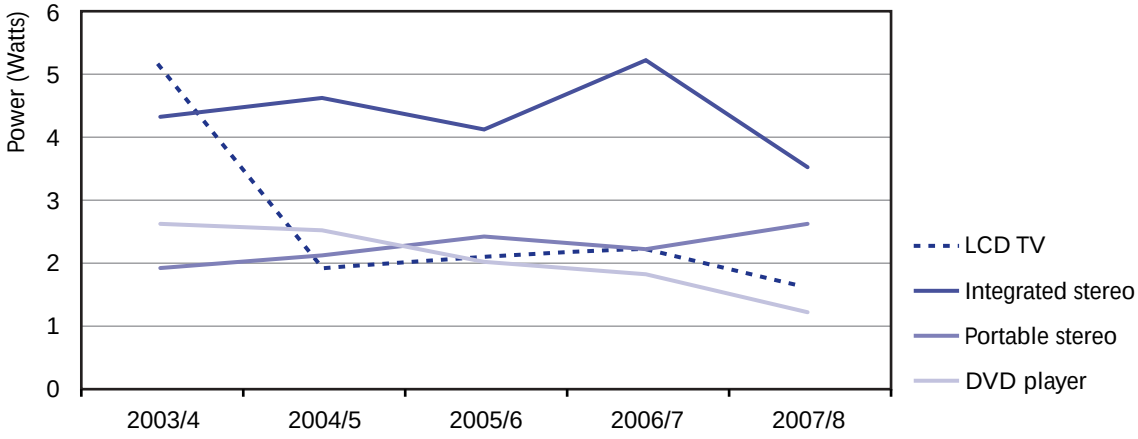
Figure 167 • Time series, passive standby demand in selected home appliances in Australia, 2003/4-2007/8



Source: EnergyConsult, 2008.

Box 4 • APP Standby measurement project

In order to assist cross-country comparisons, the Asia-Pacific Partnership (APP) is encouraging all countries to collect data on standby power levels in a core group of new appliances.

Outputs, such as reports containing statistical analysis, will help countries to see how the performance of their products compares with other regions (for an example see: EnergyConsult, 2008).

Based on a successful model run in Australia, the APP project provides a range of tools to participants in order to standardise data collection and ensure the consistency of results.

The project has identified the following core group of 14 appliances for regular measurements. These have been selected because they tend to have higher standby power levels and are either already widely used or have growing penetration rates.

- clothes washers
- microwave ovens
- televisions – CRT
- televisions – LCD
- televisions – plasma
- portable stereos
- integrated stereos
- digital video disc players (DVDs)
- computer monitors – CRT
- computer monitors – LCD
- computer printers – laser B&W
- computer printers – inkjet
- multi-function devices
- external power supplies (no load)

Measurements are being taken in all APP countries (Australia, Canada, Korea, China, United States, India and Japan) and fed into the on-line database. Several other countries appear likely to participate including New Zealand, United Kingdom, Czech Republic and Hungary, and other European countries.

Each country agrees to measure at least 20 models for each product type on an annual basis, although the collection of further models and product types is encouraged.

Participants can receive training in the design and organisation of surveys, as well as measurement procedures, and request further technical support.

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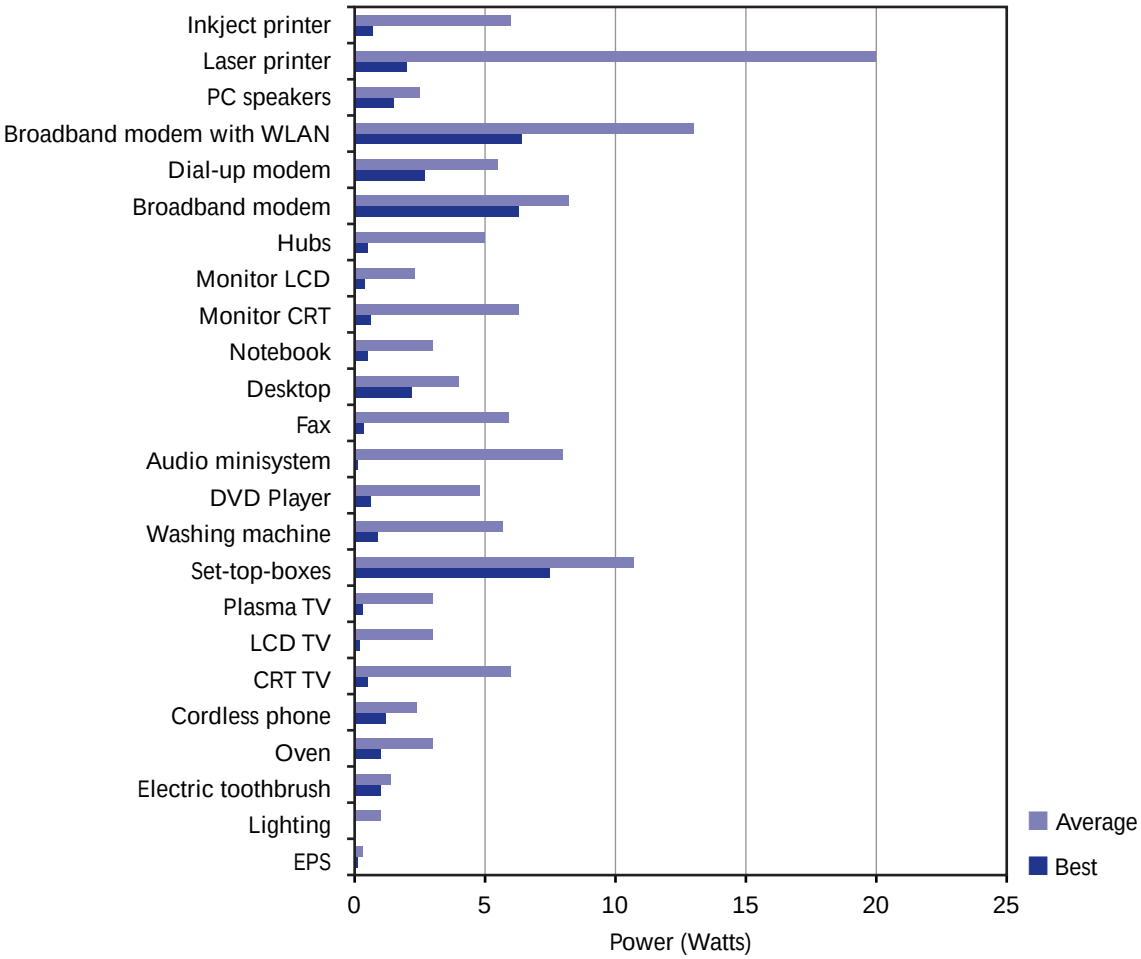
In a slightly different exercise, a recent desktop study in Europe, which involved collecting information from other recent surveys and from manufacturers, made an assessment of the current power levels for best available technology (BAT). Shown in Figure 168, the BAT values for appliances in common low-power modes are compared to the typical values of stock products in Europe. From this it is evident that there are considerable opportunities for further improvement through the adoption of the better performing products in the market today.

Figure 168 • Average and best available (BAT) standby power values for European devices, 2007



Source: Fraunhofer, 2007.

The development of well-targeted policy measures is reliant upon access to good quality data, illustrating the importance of relevant information. As shown in the examples above, standby power surveys are undertaken in many parts of the world which help to build an understanding of policy priorities. While different national circumstances and methodological variations sometimes make cross-comparisons difficult, some trends appear universal. For example, the number of products within households with a standby component is growing; in some cases this outweighs

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the benefits from the introduction of new products with lower standby power levels. A trend towards a larger number of functions which are, or could be, provided by appliances in standby is also discernable.

Standby power policies around the world

Contributing to the decline in standby power levels in new products has been the wide range of different policies used by governments to target standby power in electrical appliances. Some of these are mandatory in nature, and others voluntary. A few programmes cover a range of products while others set specifications for single products. The following table provides a summary of the key programmes which are either currently in force or which are in advanced planning stages.

Key policy challenges

The measures shown above have achieved a great deal, as demonstrated by the reduction of standby power in new appliances. Procurement policies have helped to create new markets for low-power standby appliances in government agencies, assisted by the presence of endorsement labels which have also enabled consumers to select the better performing products. Robust test methods have been developed to underpin these programmes and ensure their technical credibility. These have helped to provide the market pull required by industry to develop and market improved products.

However, as appliances are becoming more diverse and complex, a new set of challenges is emerging which requires new policy approaches.

The products targeted by the policies above all tend to focus on between 10 to 15 appliance types which generally consume significant quantities of energy in all modes. These include major items of office equipment, home entertainment equipment, and widely used devices such as external power supplies. However, as surveys have shown, there are over 100 product types with a standby power component. Analysis undertaken in Australia suggests that the 15 most often targeted appliances contribute only about 25% of total household standby energy consumption (Harrington *et al.*, 2008).

While these proportions will vary for each country depending upon the stock of different appliances, most countries are experiencing a rapid growth in small household electronics. Therefore, to capture the majority of standby energy consumption is going to require extending the policy scope to cover a far wider range of products.

The current range of standby policies relies upon a close definition of appliance types, so that manufacturers and other stakeholders can clearly see whether policy measures apply to particular individual models. Therefore, the process of designing policies for these smaller products is complicated by the rapidity with which they alter designs, features and functionality. Keeping pace with designing requirements for new products entering the market and gaining significant penetration is becoming a major task, which is accentuated by the growth in the numbers of low-power modes which potentially exist in ever more devices.

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Table 73 • Table of major existing national energy efficiency policies targeting standby power in place

Country	Policy type	Products covered	Status
Australia and NZ	Comparison label	Standby in energy label for whitegoods	Current
	MEPS	Air conditioners, televisions, set-top boxes, computers	2008-2010
	MEPS	All electronic appliances and equipment	by 2012
	Endorsement label (Energy Star)	Office equipment	Current
Brazil	Comparison label	CRT televisions	Current
Canada	Energy Star programme	Office and home entertainment equipment, external power supplies, household appliances	Current
	Comparison label	Standby in energy label for dishwashers	Current
	MEPS	Home entertainment, external power supplies	2008-9
China	Endorsement label (aligned with Energy Star)	Office and home entertainment equipment, external power supplies, household appliances	Current
	Procurement policy	Office equipment	Current
	MEPS	External power supplies	Current
Chinese Taipei	Voluntary agreement	DVD players, desktop PCs, integrated stereos, microwave ovens, set-top boxes, ADSL modems, digital TVs.	Current
Korea	Energy Boy endorsement label	Office equipment	Current
	MEPS	External power supplies, battery chargers	2008-9
	Comparison label	1 watt	2008-9
	Mandatory warning label	Appliances not meeting the 1 Watt standby	2008-9
Europe	Voluntary agreement (code of conduct)	Set-top boxes, external power supplies	Current
	Energy Star	Office equipment	Current
	EcoDesign directive	Electrical household and office equipment	Approved
Japan	Top Runner	Televisions, VCRs, DVD players/recorders, copiers, computers, microwave ovens, toilet seats, routers	Current
	Voluntary agreement	Gas and kerosene fired space heaters and water heaters	Current
	Endorsement label (Energy Star)	Office equipment	Current
Thailand	MEPS	All electronic appliances and equipment	by 2011
United States	Executive order 13221 & 12845	Office equipment	Current
	Endorsement label (Energy Star)	Office and home entertainment equipment, external power supplies, household appliances	Current
	Comparison label	Standby in energy label for dishwashers	Current
	DOE Standards	External power supplies, battery chargers	Current

Source: BUSH, 2001; EC, 2008B; EO, 1993; Hu, 2006; IEA, 2008; KEMCO; 2007; Kim, 2008; Novgorocev, 2008; Ohkuni, 2008; U.S. DOE, 2008.

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The levels of vigilance required to keep pace with these developments and the burden imposed by the need to define and produce specifications for these many devices is costly and beyond the resources of many administrations.

But is there a viable alternative? The following section looks at the range of policy measures used today in relation to their ability to tackle these key policy issues, by categorising them into three general types.

Specific standby power targets by product

The most common policy measures involve maximum power allowances for each major low-power mode in a specified appliance. Allowances can be tailored to suit the category of appliance and the typical range of product designs and modes.

While this suits those appliances where standby power makes a substantial contribution to overall electricity consumption, it is increasingly difficult to identify and make specifications for all of the large number of products which have a standby power component. The task of tracking new products or changes in existing products, classifying them and setting appropriate performance target is becoming administratively burdensome and difficult to justify when the contribution of each product is relatively small.

*Inclusion of standby with other modes (*Vertical *approach)*

In the vertical approach, policy measures are developed based on a typical usage profile (or duty cycle) to assess the total electricity consumed by a product over a period of a day or a year. The power consumed in each and every mode is multiplied by an appropriate allocation of time that the product spends in each mode, all of which are added together to provide a total electricity consumption (TEC) value. Because all modes are considered for a particular product, this is sometimes referred to as a *vertical* policy approach. Good examples of programmes which use this approach are Top Runner in Japan and the Energy Star specifications for imaging equipment, computers and monitors are others.

Policies of this kind promote a balanced view of standby power consumption, enabling consumers to select products which have low total energy consumption. This approach avoids situations where consumers may choose products which draw very little standby power but actually use large quantities of energy in *on* mode. It also provides manufacturers with the choice of where to focus energy saving investments.

Applying a policy using the vertical approach requires a product to be closely defined and for there to be a good understanding of the power consumed by all modes and knowledge about typical usage patterns. In practice therefore it is limited to products which use significant quantities of energy, rather than the complete range of products which contribute to standby energy consumption.

Horizontal approaches

The third approach involves a uniform target for a specified standby power mode across all products. This is sometimes referred to as a horizontal policy, an example of which is the IEA proposal that countries limit standby power in all appliances to a maximum of 1 watt.

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This approach is simple to understand and, because it applies to all products, there is no need to clearly define individual product categories or establish new requirements for products as they enter the market. Manufacturers are aware of their requirements from the outset of the product development cycle. Although it is likely that some exceptions will need to be made, identifying the exceptions is considered a relatively easier task than identifying all the products which are included.

However, by applying a uniform target, no account is taken of the varying efforts required to achieve this target by different technologies. For simple products, a 1 watt target is quite easy to meet but for more complex devices with multiple functions in standby mode, the threshold may be difficult. It also applies typically to only the lowest standby levels, such as *off* and passive standby in many products and not to other low-power modes such as when a device is network connected.

The first major practical example of horizontal policy has been developed by the European Commission under the Ecodesign Directive and was endorsed by delegates of the EU member states and EC in July 2008. This measure is designed to cover all electrical and electronic household and office equipment which is currently available or may be supplied in the future. In addition to stipulating the power thresholds, as shown in Table 74, the implementing measure includes a requirement for power management (EC, 2005, EC, 2008a).

Table 74 • EU Ecodesign requirements for standby and off mode contained in implementing directive

Mode	Maximum power (watts)
Tier 1 (1 year after implementing measure has come into force)	
Off (no function)	1.0 W
Standby (only reactivation function)	1.0 W
Standby (information or status display plus reactivation function*)	2.0 W
Tier 2 (4 years after implementing measure has come into force)	
Off (no function)	0.5 W
Standby (all variants)	1.0 W

Source: EC 2008a. *A reactivation function means a function intended to switch the equipment by remote switch, internal sensor.

Included in the thinking behind the Ecodesign standby measure is that it could be compatible with vertical type policies which deal with other modes, and remain a sensible policy approach for those products which account for relatively large quantities of energy in all modes. In this case the calculation for total energy consumption would assume the appropriate maximum standby value provided by the horizontal measure.

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Future policy approaches for standby

The fact that standby power is now widely recognised amongst policy-maker circles is a major achievement, and has led to the development of policies which have helped to drive down the standby energy consumption of many appliances in recent years. Manufacturers have responded to the challenge with often remarkable ingenuity, using innovative approaches pioneered by mobile appliances such as laptops computers and mobile phones.

At the same time, the concept that a large number of different appliance types operate in several modes, such as *sleep*, *hibernate* and *on*, has also become better understood. Policies to tackle standby power are also evolving and the concept of a horizontal policy approach to a horizontal problem is gaining favour (Harrington *et al.*, 2007). The use of cross-the-board measures for the large majority of appliance types, designed to focus on reducing standby in some of the most prevalent low-power modes around today, appears to offer the best policy option.

However, as devices become increasingly complex and offer more functionality, even this approach may require a more tailored solution. In the future it may be more useful to think about the functions a product provides at any point in time, since this is the primary indicator of how much power is required (Siderius, 2006).

For example, a typical function that occurs in a standby mode is the ability to respond to a remote signal to switch on; another is to remain connected to a network such as the Internet. There are many more of these largely distinct functions which are shared by a range of products which may otherwise have little in common. A clock or timer requires similar energy, whether it is included in a DVD player, a washing machine or an oven.

In this way, the level of standby power needed can be seen as comprising a series of individual requirements depending upon what functions are being provided by an individual product (and being used by the consumer) at any one time.

In terms of policy measures, it therefore makes sense to focus on these common functions, rather than individual products or modes. It suggests that a system whereby a power budget or allowance could be given for a specified type of function across the full range of products, would overcome many of the problems associated with current policy measures.

This type of policy extends the idea of a horizontal approach (termed the *horizontal functionality* approach) is in fact similar to that used by the European Code of Conduct on Broadband and the Energy Star specification for imaging technology (Harrington *et al.*, 2008).

To understand this approach better, imagine that a product with a remote control would be given a certain allowance, while a product with a remote control and a clock display would get a higher allowance. The allowance for individual products would be the sum of the relevant allowances for functions present for that product.

Although it sounds as though there would be a large number of different permutations of allowances, in reality a single level would apply to broad groups of products with the same combinations of functions. This approach has the advantage of being able to keep up with changes in the technical design of products over time and with new products as they appear on the market in a way that is more comprehensive and coherent than any other policy platform developed to date.

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Table 75 • Example of functional adder approach for two devices

	Product A		Product B	
	Functions present	Power allowance	Functions present	Power allowance
Clock	✓	0.5 W	✓	0.5 W
Remote control	✓	0.5 W	✓	0.5 W
Ethernet connection	✓	1.0 W	✗	0
USB	✓	2.0 W	✗	0
Total power allowance		4.0 W		1.0 W

However, quite some research is required in order to fully develop a workable matrix of functions and appropriate thresholds. Recognising that this will be of international relevance, a project located within the IEA Implementing Agreement on Efficient Electrical End-use Equipment (4E)[11] aims to undertake collaborative research to assist countries wishing to pursue this approach.

The benefits of co-operative international action on standby power are well recognised within the statements by G8 leaders, the Asia Pacific Partnership, APEC and the Commission on Sustainable Development Marrakech accord, amongst others. It is also a major reason for the historic IEA involvement in the topic and why the IEA launched a call for all governments to adopt a horizontal 1-Watt policy.

Despite its acknowledged shortcomings, a 1-Watt standby policy in combination with vertical policies for larger appliances is the most effective strategy if adopted by governments globally. In the longer term, this could evolve into a more comprehensive approach based on the functionality of devices.

Policy recommendations

As part of the package of recommendations on energy efficiency policies made to G8 Summits in 2006, 2007 and 2008, the IEA included several policies relevant to standby power (IEA, 2008). These are:

> *(2.2 a) Governments should adopt the same "horizontal" 1-Watt limit and apply it to all products covered by the International Electrotechnical Commission definition of standby power with limited exceptions; and*
>
> *(2.2 b) Governments should adopt policies which require electronic devices to enter low-power modes automatically after a reasonable period when not being used.*

- In addition, governments should work co-operatively to develop a horizontal functionality approach suitable for implementation as voluntary or mandatory policy measures covering all major functions and low-power modes.

11. See http://www.iea-4e.org/

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Digital networks

For most people the ICT world is developing far quicker than their technical understanding, and even those involved directly cannot always keep up to date with topics outside their field. Understanding the relationship between these technologies and energy consumption can be similarly bewildering. Faced with terminology such as network appliances, smart homes, server farms and concepts such as *Power over Ethernet* (PoE), USB charging, even power over wireless connections, the implications for energy consumption are often difficult to comprehend (SMH, 2008; Economist, 2007a).

At the heart of many of these technology developments are networks which connect one device to another or to several. Although networks are not new – for example the system upon which we rely to distribute electricity is a vast network – digitalisation has opened up vast new opportunities.

Today, we all use a digital network when connecting to the Internet or using a mobile phone and, although these are perhaps two of the most extensive examples of digital networks, these are not the only instances. Many households connect televisions to audio and video equipment in a local network, join PCs to printers, and increasingly use a wireless network to link mobile devices together and to the outside world.

While the majority of devices associated with digital networks are electronic, this is not necessarily always the case. Air-conditioning and lighting systems are commonly connected via local networks to control devices such as thermostats, room sensors and building management technologies. In some countries, control equipment for residential air-conditioners allows utilities to reduce the electricity system's peak load by switching off individual appliances in households. Security alarms are often connected to a series of sensors and to police stations using a telecom network. Refrigerators are now available with built in TV screens and Internet connection.

In fact there are numerous networks that co-exist at a local, national and international level. Some of these are required to work with each other, interfacing to transfer information across the boundaries between one network and another. This introduces the notion of interoperability, or the ability of two or more networks being able to function together. For this to happen requires a degree of commonality in the basic packaging of digital information – in effect, they need to speak the same language – and these standards are contained in industry-wide protocols (Christensen *et al*, 2004). By using the appropriate protocols, manufacturers are able to design products which will successfully send, receive and understand information when connected to the relevant network.

Of course there are many network applications which offer the potential to reduce energy consumption. Presence-activated lighting controls, automated window shading devices, and other building climate control technologies enable the provision of energy services to be better matched to building occupancy (WWW, 2008).

Looking forward, the potential applications for networked equipment and devices are almost unfathomable. At a recent IEA workshop on the subject, a list of products under development included retail lighting systems which alter colour according to the time of day; in-home devices which track the location of family members by sensing their mobile phones; and wireless sensors for monitoring the health of plants (Banks, 2007; IEA, 2007).

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Digital networks extend beyond buildings to many other sectors. Global positioning systems (GPS) are now being integrated in cars and commercial vehicles, alongside Bluetooth facilities and aids for reversing. Toll payment systems use wireless networks and road guidance systems are under development (Economist, 2007b, 2007d). In the medical field, networks are used to monitor patients' well-being at home and enable surgeons to remotely perform operations from another country.

As the number of new network applications entering markets steadily grows, it is evident that a few of these many technologies and systems have energy efficiency as their primary purpose (Economist, 2007c). However the majority are designed to offer a wide range of other attributes such as greater comfort, control, security, productivity and entertainment.

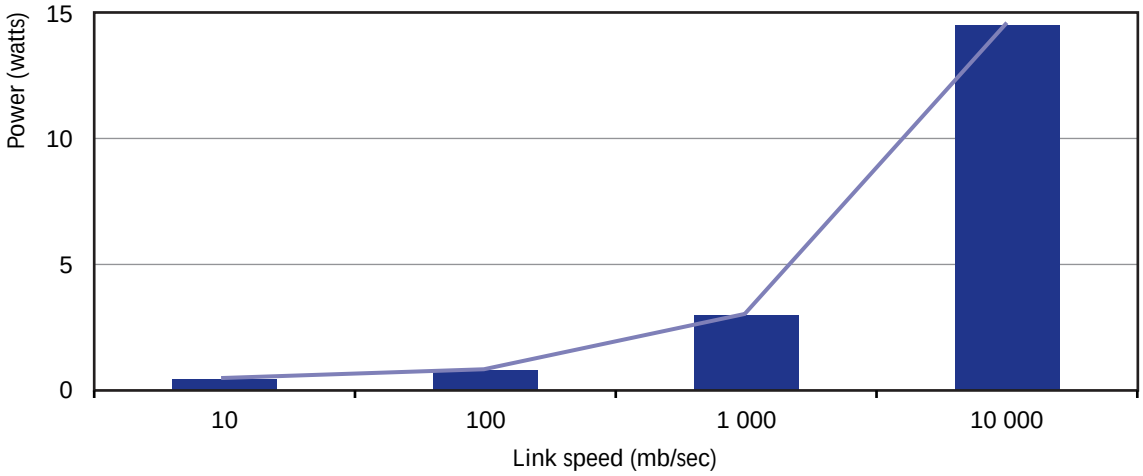
Networks and energy consumption

In considering energy use in networks, it is helpful to distinguish between the energy used in making the network function, from the operation of devices which are connected to a network.

Dedicated network products whose main purpose is to support the operation of a network include devices such as routers, switches, hubs and modems of various kinds. Perhaps less obvious are the upstream products which are required within telecommunications facilities, data centres and the like which are also part of the infrastructure required to maintain functioning networks, and which also consume energy. These have been discussed briefly in the chapter on computers and monitors (Chapter 6), providing some insight into their relative energy consumption.

Then there are network interface components within each connected device which allow the devices to 'talk' to each other, as well as providing security and other functions. These network interface components (NICs) typically draw fairly small amounts of power related to the speed of the link which they provide. For example a 100 MB/sec NIC typically draws less than 0.5 watt, while one with a speed of 10,000 MB/sec can draw close to 15 watts (see Figure 169) (Nordman, 2007b).

Figure 169 • Power draw by network interface components



Source: Nordman, 2007b.

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As with most of these infrastructure elements, although the energy consumed by individual items is quite small, the total impact is related to the number of connected devices and is therefore significant. With potentially many billions of connected devices in the not too distant future, the implication of even small power loads from network components is very considerable.

However, there is another impact that digital networks have on energy consumption which is indirect but of greater significance. This is the energy used by equipment in order to stay connected to a network. The most common example of this phenomenon occurs in personal computers which normally have the facility to power down into a low power mode after a period of inactivity: however when a PC is connected to a network, this power management function is often disabled to stop the connection from being lost. As a result the networked device, in this case the computer, remains permanently in a higher power state than is really needed.

Similarly, many set-top boxes which have conditional access facilities to TV service providers in order to provide programme information and software updates remain drawing near maximum power even when no material is being received, rather than going into standby.

Most electronic or electronically controlled devices now have sophisticated power management capabilities, enabling them to regulate their power demand to the tasks that are being required of them. However these examples demonstrate how the act of being connected to a network can affect the ability of an appliance to utilise these power management features.

To understand the scale of the issue, consider a network appliance which draws 50 watts when fully on, of which 2 watts is required to maintain the network connection. If used for four hours per day, the device which must remain switched on to maintain connection will use five times the energy of one which can effectively modulate its power usage to functionality. When multiplied by the number of appliances likely to be connected to networks in the future this issue outweighs most other network energy considerations.

As described in Chapter 6, attempts to reduce energy consumption from PC connection to the Internet were made through a combination of hardware and software adjustments to switch off power to components other than those required to stay on-line, together with protocol called Wake-on-LAN (WOL) to provide instructions to the PC (Nordman *et al.*, 2007). However, WOL and later improvements often result in connected PCs waking up more or less frequently than is necessary, so that energy is still wasted. This illustrates the limitations of retrofitting a solution rather than ensuring that power management is built into the basic architecture of networks and network equipment from the outset.

The need for an energy efficiency protocol for networks and network equipment

A mentioned previously, most networks are being developed to meet demands for a wide range of services, in different sectors and for a variety of types of end-user. For commercial reasons, considerable attention is given to ensure interoperability for particular networks, ranges of equipments and functions. On the other hand there is insufficient thought being given to how all the various networks and devices will support power management (Nordman, 2007b).

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As we move away from the concept of individual appliances and devices, towards a world where there are many networks linking these devices, so ideas about power management also have to evolve to include interoperability.

This means that in a connected world, all appliances have to be able to follow common power management commands from other appliances, so that any device can instruct another linked appliance to go into standby or to wake upstart up. As an adjunct to this, a network appliance also needs to be able to declare its current power status to other appliances in the network. The network itself, and all the equipment which is there to maintain the network, also has to be able to support this type of communication.

While this sounds like a very complex process, the design of such basic network architectures is being undertaken constantly by the industry in order to support developing areas of functionality. And while it is a complex field, the opportunity exists to firmly embed power management capabilities within the basic building blocks of emerging networks.

Failure to introduce such industry-wide standards will have severe consequences, locking us into a high energy consuming future with limited ability to dampen demand. As the number of networks and connected equipment grows, proprietary issues will make retrofitted solutions increasingly complicated. In addition, with the inclusion of more connected building technologies, which typically have far longer lifetimes than electronic equipment, the opportunities for introducing solutions at a later date will become increasingly difficult and expensive.

Aware of these issues, an IEA workshop in 2007 put forward a set of principles to guide the development of networks (IEA, 2007; Meier *et al.*, 2007). These are targeted at international, national and industry standards bodies which are involved in the development of protocols for networks. Organisations such as the International Electrotechnical Commission (IEC) and the Institute of Electrical and Electronics Engineers (IEEE) could play a key role in galvanising attention to this issue and co-ordinating the technical development activities.

In addition, governments need to recognise that there are few commercial drivers to ensure that the medium-term economic and environmental interests are taken into account. As a result, governments will also need to exert their authority, which could be achieved by integrating these principles into national energy policy.

Policy recommendations

To ensure that digital networks and network-connected devices support the minimisation of direct and induced energy consumption, the following the principles should be adopted:

For digital networks

- All network technologies should actively support power management;
- Connection to a network should not impede a device from power management activities;
- The network should be designed such that a legacy or incompatible device does not prevent

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the rest of the network from effective power management;
- Connections should have the ability to modulate their own energy use in response to the amount of the service required by the system; and
- Terminology and concepts relating to energy management used in the design of all networks should be internationally harmonised.

For network connected devices

- Devices should not impede power management activities in other connected devices;
- Devices should expose their own power state to the network and be able to report estimated or actual energy use;
- User interfaces should follow (international) energy management standard principles and designs;
- Devices and connections should have the ability to modulate their own energy use in response to the amount of the service required by the system;
- Terminology and concepts relating to energy management used in the design of all devices should be internationally harmonised; and
- The behaviour and communication of devices relevant to energy consumption should adhere to (international) standards.

In addition:

- Governments should ensure that electronic devices enter low-power modes automatically after a reasonable period when not being used;
- Governments should ensure that network connected electronic devices minimise energy consumption, with a priority placed on the establishment of industry-wide protocols for power management;
- Energy efficiency efforts should not favour any particular hardware or software technology; and
- Energy efficiency policy should identify digital networks as a promising method for attaining energy efficiency.

These principles add further detail to the specific policy recommendations included in the IEA 25 recommendations to the G8, which are applicable to all governments and repeated below:

> *(3.2 c) Governments should ensure that network-connected electronic devices minimise energy consumption, with a priority placed on the establishment of industry-wide protocols for power management.*
>
> *i) In order to enhance energy efficiency across electronic networks, governments should:*
>
> > *I. Instruct relevant public and private standards authorities to ensure that industry-wide protocols are developed to support power management in appliances and equipment, including networked devices; and*
> >
> > *II. Ensure such protocols are developed and implemented. (OECD/IEA, 2008)*

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CHAPTER 10 • SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Objectives

In 2003, the IEA published *Cool Appliances*, an examination of electricity consumption by residential appliances in IEA countries, policies to promote increased energy efficiency and estimates for potential additional savings of energy and greenhouse gases. The book estimated that residential electricity consumption in 22 IEA countries would grow by 1.3% per annum between 2001 and 2006 to approximately 2 540 TWh. However, current analysis shows that actual electricity consumption in these countries grew by 2.3% per annum during this period and exceeded the projection by over 80 TWh in 2006, or approximately 3.3%.

As governments around the world wrestle with the challenges of climate change, energy security and economic development, the growth in residential electricity consumption in all regions jeopardises many policy objectives in these fields. While most governments now recognise the need to reduce energy consumption, and some are proposing targets which represent significant cuts, there is less agreement or clarity on how this can be achieved.

This book has provided a detailed examination of the energy efficiency policies implemented by IEA countries and five major developing countries in respect to electrical appliances. It sheds more light on the underlying issues behind the growth in residential electricity consumption, and identifies the measures required to slow or reverse the trend.

Major findings

Trends in electricity consumption

In OECD countries, the major appliance categories are close to saturation levels and the efficiency of these appliances has improved (partly due to government policies) with the result that their share of residential electricity consumption has fallen. On the other hand, the ownership of air-conditioning and use of lighting equipment has increased in several regions.

In non-OECD countries, while the ownership level for major appliances is already high in urban areas, increased access to electricity in rural areas and growing urbanisation is driving up overall ownership levels and hence electricity consumption.

However, the growth of electricity consumption by electronic devices has been the most rapid of all appliance categories over the past five years in both OECD and non-OECD countries. Quickly rising global ownership levels of information and communication technologies (ICT) and consumer electronics (CE) means that these products now account for approximately

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15% of global residential electricity consumption. While efficiency improvements have been made, savings have been overwhelmed by the demand for equipment which provides more functionality, or is larger or more powerful, and therefore uses more electricity.

Looking ahead, the IEA estimates that energy use by these devices will double by 2022 and increase threefold by 2030 unless policy measures are introduced to increase energy efficiency.

Considered together with other areas of electricity growth in the residential sector, this scenario poses a serious threat to all governments with policy ambitions to achieve a stabilisation or reduction in residential energy consumption.

Trends in national energy efficiency programmes

All governments now have policies and programmes in place designed to achieve long-term market transformation in the supply and adoption of energy efficient appliances, with a particular focus on those appliances which have previously used the majority of electricity, such as refrigerators, clothes washers and water heaters.

A wide range of policy measures have been used, designed to overcome particular barriers and often targeted at a range of market participants. Minimum energy performance standards and energy performance labels have been the most widely employed measures, but frequently supported by government procurement policies, financial incentives such as discounts and rebates, and general awareness raising programmes.

The success of these highly targeted programmes is evident: unit energy consumption for major appliances has fallen dramatically over the past decade in most economies, while at the same time many products have increased in size, capacity and power. Appliance prices have also fallen in real terms, confirming that the correlation between prices and energy performance is generally very low or even negative.

In the light of these results and as governments have become increasing aware of the benefits of energy efficiency, all national appliance energy efficiency programmes have continued to progress, developing in scope, ambition and expertise. Several of the more mature programmes have needed to make adjustments to their mandate or framework and are now emerging considerably strengthened. Newer programmes show every sign of learning valuable lessons from these, and with adequate support from their governments, should progress rapidly.

National appliance programmes have been highly cost-effective and have delivered significant quantities of energy and greenhouse gas savings at a lower cost compared to many other types of government programmes. A selection of programmes analysed in this publication showed a total net benefit of USD 0.6/GJ saved. However, their continued reliance of these programmes on low numbers of staff and relatively small budgets impedes their effectiveness. Greater government investment is required in order to better implement existing policies and programmes so that they keep pace with technological and market advances.

Many existing programmes are missing the opportunity to deliver 20% to 50% more savings due to poor attention to detailed implementation issues. Activities such as the development of protocols and infrastructure to test the performance of appliances, market surveillance and enforcement of

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a comprehensive compliance regime, and reviews of programme requirements are all required on an on-going basis to maximise the effectiveness of energy efficiency programmes.

The rapidly changing structure of residential electricity consumption also highlights the need for greater scrutiny of end-use trends so that governments are better able to make informed and timely policy decisions.

Policy options

Governments have a range of policy tools available to help stimulate a sustainable market for more energy efficient technologies, many of which have already proven to be effective when fully implemented. New policies which internalise a carbon price will help to make energy efficiency more cost-effective; however they will not overcome the majority of barriers facing energy efficient appliances in general and ICT and CE equipment in particular. For example, motivated consumers still need to differentiate between the performance of products; and consumers that take equipment as part of a rental or service agreement will still have no say in the product's efficiency.

For governments to adequately respond to the new challenges posed by increasing residential electricity consumption, and particularly in the ICT and CE fields, they will need to build on the established infrastructure of existing programmes to deliver targeted policy measures.

Recommendations to improve energy efficient residential appliances

In 2006, 2007 and 2008, the IEA presented energy efficiency policy recommendations across 25 fields of action to successive G8 summits (OECD/IEA, 2008). These included several that targeted residential electrical appliances, based on analysis available at the time. As a result of the information presented in this publication, it has been possible to make a number of more detailed recommendations to stimulate best practice in residential electrical appliance policy. The full list of relevant recommendations are summarised below.

- Policy frameworks, supporting legislation and organisation structures should provide a broad and flexible mandate to enable the implementation of a range of measures, and their maintenance, without recourse to further legislation but subject to specified checks and balances.
- Governments should establish transparent threshold conditions before new policies can be implemented, and undertake such examinations necessary to demonstrate whether these have been met. Care needs to be taken to ensure that important processes, such as cost-benefit analysis and consultation, do not become excessively burdensome.
- Budget and staff allocations need to be set at levels which are commensurate with the policy aspirations of countries. These should take into account the requirements for the maintenance and development of policy instruments, as well as verification and enforcement activities.

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- Governments should ensure that programme thresholds are sufficiently ambitious to meet policy aspirations and undertake regular reviews to keep pace with technological advances and changes in fuel prices.
- All countries need to improve their capacity to undertake appropriate verification and enforcement activities in respect of programme requirements (voluntary and mandatory). In this regard, the recommendations made by the IEA to the 2008 G8 Summit should be noted (OECD/IEA, 2008):

  (7.3 a) Governments should ensure that both voluntary and mandatory energy efficiency policies are adequately monitored, enforced and evaluated so as to ensure maximum compliance. At a minimum, this should include:

  - *Considering and planning for optimal compliance, monitoring and evaluation procedures at the time new policies and measures are formulated;*
  - Establishing legal and institutional infrastructure for ensuring compliance with energy efficiency requirements;
  - *Ensuring transparent and fair procedures for assessing compliance; including specification of the methods, frequency and scope of monitoring activities;*
  - *Ensuring regular and public reporting of monitoring activities, including instances of non-compliance;*
  - *Establishing and implementing a suite of enforcement actions commensurate with the scale of non-compliance and the value of lost energy savings; and*
  - *Establishing and implementing a robust system for evaluating policy and programme success during and after implementation.*
- More attention needs to be given to tracking end-use energy consumption and identifying areas of high growth. Improved monitoring of end-use consumption is also required to assist in evaluating the impact of policy measures.
- Policy measures need to be developed and implemented for electronic equipment, particularly for home entertainment, and information and communication technologies (see detailed recommendations below).
- Governments should continue to participate in international collaboration and co-operation in order to share information and development costs, improve the alignment between programmes and enhance compliance.

Recommended policies for energy efficient ICT and CE equipment

Smarter electronics which match the energy used by appliances to the services demanded by the user can lead to large improvements in energy efficiency, particularly in the growing number of appliances connected in digital networks. Already many portable devices manage their energy consumption effectively and, with the implementation of some key policies, these same techniques will become more generally used.

For governments to expect energy efficiency programmes to extend to the delivery of new policies for ICT and CE equipment, while maintaining existing coverage, is unrealistic without a commensurate increase in the allocation of resources. However, this would be fully justified because many of the same techniques which will save energy in ICT and CE equipment will also have application in other residential appliances and in the commercial sector.

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This can be achieved by governments defining key long-term policy objectives for technology in this field, and working with industry and other stakeholders to agree on implementation plans which meet these objectives.

For example, policy objectives should include performance targets by specified dates for individual appliances categories, based on assessments of technical feasibility and projections of cost-effectiveness which factor in the cost of carbon, economies of scale and learning by doing. Such individual national targets should be decided with reference to targets established in other countries, and where possible, aligned.

Horizontal policies based on functionality offer several major benefits for electronic appliances. As noted, this approach is not product-specific and therefore copes with the changing design and functionality of appliances, and new market entrants. It is highly transparent: product designers know what is expected well in advance, and do not have to consider whether their particular products will be covered by policy measures.

Most policy measures ultimately require the establishment of energy performance targets, thresholds or limits on products or functions, whether these are mandatory and voluntary. In the past, these thresholds have included a scaling factor such that the energy which is allowed to be used by products is related to their capacity, size or volume. This provides a reasonably accurate method of comparing the energy efficiency of appliances. However, when this information is used as the basis for consumer information, consumers may infer that products with the same label rating, or which carry an endorsement label, consume similar quantities of electricity, which can be far from the truth.

This is an important issue since the penetration of larger appliances has played a significant role in reducing the savings from improvements in the energy performance of appliances. Policy measures would better reflect national policy objectives for energy and greenhouse gas reduction through restructuring these thresholds so that larger appliances were required to have higher, but attainable, efficiency levels.

Electronic devices are now the most globally traded of all household appliances, and considerable benefits could flow from increased international co-operation in the development of energy efficiency policy and measures. While progress has been made in recent years, this situation can quickly reverse without continuing attention to grass root activities such as maintaining the relevance of test methodologies, information sharing about current and future policy intentions and dialogue between energy efficiency programme managers. Efforts to increase international alignment can also conflict with short-term national interests and so strong political support is required, together with the mechanisms to disseminate and reflect this through all decision-making processes.

Consuming nearly 700 TWh currently, electricity consumption by ICT and CE equipment grew by approximately 7% per annum between 1990 and 2008. This sector now accounts for nearly 15% of residential electricity use, and can make up a much higher share in some households. Although growth is expected to slow to 4.5% per annum in the period up to 2030, electricity consumption is expected to rise to 1 700 TWh by 2030.

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This analysis found that electricity consumption from residential ICT and CE devices could be cut by more than half through the use of the best technology and processes which are currently available. Over 30% of electricity savings could be forthcoming from adopting Least Life-cycle Cost (LLCC) technologies resulting in no increase in the combined capital and running costs discounted over the appliance lifetimes.

In addition to substantial reductions in greenhouse gas emissions, between 140-260 GW of additional power generation capacity would be avoided through the implementation of energy efficiency policies targeted at ICT and CE equipment. The flow-on effects could be even larger by using electronics to better control energy consumption in all types of equipment.

Governments should implement the broad policies identified, but also need to consider a number of specific policy measures for electronic devices, as described below.

Televisions

As part of the package of recommendations on energy efficiency policies made to G8 Summits in 2006, 2007 and 2008, the IEA made the following recommendations regarding policies to encourage more energy efficient televisions (OECD/IEA, 2008):

> *(3.3 c) Governments should implement energy efficiency policy measures for TVs and set-top boxes designed to:*
>
> > *i) Promote the best-performing current TV products and technologies;*
> >
> > *ii) Stimulate the market entry of new television technologies which aim to halve TV energy consumption compared to current performance levels;*

Analysis in this publication has supported the addition of more detail to these recommendations, as follows:

- Policy measures should be designed to move the market towards the most efficient products currently available, and which provide a market incentive for manufacturers to offer increasingly efficient products. A combination of minimum energy performance standards and appliance labels will achieve these objectives.
- Energy performance labelling in particular should be technology neutral to allow consumers to compare all types of televisions, and include information on the estimated running cost of TVs according to an average duty cycle.
- Energy performance indices used for MEPS and labels should ensure that thresholds better reflect overall energy consumption (not just efficiency) by requiring larger screens to meet more stringent levels compared to smaller screens.
- Policy measures should move towards horizontal measures spanning all display technologies, with allowances for particular functions, such as for tuners, as appropriate.
- The development and implementation of strategies should be designed to support the commercialisation of new television technologies which offer the potential to halve the unit area consumption of displays. There are several candidate technologies which offer potential, including advance backlight modulation of LCDs and OLEDS, but other options may also warrant this support.

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Computers and monitors

The IEA 25 policy recommendations to the G8 (OECD/IEA, 2008) did not address computers and monitors specifically. However, it is now recommended that all governments should consider implementing a range of policy measures for computers and monitors, covering technology and power management issues, in new and existing products. These include:

- Mandatory requirements for all PCs to be supplied with power management should be enabled at levels decided on by governments after consultation with other stakeholders. Governments should also work with industry to design and implement appropriate consumer education programmes with the aim of increasing the implementation rate of power management in existing PCs.
- Procurement policies for all governments and government agencies should be designed to purchase the best performing PCs and monitors which are fit for purpose. It should be noted that many governments have optional procurement policies which have proven to under-perform and therefore if policies are not mandatory then they need to ensure that non-compliance requires justification.
- A number of policy measures should be considered for improving the performance of all PCs in all modes of operation, including minimum energy performance standards and energy performance labels. Labels for PCs should be technology neutral allowing comparison of PCs and laptops.
- Measures for monitors, such as labelling, should be developed to apply for all display technologies, in line with recommendations for televisions.
- Requirements should be adopted to improve efficiency of external power supplies (see below).
- Governments should work with industry to develop measures to remove older inefficient products from the local or overseas market and ensure their safe disposal.

Set-top boxes

As part of the package of recommendations on energy efficiency policies made to G8 Summits in 2006, 2007 and 2008, the IEA included several policies relevant to set-top boxes (OECD/IEA, 2008). These policy recommendations are applicable to all governments and still relevant:

> *(3.3 a) The IEA concludes that international best practice, with respect to energy efficient set-top boxes, are policies that establish a minimum efficiency standard for Digital Television Adaptors. These regulations should:*
>
> > *i) Specify the maximum power levels while "on" and "off"; and*
> >
> > *ii) Ensure that the consumer can easily switch the unit to the lower power level.*
>
> *(3.3 b) A second aspect of best practice is to ensure that government-subsidised units meet higher efficiency requirements.*
>
> *(3.3 c) Governments should implement energy efficiency policy measures for set-top boxes designed to minimise the energy used by TVSP customers in receiving TV services by ensuring that such requirements are included in relevant franchise or licensing agreements that allow TVSPs to operate.*

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In view of the changing markets for STBs, in particular the increasing penetration of products with conditional access, recording and high definition capabilities, together with a pressing need for action, the following additional policies are required:

- Policies should be implemented which span the full range of products which provide STB functionality, with sufficient flexibility to encompass products which may emerge in the foreseeable future. Such policies should aim to minimise energy consumption by including all modes of operation and auto-power down requirements.
- Governments are encouraged to use a range of policy instruments, including but not limited to minimum energy performance standards, comparative and endorsement labelling to achieve long-term market transformation. There are strong arguments for using mandatory measures to remove the worst performing products, combined with endorsement labelling in markets where consumers have choice.
- In addition to including requirements for TVSPs in franchise or licensing agreements, governments should work with TVSPs to assist them to fulfil their obligations, such as by setting targets, providing endorsement and other means of support.
- Governments should encourage industry to develop simple power management interfaces for STBs which enable consumers to choose appropriate settings in order to minimise energy consumption. Alongside this, there is also a role for governments, also in collaboration with industry, to educate consumers about actions they can take to minimise consumption.

Miscellaneous ICT and CE equipment

The IEA 25 policy recommendations to the G8 (OECD/IEA, 2008) address some of the issues facing miscellaneous ICT and CE equipment, however further detailed recommendations are provided below.

Since many of these miscellaneous products are particularly difficult to define and are subject to convergence, they are particularly suitable to horizontal policy measures. As a result the majority of savings in this category result from the following policy measures described elsewhere:

- Implementation of power management requirements for all products;
- 1-Watt horizontal standby policy measures;
- Requirements for external power supplies.

External power supplies

The energy losses in the current stock of EPS are significant and projected to continue growing over the near future, while the technology to improve efficiency is well-known. The list of efficient products already available is expanding quickly, as policy measures designed to enable them to access market share are implemented and production volumes increase sufficiently to reduce costs.

A considerable amount of work has been done to design a range of different types of programmes able to meet the major policy objectives of most regions, while maintaining a framework of global alignment. These circumstances lend themselves to the speedy and wide-scale adoption of S&L type programmes specifically for EPS, based on the current examples of policy measures.

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The IEA 25 policy recommendations to the G8 (OECD/IEA, 2008) did not address external power supplies specifically. However, it is now recommended that all governments should consider implementing the following policy measures for external power supplies:

- Governments should consider the adoption of mandatory minimum energy performance standards for the majority of external power supply categories, using the current range of programmes as a basis for development. Government should also consider implementing labelling programmes for end-use equipment supplied with EPS, to encourage the bundling of the most efficient EPS.

Standby power

As part of the package of recommendations on energy efficiency policies made to G8 Summits in 2006, 2007 and 2008, the IEA included several policies relevant to standby power (OECD/IEA, 2008). These include:

> *(3.2 a) Governments should adopt the same "horizontal" 1-Watt limit and apply it to all products covered by the International Electrotechnical Commission definition of standby power with limited exceptions; and*
>
> *(3.2 b) Governments should adopt policies which require electronic devices to enter low-power modes automatically after a reasonable period when not being used.*

- In addition, governments should work co-operatively to develop a horizontal functionality approach suitable for implementation as voluntary or mandatory policy measures covering all major functions and low-power modes.

Digital networks

To ensure that digital networks and network-connected devices support the minimisation of direct and induced energy consumption, the following principles should be adopted:

- All network technologies should actively support power management;
- Connection to a network should not impede a device from power management activities;
- The network should be designed such that a legacy or incompatible device does not prevent the rest of the network from effective power management;
- Connections should have the ability to modulate their own energy use in response to the amount of the service required by the system; and
- Terminology and concepts relating to energy management used in the design of all networks should be internationally harmonised.

Network connected devices

- Devices should not impede power management activities in other connected devices;
- Devices should expose their own power state to the network and be able to report estimated or actual energy use;
- User interfaces should follow (international) energy management standard principles and designs.
- Devices and connections should have the ability to modulate their own energy use in response to the amount of the service required by the system;

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- Terminology and concepts relating to energy management used in the design of all devices should be internationally harmonised; and
- The behaviour and communication of devices relevant to energy consumption should adhere to (international) standards.

In addition:

- Governments should ensure that electronic devices enter low-power modes automatically after a reasonable period when not being used;
- Governments should ensure that network connected electronic devices minimise energy consumption, with a priority placed on the establishment of industry-wide protocols for power management;
- Energy efficiency efforts should not favour any particular hardware or software technology; and
- Energy efficiency policy should identify digital networks as a promising method for attaining energy efficiency.

These principles add further detail to the specific policy recommendations included in the 25 IEA recommendations to the G8, which are applicable to all governments and repeated below:

> *(3.2 c) Governments should ensure that network-connected electronic devices minimise energy consumption, with a priority placed on the establishment of industry-wide protocols for power management.*
>
> *i) In order to enhance energy efficiency across electronic networks, governments should:*
>
> > *I. Instruct relevant public and private standards authorities to ensure that industry-wide protocols are developed to support power management in appliances and equipment, including networked devices; and*
> >
> > *II. Ensure such protocols are developed and implemented. (OECD/IEA, 2008).*

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ANNEX I • SUMMARY OF ESTIMATED BAU, LLCC AND BAT ELECTRICITY CONSUMPTION

Table 76 • Estimated global residential electricity consumption by ICT and CE equipment (TWh), 1990-2030

Year	Business as usual	Least life-cycle cost	Best available technology
1990	205	205	205
1995	270	270	270
2000	373	373	373
2005	548	548	548
2010	776	776	776
2015	1 018	819	686
2020	1 253	914	665
2025	1 485	1 051	703
2030	1 736	1 219	776

Source: IEA estimates.

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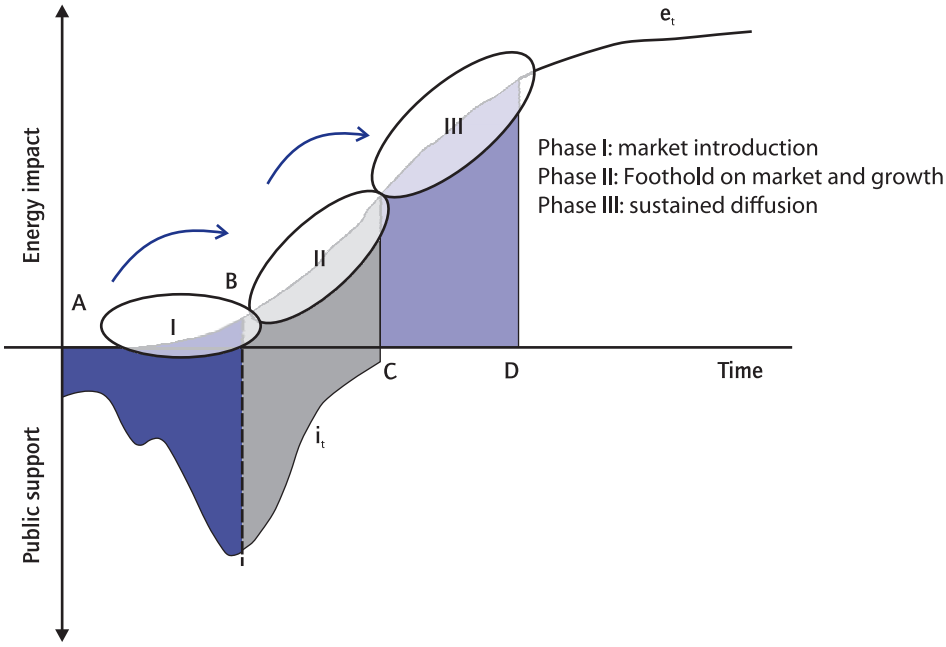
ANNEX II • EVALUATION METRICS USED IN ANALYSIS

A common indicator of the effectiveness of public policies is the ratio of resources (input) used to the output. In the energy efficiency context this indicator can be presented as USD/GJ saved. This can also be translated into a public cost of saved CO_2 emissions USD/CO_2 emissions.

When measuring the effectiveness of the programme, not only the immediate observed impacts but also the future impacts from the measures may need to be considered in some way. Lund (2007) provides a useful framework for illustrating how the impacts from policy measures and public support evolve over time. According to Lund (2007, pp. 629 - 630), the market diffusion comprises three distinct phases of which the market introduction and market foothold are most critical for the breakthrough.



Source: Lund, 2007.

The energy impacts are obtained from the cumulative installed capacity or a number of installations (e_t) by multiplying with unit energy production or savings per unit (u). The energy impacts are obtained from the cumulative installed capacity or number of installations (e_t) by multiplying with unit energy production or savings per unit (u). The observed effects of the measures are those represented in above figure by the curve e_t from point t_A to t_B. public funding support is denoted it. The specific cost of the public measures can then be written as

$$c_{observed} = \frac{\int_A^B i(t)\,\mathrm{d}t}{u\int_A^B \frac{\partial e(t)}{\partial t}\,\mathrm{d}t}$$

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In other words, the area under the curve e_t between t_A and t_B.

However, energy efficiency programmes are best evaluated considering the effects of a whole lifetime of the investments.

$$c_{lagging} = \frac{\int_A^C i(t)\,\mathrm{d}t}{u\,\Delta t_{life} \int_A^D \frac{\partial e(t)}{\partial t}\,\mathrm{d}t}$$

The Equation above shows that stretching the time interval to tD would improve the effectiveness of the programme by accounting for a larger accumulated energy savings impact. All of the detailed case studies presented here account for lifetime savings.

Energy efficiency policies tend to target new technologies that would have been improbable without the policy measures. Some free-rider or spill-over effects (that is, where the policy is inadvertently supporting a technology/behaviour change that would have occurred regardless of the policy) may occur that would decrease the true impact from the policy measures. Free rider effects were accounted for in 6 of the 8 detailed case study evaluations (California, Germany KfW, the Netherlands appliance labelling, the UK energy efficiency commitment, and the New York programmes). The free rider effect was not made in Thailand because "*Free ridership refers to the proportion of energy efficient appliance purchasers who would have bought the energy efficient appliance in the absence of a monetary incentive. There were no monetary incentives for the Thin Tube [programme]. ... Thus, free ridership was not estimated*" (see Agra Monenco, 2000, pp. 2-11).

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ABBREVIATIONS AND ACRONYMS

AC	alternating current
ACCC	Australian Competition and Consumer Commission
ACEEE	American Council for Equipment Energy Efficiency
ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie, France
AGO	Australian Greenhouse Office
AHAM	Association of Home Appliance Manufacturers
AMD	Advanced Micro Devices
ANCE	Asociación de Normalización y Certificación, A.C. (Mexico)
ANEEL	Agência Nacional de Energia Elétrica (Brazilian Electricity Regulatory Agency)
ANOPR	Advance Notice of Proposed Rulemaking
ANRE	Agency for Natural Resources and Energy (Japan)
ANSI	American National Standards Institute
APEC	EWG Asia Pacific Economic Co-operation Energy Working Group
APP	Asia Pacific Partnership on Clean Development and Climate
AQSIQ	State Administration of Quality, Supervision, Inspection and Quarantine (China)
ASCEE	ADM Steering Committee on Energy Efficiency (Canada)
ASEAN	Association of Southeast Asian Nations
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AUD	Australian dollar
BAT	best available technology
BATF	Buildings and Appliances Task Force (APP)
BC	battery charger
BCA	Building Code of Australia
BECP	Building Energy Codes Program (United States)
BEE	Bureau of Energy Efficiency (India)
BEMS	building energy management system
Billion	1×10^9, i.e. 1 000 000 000.
BMZ	German Federal Ministry for Economic Development and Co-operation

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BRE	Building Research Establishment (United Kingdom)
BRESL	The Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labelling Project
Brics	Brazil, Russia, India, China, South Africa
Btu	British thermal unit
C	carbon
CaBEERE	Capacity Building in Energy Efficiency and Renewable Energy
CAD	Canadian dollar
CANACINTRA	National Transformation Industry Association (Mexico)
CBSA	Canada Border Services Agency
CCFL	cold-cathode fluorescent lamp
CCNNPURRE	National Consultative Committees for Preservation and Efficient Use of Energy Resources (Mexico)
CD	compact disc
CDM	clean development mechanism, a flexible mechanism under the Kyoto Protocol
CE	consumer electronics
CEC	California Energy Commission (United States)
CECED	European Committee of Domestic Equipment Manufacturers
CECP	China Certification Center for Energy Conservation Products
CECP	China Energy Conservation Product
CEE	Consortium for Energy Efficiency (United States)
CEE	Consortium on Energy Efficiency (Unites States)
CEF	Central Energy Fund (South Africa)
CELC	China's Energy Label Centre
CELMA	Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires in the European Union
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CENELEC	European Committee for Electrotechnical Standardization
CEPEL	Centro de Pesquisas de Energia Electrica (Brazil)
CFE	Comision Federal de Elecricidad (Mexico)
CFL	compact fluorescent lamp
CLASP	Collaborative Labelling and Appliance Standards Program

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CLCV	La Confédération de la Consommation, du Logement et du Cadre de Vie
CLU	City of Lompoc Utilities (United States)
CNIS	China National Institute of Standardisation
CNY	Yuan renminbi (China)
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
CONAE	Comision Nacional para el Ahorro de Energia (National Commission for Energy Conservation) (Mexico)
CONIQQ	National Chemical Engineers Association (Mexico)
COP	coefficient of performance
CPRS	Carbon Pollution Reduction Scheme (Australia)
CPU	central processing unit
CPUC	California Public Utilities Commission (United States)
CQC	China Quality Certification Centre
CRIEPI	Central Research Institute of Electric Power Industry (Japan)
CRT	cathode ray tube
CSC	China Standard Certification Center
DANIDA	Danish International Development Assistance
DC	direct current
DD	degree days
DEFRA	Department for Environment, Food and Rural Affairs (United Kingdom)
Dena	Deutsche Energie-Agentur (German Energy Agency)
DEST	Danish Electricity Saving Trust
DG TREN	Directorate-General for Energy and Transport (Europe)
DIY	do-it-yourself
DLP	digital light processing
DME	Department of Minerals and Energy (South Africa)
DNA	Designated National Authority (South Africa)
DOE	Department of Energy (United States)
DSM	demand-side management
DST	daylight-saving time
DVD	digital video disc
DVR	digital video recorders

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E3	Equipment Energy Efficiency Committee (Australia)
EACEM	European Association of Consumer Electronics Manufacturers
EBSST	Electricity Basic Support Services Tariff (South Africa)
EC	European Commission
ECBCS	Energy Conservation in Buildings and Community Systems (IEA Implementing Agreement)
ECCJ	Energy Conservation Centre (Japan)
ECL	Energy Conservation Law (China)
EDF	Environment and Development Foundation (Taiwan)
EECA	Energy Efficiency and Conservation Authority (New Zealand)
EECA	New Zealand's Energy Efficiency and Conservation Authority
EED	Energy Efficiency Directorate (South Africa)
EEI	energy efficiency index
EEO	energy efficiency obligation
EERS	energy efficiency resource standards
EFTA	European Free Trade Association
EGEE&C	Expert Group on Energy Efficiency & Conservation (APEC)
EIA	Energy Information Administration (United States)
EICTA	European Information & Communications Technology Industry Association
EISAct	Energy Independence and Security Act 2007 (United States)
ELI	Efficient Lighting Initiative
ELV	extra low voltage
EM	electromagnetic
EMA	Entidad Mexicana de Acreditación (Mexico)
EMF	electromotive force
EPA	Environmental Protection Agency (United States)
EPAct	Energy Policy Act (United States)
EPBD	Energy Performance of Buildings (Europe)
EPE	Empresa de Pesquisa Energetica (Brazil)
EPG	electronic programme guide
EPS	external power supplies
ESCO	energy service company
EST	Energy Savings Trust (United Kingdom)

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ETS	emission trading scheme
EU	European Union
EUEEP	End-Use Energy Efficiency Project (China)
EuP	energy-using products
EUR	euros
ExCo	executive committee IEA Implementing Agreement
FEMP	Federal Energy Management Program (United States)
FIDE	Fideicomiso para el Ahorro de Energía Eléctrica (Private Trust Fund for Electric Energy Saving) (Mexico)
FTC	Federal Trade Commission (United States).
GBP	British pounds (sterling)
GDP	gross domestic product
GEEA	Group for Energy Efficient Appliances
GEF	Global Environment Fund
GHG	greenhouse gas
GJ	gigajoule (1 joule $\times$ 10^9)
GLS	general lighting service
GPOA	Gleneagles Plan of Action
GW	gigawatt (1 watt $\times$ 10^9)
GWh	gigawatt-hour (1 watt $\times$ 10^9)
HDD	hard disk drive
HID	high-intensity discharge
HVAC	heating, ventilation and air-conditioning
ICT	information and communication technology
IEA	International Energy Agency
IEC	International Electrical Commission
IECC	International Energy Conservation Code
IEE	Intelligent Energy Europe
IEEJ	The Institute of Energy Economics Japan

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IES	Illuminating Engineering Society
IESNA	Illuminating Engineering Society of North America
IFC	International Finance Corporation
IIE	Institute for Electric Research (Mexico)
IMP	Mexican Petroleum Institute
INEP	Integrated National Electrification Programme (South Africa)
INR	Indian rupee
IP	Internet protocol
IPART	Independent Pricing and Regulatory Tribunal (Australia)
IPTV	Internet protocol television
IRD	Integrated receiver decoder
IRR	internal rate of return
ISO	International Standards Organisation
JEITA	Japan Electronics & Information Technology Industries Association
JELMA	Japan Electric Lamp Manufacturers Association
JEMA	Japan Electrical Manufacturers Association
JGKA	Japan Industrial Association of Gas and Kerosene
JI	Joint Implementation
JLA	Japan Lighting Association
JRAIA	Japan Refrigerator & Air Conditioning Industry Association
JRC	Joint Research Council (European Union)
KEMCO	Korea Energy Management Corporation
KIER	Korea Institute of Energy Research
KONEPS	Korea's ON-line E-Procurement System
KRW	Korean wons
kW	kilowatt (1 watt $\times$ 10^3)
kWh	kilowatt-hour
LBNL	Lawrence Berkley National Laboratory (United States)
LCC	life-cycle cost
LCD	liquid crystal display

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LCoS	liquid crystal on silicon
LED	light-emitting diode
LFL	linear fluorescent lamp
LLCC	least life-cycle cost
lm	lumen
lm/W	lumens/watt
LPG	liquefied petroleum gas
MCE	Ministerial Council on Energy (Australia)
MEC	Model Energy Code (United States)
MEPS	minimum energy performance standard
METI	Ministry of Economy,Trade and Industry (Japan)
MKE	Korean Ministry of Knowledge Economy
MLIT	Ministry of Land, Infrastructure and Transport (Japan)
MME	Ministry of Mines and Energy (Brazil)
MP3	MPEG-1 Audio Layer 3
Mt	megatonne (1 million tonnes)
Mtoe	million tonnes of oil equivalent
MTP	Market Transformation Program
MTPROG	Market Transformation Programme (United Kingdom)
MW	megawatt (1 watt $\times$ 10^6)
NACEE	National Advisory Council on Energy Efficiency (Canada)
NAECA	National Appliance Energy Conservation Act (United States)
NAEEEC	National Appliance and Equipment Energy Efficiency Committee (Australia)
NAEWG	North American Energy Working Group
NDRC	National Development and Reform Commission (China)
NEDO	New Energy and Industrial Technology Development Organization (Japan)
NEEA	National Energy Efficiency Agency (South Africa)
NEEAPs	National Energy Efficiency Action Plans (Europe)
NEMA	National Electrical Manufacturers Association (United States)
NEPCA	National Energy Policy and Conservation Act (1978)
NER	National Energy Regulator (South Africa)

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NERSA	National Energy Regulator of South Africa (South Africa)
NGAC	NSW Greenhouse Abatement Certificate (Australia)
NGO	non-governmental organisation
NMX	Normas Mexicanas (Mexican Standards)
NOM	Official Mexican Standards
NOPR	Notice of Proposed Rulemaking
NPV	net present value
NRCan	Natural Resources Canada
NRDC	Natural Resources Defence Council (United States)
NSI	National Supervision and Inspection (China)
NYSERDA	New York State Energy research and Development Authority
NZD	New Zealand dollar
OBPR	Office of Best Practice Regulation (Australia)
OECD	Organisation for Economic Co-operation and Development
OEE	Office of Energy Efficiency (Canada)
OEM	original equipment manufacturer
OLED	organic light-emitting diode
PBE	Brazilian Labelling Programme
PCRA	Petroleum Conservation Research Association (India)
PDA	personal digital assistant
PDP	plasma display panel
PEMEX	Petróleos Mexicanos (national oil company)
PF	power factor ratio
PFAEE	Programa de Financiamiento para el Ahorro de Energía Electríca (Mexico)
PMP	portable media player
Pno	maximum nameplate output power
PoE	Power over Ethernet
PV	photovoltaic
R&D	research & development
RGGVY	Rajiv Gandhi Grameen Vidhyutikaran Yojana (India)

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RP	rear projection TV
RST	retail sales tax
S&L	standards & labelling energy efficiency programmes
S.A.F.E.	Swiss Agency for Efficient Energy Use
SABS	South African Bureau of Standards
SAC	Standardization Administration of China
SDAs	State Designated Agencies (India)
SED	surface-conduction electron-emitter display
SEP	State Energy Program (United States)
SERP	Super Efficient Refrigerator Program, STEM Swedish National Energy Authority
SHC	Solar Heating and Cooling (IEA Implementing Agreement)
SPP	Security and Prosperity Partnership
SSL	solid-state lighting
STB	set-top box
t	tonnes
TJ	terrajoule (1 joule $\times$ 10^{12})
TVSP	TV service provider
TWh	terawatt-hours (1 watt-hour $\times$ 10^{12})
UEC	unit energy consumption
UNAM	National University of Mexico
UNCSD	United Nations Commission on Sustainable Development
UNDESA	UN Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	UN Environment Program
UNESCAP	UN Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UPS	uninterrupted power supply
USAID	US Agency for International Development
USB	Universal Serial Bus
USD	US dollars

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VA	voluntary agreement
VAT	value-added tax
VCR	video cassette recorder
VoIP	voice-over-Internet protocol
WEEE	Waste Electrical and Electronic Equipment Directive
WEO	World Energy Outlook of the IEA
Wh	watt-hour
WOL	wake on LAN
WWF	World Wildlife Fund
ZAR	South African rand

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GLOSSARY

alternating current (AC): an electric current whose direction reverses cyclically. In electricity supply systems the frequency of this reversal is typically between 50 and 60 times per second.

coefficient of performance (COP): the cooling power of an air-conditioning system (measured in watts) divided by the input electrical power (measured in watts).

cold-cathode fluorescent lamp (CCFL): a very thin low-pressure fluorescent lamp that creates a discharge current by ionic bombardment of the cathode rather than via thermionic emission, which is the technique used by standard fluorescent lamps. CCFLs are used for exit signs and backlighting of monitors. Neon fluorescent lamps are also a type of CCFL.

compact fluorescent lamp (CFL): a fluorescent lamp with bent tubes to reduce the size of the lamp. A CFL is constructed either with an integrated ballast, in which case it is designed to be directly interchangeable with a general lighting service lamp, or in a modular form where the ballast is supplied independently of the fluorescent tube.

contrast: the difference between the brightness of an object and that of its immediate background.

daylight-saving time: also known as "summer time"; the practice of advancing local time by a certain period (most commonly one hour) during the summer months in order to maximise the coincidence of the hours when people are awake with the availability of daylight. Applying daylightsaving time saves energy because it reduces the need for artificial lighting.

demand-side management (DSM): the methods used to manage energy demand, including energy efficiency, load management, fuel substitution and load building.

direct current (DC): an electric current produced by electric charges flowing in the same direction, distinguishing it from alternating current (AC).

efficacy: also known as the "luminous efficacy of a light source"; the ratio of light from a lamp (measured in source-lumens) to the electrical power (watts) consumed, expressed in lumens per watt (lm/W). System efficacy includes the ballast losses.

ethernet: is the most widely-installed local area network (LAN) technology, specified in the standard, IEEE 802.3.

general lighting service (GLS) lamp: always used to refer to a standard incandescent light-bulb.

hibernate: a low power mode included as a power management option in Windows XP.

illuminance: the amount of light (strictly, the luminous flux) incident on a surface/plane per unit area; measured in units of lux (lm/m^2).

incandescence: the emission of light through being heated, *i.e.* glowing.

life-cycle cost: the total capital and running costs (of a product), over the lifetime of a product.

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light-emitting diode (LED): a semi-conductor device that emits light when a current is passed through it.

linear fluorescent lamp (LFL): a straight fluorescent lamp.

low-power mode (s): the state of an electronic device when consuming power but not performing its primary function.

lumen (lm): SI unit of luminous flux. Radiometrically, it is determined from the radiant power. Photometrically, it is the luminous flux emitted within a unit solid angle (one steradian) by a point-source with a uniform luminous intensity of one candela.

luminaire: a complete lighting unit consisting of a lamp (or lamps), or ballasts where applicable, together with the parts designed to distribute the light, position and protect lamps and connect them to the power supply.

luminance: the luminous flux emitted in a given direction divided by the product of the projected area of the source element perpendicular to the direction and the solid angle containing that direction, *i.e.* luminous intensity per unit area; measured in units of candela per square metre (cd/m^2). In effect it is the physical measure of the subjective sensation of brightness.

mains electricity: AC electric power supplied from wall sockets or other outlets within a dwelling or other type of building.

megatonne (Mt): 1×10^6 tonnes; a quantity of weight.

mode: discernable power states or levels of an electrical or electronic device typically associated with providing one or more distinct functions.

Mt of CO_2 emissions: megatonne of CO_2 emissions (*i.e.* 1×10^6 tonnes of CO_2). Not to be confused with Mt of C (which is 1×10^6 tonnes of carbon and is converted to Mt of CO_2 through multiplying by 3.46).

Moore's Law: states that the number of transistors that can be placed inexpensively on an integrated circuit has increased exponentially, doubling approximately every two years. First described by co-founder of Intel, Gordon E. Moore in 1965.

on mode: the state of an electronic device when performing its primary function. Sometimes referred to as *active* mode.

photovoltaic (PV): solar cells that convert sunlight directly into electricity.

power factor (PF): ratio of the real power to the apparent power in a circuit, where the real power is the capacity of a circuit to perform work in a particular time and the apparent power is the product of the voltage and current in the circuit; the apparent power will be greater than or equal to the real power.

principal-agent barriers: in which one party makes decisions regarding the energy efficiency of a building or energy-using device as an *agent* on behalf of the *principal*, the party that pays the end-use energy bill.

sleep: a low-power mode.

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standby power: the generic term for the power consumed by a product when not performing its primary function. A device may have several low-power modes including sleep and hibernate.

standby energy: the energy consumed by a device when drawing standby power.

VoIP: a protocol designed for the transmission of voice over the Internet.

whitegoods: a generic term for major household appliances which have an energy input, such as refrigerators, freezers, washing machines.

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REFERENCES

Foreword, Executive summary and Chapter 1

Commonwealth of Australia (2008), *Energy Use in the Australian Residential Sector 1986-2020*.

ECCJ (2007), *Handbook of Energy Economics & Economic Statistics in Japan*, February 2007

EIA (2000), *Annual Energy Outlook*, Report DOE/EIA-0383 (2000), 2000.

EIA (2008), *Annual Energy Outlook*, Report DOE/EIA-0383 (2008), 2008.

IEA (2007), *Experience with Energy Efficiency Regulations for Electrical Equipment*, Information Paper, International Energy Agency, Paris, 2007.

MTP (2008), *Pers. Com.* Mr Kevin Lane, UK Market Transformation Program, 21 May 2008.

NRCan (2006) *Energy Use Data Handbook Tables*, available from http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0.

Moore (1965), *Cramming more components onto integrated circuits*, Electronics, Volume 38, Number 8, April 19, 1965. Gordon E. Moore, Director, Research and Development Laboratories, Fairchild Semiconductor, available from ftp://download.intel.com/research/silicon/moorespaper.pdf.

OECD/IEA (2003), *Cool Appliances: Policy Strategies for Energy-Efficient Homes,* Paris, France.

OECD/IEA (2006a), *World Energy Outlook 2006,* Paris, France.

OECD/IEA (2006b), *Light's Labour's Lost: Policies for Energy-Efficient Lighting*, Paris, France.

OECD/IEA (2008a), *Worldwide Trends in Energy Use and Efficiency: Key Insights from IEA Indicator Analysis*, Paris, France. 2007.

OECD/IEA (2008b), *Energy efficiency policy recommendations prepared by the IEA for the G8 under the Gleneagles Plan of Action*, Paris, 2008.

Chapter 2: Effective policies for energy efficiency

ABS (2007), *Australian Social Trends: Trends in Household Consumption*, Catalogue No. 4102.0, Susan Linacre.

Agra Monenco, and B. Hydro (2000), Of the Electricity Generating Authority of Thailand – DSM programme evaluation – conservation programme, Agra Monenco.Danish Energy Association

© OECD/IEA, 2009

(2006). *Evaluation of Danish Electricity Saving Initiatives: Householder Consultations,* Danish Energy Association, Copenhagen.

Commonwealth of Australia (2008), *Carbon Pollution Reduction Scheme: Australia's Low Pollution Future*, White Paper, Volume 1, Canberra, December 2008.

ECCJ (2007), *Handbook of Energy Economics & Economic Statistics in Japan*, February 2007.

ECN (2008), *The impact of the EU ETS on electricity prices*, ECN-E--08-007, Final report to DG Environment of the European Commission, December 2008.

Ecofys (2007), *Success and failure in energy efficiency policies: ex-post evaluation of 20 instruments to improve energy efficiency across Europe*, Ecofys, Utrecht.

EETD Newsletter (2002), *IPMVP* – from a DOE-Funded Initiative to a Not-for-Profit Organization.

Energy Charter Secretariat (2006), *Evaluating Energy Efficiency Policies and Measures*, Draft report CS (06)1064 PEEREA 109.

Forfori, F. (2006), *Evaluation of British Energy Efficiency Commitment - case study executed within the framework of the AID-EE project*, Ecofys, Lund University, ERG and the Institute of Work and Technology, North Rhine, Westphalia.

Gillingham, K., R. Newell, and K. Palmer (2004), *Retrospective Examination of Demand-Side Energy Efficiency Policies*, Resources for the Future, Washington, DC.

IEA (2007), *Experience with Energy Efficiency Regulations for Electrical Equipment*, Information Paper, International Energy Agency, Paris, 2007.

IEA (2008), *Meeting Energy Efficiency Goals: Enhancing compliance, monitoring and evaluation*, Workshop report, 28-29 February 2008, International Energy Agency, Paris.

IEA DSM (2005), *Evaluating Energy Efficiency Policy Measures & DSM programmes - volume 1: Evaluation Guidebook*, IEA Implementing Agreement on Demand-Side Management Technologies and Programs, Paris.

ILEX (2004), *Impact of the EU ETS on European Electricity Prices*, a report to DTI (UK), July 2004.

KEMA. 2006. E*valuation of the 2004-2005 Statewide Multifamily Rebate Program – Volume I,* The California Public Utilities Commission, Pacific Gas & Electric Company, San Diego Gas & Electric Company, Southern California Edison, Southern California Gas Company, San Diego.

Korytarova, K. (2006), *Evaluation of KFW for a building modernisation - case study executed within the framework of the AID-EE project,* Ecofys, Lund University, ERG and the Institute of Work and Technology, North Rhine, Westphalia.

Lund, P. (2007), *Effectiveness of policy measures in transforming the energy system*, Energy Policy 35, pp.627- 639.

© OECD/IEA, 2009

Luttmer, M. (2006), *Evaluation of labelling of Appliances in the Netherland – case study executed within the framework of the AID-EE project,* Ecofys, Lund University, ERG and the Institute of Work and Technology, North Rhine, Westphalia.

McKinsey (2007a), *A cost curve for greenhouse gas reduction*, Per-Anders Enkvist, Tomas Naucler and Jerker Rosander.

McKinsey (2007b), *Curbing Global Energy Demand Growth: The Energy Productivity Opportunity*, McKinsey Global Institute, May 2007.

NS (2007), *Family Spending*, Office for National Statistics UK, 2007.

NYSERDA (2007), *New York Energy $MART^{SM} program quarterly evaluation and status report - quarterly report to the Public Service Commission* – quarter ending 31 March, 2007. New York State Energy Research and Development Authority, New York.

OECD/IEA (2003), *Cool Appliances: Policy Strategies for Energy-Efficient Homes,* Paris, France.

OECD/IEA (2005), *Act Locally, Trade Globally: Emissions Trading for Climate Policy,* Paris, France.

OECD/IEA (2006), *Light's Labour's Lost: Policies for Energy-Efficient Lighting*, Paris, France.

OECD/IEA (2007), *Mind the Gap, Quantifying Principal-Agent Problems in Energy Efficiency*, Paris 2007.

OECD/IEA (2008), *Worldwide Trends in Energy Use and Efficiency - Key Insights from IEA Indicator Analysis*, Paris, France.

UKP (2007), *Personal Carbon Allowances*, Environmental Audit Committee, United Kingdom Parliament, 24 April 2007, available from http://www.parliament.uk/parliamentary_committees/environmental_audit_committee/eac_24_04_07.cfm.

USDOL (2007), *The Consumer Expenditure Survey (CE)*, Bureau of Labor Statistics, 2007.

Waide, P. and B. Buchner (2008), *Utility energy efficiency schemes: savings obligations and trading*, International Energy Agency, France.

Chapter 3: Country and regional reviews

Introduction

McKinsey (2007), *A cost curve for greenhouse gas reduction*, Per-Anders Enkvist, Tomas Naucler and Jerker Rosander.

CLASP (2005), *Energy Efficiency Labels and Standards: A Guidebook for Appliances, Equipment and Lighting*, Collaborative Labelling and Appliances Standards Program (CLASP), Washington DC, February 2005.

© OECD/IEA, 2009

IEA (2007), *Experience with Energy Efficiency Regulations for Electrical Equipment*, Information Paper, International Energy Agency, Paris, 2007.

IEA (2008), *Workshop report, Meeting Energy Efficiency Goals: Enhancing compliance, monitoring and evaluation*, , 28-29 February 2008, International Energy Agency, Paris, 2008.

OECD/IEA (2000), *Energy Labels & Standards*, Paris, France.

OECD/IEA (2003), *Cool Appliances: Policy Strategies for Energy-Efficient Homes*. Paris, France.

OECD/IEA (2006), *Light's Labour's Lost: Policies for Energy-Efficient Lighting*, Paris, France.

Australasia

ACCC (2006)*, LG Compensates Consumers over Misleading Energy Ratings*, Press release by Australian Consumer and Competition Commission, 28 September 2006.

Australian Government (2007), *Partnership for Action Asia-Pacific Partnership on Clean Development and Climate, Second Edition*.

Commonwealth of Australia (2006), *Changes to the Building Code of Australia*, EE Seminar Vol 1 part 1, http://www.abcb.gov.au/go/training/seminars.

Commonwealth of Australia (2008), *Energy Use in the Australian Residential Sector 1986-2020*.

E3 (2006a), *Compliance Newsletter*, Issue 1 October 2006, http://www.energyrating.gov.au/library/index.html.

E3 (2006b), *Equipment Energy Efficiency Programme Achievements 2005* (Report No. 2006/03), Canberra, August 2006.

E3 (2006c), *Appliance Performance Labelling In Australia and New Zealand, Final Report on a Major Quantitative Study among Consumers and Retailers on the Labelling of Household Appliances,* conducted during September-October 2005 for the Australian Greenhouse Office and Department of the Environment and Heritage, August, 2006.

E3 (2007a), *Equipment Energy Efficiency Programme Achievements 2006* (Report No. 2007/01), Canberra, May 2007.

E3 (2007b), *Compliance Newsletter*, Whitegoods Edition, February 2007, http://www.energyrating.gov.au/library/index.html.

E3 (2007c), *Compliance Newsletter*, Air conditioner Edition, May 2007, http://www.energyrating.gov.au/library/index.html.

E3, (2007d), *Compliance Newsletter*, Issue No. 4, November 2007, http://www.energyrating.gov.au/library/index.html.

© OECD/IEA, 2009

E3 (2007e), *Refrigerator Star Rating Algorithms in Australia and New Zealand – Revised Proposal*, Report No 2007/09, discussion draft for stakeholder comment issued under the auspices of the Ministerial Council on Energy.

E3 (2008), *Voluntary Labelling Program for Televisions: Rules for Participation*, Report No 2008/01, May 2008.

EECA (2007), The Energy Efficiency and Conservation Authority Annual Report 2006/07.

EECA (2008), *pers. com.*, Energy Efficiency and Conservation Authority, 1 July 2008.

EES (2005), *Air Conditioner Algorithm Working Group - Discussion Paper*, Appliance Labelling Review Committee prepared by EES, July 2005.

EES (2006), *Standby Power – Current Status*, A report for the Equipment Energy Efficiency (E3) Committee which documents the state of standby power in Australia and New Zealand, October 2006.

GWA (2004), *National Appliance and Equipment Energy Efficiency Programme (NAEEEP) – Coverage of Residential, Commercial and Manufacturing Sectors* (Report No. 2004/23), prepared for the Australian Greenhouse Office by George Wilkenfeld and Associates Pty Ltd, August 2004.

GWA (2005), *Energy Allstars Product Database – Proposed Use in Government Procurement*, Report to the Australian Greenhouse Office by George Wilkenfeld and Associates Pty Ltd, May 2005.

IPART (2006), *Introduction to the Greenhouse Gas Reduction Scheme (GGAS)*, http://www.greenhousegas.nsw.gov.au/documents/Intro-GGAS.pdf, accessed April 2008.

IPART (2007a), *GGAS Newsletter*, Issue 6, November 2007.

IPART (2007b), *Compliance and Operation of the NSW Greenhouse Gas Reduction Scheme during 2006*, report to Minister.

IPART (2008), *NSW GGAS registry*, http://www.ggas-registry.nsw.gov.au/, accessed September 2008.

NAEEC (2004a), *Energy Rating Labelling Program - Whitegoods Audit 2004,* conducted by Millward Brown on contract to National Appliance and Equipment Energy Efficiency Committee (NAEEEC), Summary Report prepared by Energy Efficient Strategies, December 2004.

NAEEC (2004b), *Energy Rating Labelling Program - Air Conditioner Audit 2005*, conducted by Millward Brown on contract to National Appliance and Equipment Energy Efficiency Committee (NAEEEC), Summary Report prepared by Energy Efficient Strategies, December 2004.

NAEEEP (2005a), *National Appliance and Equipment Energy Efficiency Programme Achievements 2004* (Report No. 2005/06), Canberra, April 2005.

NAEEP (2005b), *When You Keep Measuring It, You Know Even More About It! Projected Impacts 2005-2020*, report for National Appliance and Equipment Energy Efficiency Committee (NAEEEC).

© OECD/IEA, 2009

O'Neill, M. (2003), *Appliance Industry National Resource Labelling Project*, prepared for the Australian Greenhouse Office by BigStep! Services, Oncon Pty Ltd, 14 November 2003.

Winton (2007), *Final Report on Community Attitudes to the Possibility of Energy Efficiency Labelling of Television Sets and Home Computers*, Winton Sustainable Research Strategies for Australian Greenhouse Office (AGO), 23 April 2007.

Winton (2008), *Towards a 10-Star Energy Efficiency Rating System for Major Household Appliances, Final Report n a Series of Focus Group Discussions in Australia and New Zealand*, conducted for the Department of the Environment, Water, Heritage and the Arts, 8 May 2008.

Canada

Canada Gazette (2006), *Regulations Amending the Energy Efficiency Regulations,* Volume 140, No 18 – May 6, 2006.

CREA (2006), *Energy Efficiency and Conservation: The Cornerstone of a Sustainable Energy Future*. Canadian Renewable Energy Alliance, August 2006.

DoE (2007), *Security and Prosperity Partnership (SPP)/North American Energy Working Group (NAEWG)*, U.S. Department of Energy, http://www.pi.energy.gov/naewg.html, accessed November 2007.

Government of Canada (2007), *Regulatory Framework for Air Emissions*, 2007.

Laplante, M. (2008), *pers. com*., 17 March, 2008.

NAEWG (2002), *North American Energy Efficiency Standards and Labelling*, 2002.

NAEWG (2007), *Standby Power Workshop Presentation*, Sep 2007.

NRCan (2005), *2003 Survey of Household Energy Use (SHEU)*.

NRCan (2007), *Tracking Study: Awareness of Energy Star/Energuide Symbols*.

OEE (2004), *Improving Energy Performance in Canada- Report to Parliament Under the Energy Efficiency Act for the Fiscal Year 2003-2004*.

OEE (2005a), *Improving Energy Performance in Canada- Report to Parliament Under the Energy Efficiency Act for the Fiscal Year 2004-2005*.

OEE (2005b), *Energy Star Newsletter*, 2005.

OEE (2006a), *Improving Energy Performance in Canada- Report to Parliament Under the Energy Efficiency Act for the Fiscal Year 2005-2006*.

OEE (2006b), *State of Energy Efficiency in Canada*, Report 2006.

OEE (2006c), *Energy Star Newsletter*, 2006.

OEE (2006d), *About R-2000: Every Home Should Be This Good!* 28 April 2006, http://oee.rncan.gc.ca/residential/personal/new-homes/r-2000/About-r-2000.cfm?attr=4, accessed November 2008.

© OECD/IEA, 2009

OEE (2007a), *Energy Star Newsletter*, 2007.

OEE (2007b), *Energy Star in Canada*, revised March 2007.

OEE (2008a), ENERGY STAR Fact Sheets, 9 May 2008, http://oee.nrcan.gc.ca/energystar/english/participants/library/fact.cfm?text=N&printview=N, accessed November 2007.

OEE (2008b), *Energy Handbook,* 2008.

OEE (2008c), *OEE Grants under ecoENERGY Retrofit – Homes: Questions and Answers*, http://www.oee.nrcan.gc.ca/residential/personal/retrofit-homes/questions-answers.cfm?attr=4#q2, accessed July 2008.

OMR (2007), *Retail Sales Tax- Information Notice*, Ontario Ministry of Revenue, June 2007.

ONT (2008), *Exemption for ENERGY STAR Household Appliances and Lighting Products*, Ministry of Revenue, http://www.rev.gov.on.ca/english/notices/rst/56.html, accessed November 2007.

OPA (2008), *Every Kilowatt Counts, Ontario Power Authority*, http://everykilowattcounts.com/residential/, accessed July 2008.

Wilkins (2008), *Pers. Com.*, 18 June 2008.

European Union

ANEC (2007), *A review of the range of activity throughout member states related to compliance with the EU Energy Label regulations in those countries,* ANEC-R&T-2006-ENV-008, ANEC and the UK Department for Environment, Food and Rural Affairs, January 2007.

Bush, E., Attali, S., Brunner C., Arquit Niederberger A. (2006), *Topten.info: Fast selection, best choice*, presented to EEDAL 2006, London, 23 June 2006.

CECED (2002), *Voluntary Commitment on Reducing Energy Consumption of Household Refrigerators, Freezers and their Combinations (2002-2010)*, Brussels, 31 October 2002.

CECED (2007a), *Top Executives Discontinue Voluntary Energy Efficiency Agreements for Large Appliances,* press release, Brussels, 21 March 2007.

CECED (2007b), *CECED Vision on Energy Efficiency*, Brussels, 1 July 2007.

DEA (2006), *Evaluation of Danish Electricity Saving Initiatives: Householder Consultations, Danish Energy Association*, Troels Fjordbak Larsen, IT Energy and Niels Ejnar Helstrup, 10 May 2006.

EC (2003), *Commission Directive 2003/66/EC of 3 July 2003 amending Directive 94/2/EC implementing Council Directive 92/75/EEC with regard to energy labelling of household electric refrigerators, freezers and their combinations*, Brussels, 3 July 2003.

EC (2005), *Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products*

© OECD/IEA, 2009

and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council, Brussels, 6 July 2005 .

EC (2006), *Action Plan for Energy Efficiency: Realising the Potential*, COM(2006)545, Brussels, 19 October 2006.

EC (2008a), *Consultation Document the revision of the Energy Labelling Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances*.

EC (2008b), *Proposal for a regulation of the European Parliament and of the Council on a Community Ecolabel scheme*, COM(2008) 401/3
http://ec.europa.eu/environment/ecolabel/pdf/com_2008_401.pdf, accessed July 2008.

EC (2008c), *Background Information Paper for the Public Consultation on the Recasting of the Energy Performance of Buildings Directive (EPBD)*, (2002/91/EC), http://ec.europa.eu/energy/demand/consultations/doc/2008_public_consultation_buildings_background_en.pdf.

EE 2007, *Impact assessment study on a possible extension, tightening or simplification of the framework directive 92/75 EEC on energy labelling of household appliances,* a report by Europe Economics and Fraunhofer-ISI with BSR Sustainability and FfE, 19 October 2007.

EICTA (2005), *Industry self-Commitment to improve the energy performance of Household consumer electronic products sold in the European Union*, July 2005.

EICTA (2006), *EICTA position on Green paper on Energy Efficiency*, C)M (2005) 265 final, March 2006.

EICTA (2007), *EICTA's view on the reduction of standby power Consumption for Consumer Electronics*, Wilfied Oppermann, Panasonic Europe. German-French Expert Workshop on Standby Losses, 31 May 2007.

EVER (2005), *Evaluation of EMAS and Eco-label for their Revision*, 26 December 2005,
http://ec.europa.eu/environment/ecolabel/pdf/revision/executive_summary.pdf.

EU (2008), *The International Partnership for Energy Efficiency Cooperation (IPEEC)*, EU News 131/2008 - 2008/06/08 MEMO/08/380, Brussels, 8 June 2008.

Europa (2007), *Commission takes legal action against Member States for failing to submit their Energy Efficiency Action Plan*, press release,
http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/1526&format=HTML&aged=1&language=EN&guiLanguage=en, 17 October 2007.

Europa (2008), *Energy Performance of Buildings: Commission launches Court proceedings against Belgium and the UK*, press release,
http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/351, 28 February 2008.

Falcioni, P. (2008), *Problems and Consequences of Non-Compliance*, for European Committee of Domestic Equipment Manufacturers (CECED), presented to International Energy Agency Workshop: Meeting Energy Efficiency Goals: Enhancing compliance, monitoring and evaluation, Paris, 28-29 February 2008.

© OECD/IEA, 2009

Fraunhofer (2007), *EuP Preparatory Study Lot 6: Standby and Off-mode Losses, Task 5 Definition of Base Case, Final Report*, compiled by Fraunhofer IZM Berlin, 2 October 2007.

Harrington (2001), *Energy Labelling and Standards throughout the World*, Report prepared by Lloyd Harrington, Energy Efficient Strategies, Australia and Melissa Damnics, EnergyConsult, Australia, Report commissioned and published by The National Appliance and Equipment Energy Efficiency Committee, Australia, December 2001.

IES (2007), *Electricity Consumption and Efficiency Trends in the Enlarged European Union - Status report 2006*, Paolo Bertoldi & Bogdan Atanasiu, Institute for Environment and Sustainability, EUR 22753 EN.

Meller, P. (2007), *Europeans mandate public-sector Energy Star purchases, energy efficiency specs for the public procurement will apply to all member states and European institutions*, IDG New Service 10 July 2007.

RIC (2007), *Towards an Energy Efficient European Building Stock: A RICS Status Report on the Implementation of Directive 2002/91 on the Energy Performance Buildings (EPBD) in the EU member states*, Royal Institution of Chartered Surveyors (RICS), December 2007.

Japan

ANRE (2006), *Report of the Survey of Standby Power, FY 2005*, Agency for Natural Resources and Energy, Japan, March 2006.

ECCJ (2001), *Japan Energy Conservation Handbook 2001*, *available from http://www.eccj.or.jp/databook/index.html*.

ECCJ (2003), *Japan Energy Conservation Handbook 2002/2003*, *available from http://www.eccj.or.jp/databook/index.html*.

ECCJ (2004), *Japan Energy Conservation Handbook 2003/2004*, *available from http://www.eccj.or.jp/databook/index.html*.

ECCJ (2006), *Japan Energy Conservation Handbook 2005/2006*, *available from http://www.eccj.or.jp/databook/index.html*.

ECCJ (2007a), *Handbook of Energy Economics & Economic Statistics in Japan*, February 2007

ECCJ (2007b), *Japan Energy Conservation Handbook 2007*, October 2007, *available from http://www.eccj.or.jp/databook/index.html*.

EECJ (2008), *information from website* http://www.eccj.or.jp/eng/e1100profile.html.

EESS (2007), *Final Report DVD Recorders,* Evaluation Standard Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy, May 2007.

EESS (2008), *Final Report (SDmall Routers, L2 Switches) by Router, etc.,* Evaluation Standard Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy, 2008.

© OECD/IEA, 2009

Hashimoto, Katsumi (2006), *Technology and Market Development of CO_2 Heat Pump Water Heaters (ECO CUTE) in Japan*, IEA Heat Pump Centre Newsletter Volume 24 – No. 3/2006.

JEMA (2007), *Report on Estimates of Energy-Saving Effects: Household Refrigerators*, 12 June 2007.

Maruyama, Takehiro (2006), *Eco-Cute CO_2 Heat Pump Water Heater-in Japan*, Lawrence Berkeley National Laboratory.

METI (2008), *Top Runner Program: Developing the World's Best Energy-Efficient Appliances*, Revised Edition, January 2008.

OECD/IEA (2008), *Japan 2008 Review*, Energy Policies of IEA Countries, Paris.

Ohkuni, Kotaro (2006a), *Top Runner Program and Efforts to Reduce Standby Power Consumption in Japan*, presentation to the International Conference on Standby Power, Canberra, 6 November 2006.

Ohkuni, Kotaro (2006b), *pers. com.*, 15 December 2006.

Ohkuni, Kotaro (2008), *Standby Power in Japan,* presentation to the International Conference on Standby Power, New Delhi, India, 2 April 2008.

Saito, Kiyoshi et al. (2008), *Lesson Learnt in Japan with Checking performance: Case Study for Development the New Test Procedures Concerning Actual Energy Consumption of Household Refrigerator,* The Japan Electrical Manufacturers' Association (JEMA), presentation to IEA workshop, 28 February 2008.

Yamada, Tetsuya (2008), *pers. com.*, February 2008.

South Korea

ABC (2007), *Building Energy Efficiency: Why Green Buildings Are Key to Asia's Future, Asia Business Council*, http://www.asiabusinesscouncil.org/docs/BEE/BEEBookPartI.pdf, accessed January 2008.

Kim, Yung-rae (2008), *pers. com.*, 21 August 2008.

KEMCO (2006a), *KEMCO Annual Report*, 2006.

KEMCO (2006b), *Korea 1W Policy, Presentation by Kim Yungrae*, KEMCO, November 2006.

Lee, Ki-hyun (2007), *Korea's Promotion Policies for Energy-Efficient Products*, International Workshop on Promotion of Energy Efficient Procurement in Government Purchases, 13-14 July 2007, http://www.asiapacificpartnership.org/BATF/BATF%20Projects%20Workshops/Energy%20Efficiency/Promotion%20Policies%20for%20EE%20Products-Lee.pdf, accessed January 2008.

MKE (2006), *MKE Notification: Regulation on Energy Efficiency Standards and Labeling*, March, 2006.

© OECD/IEA, 2009

MKE & KEMCO, (2005), *Korea Standby 2010: Korea's 1 Watt Plan*.

MKE & KEMCO (2007), *Korea's Energy Standards and Labeling: Market Transformation*, 2007.

Won-Sik, Choi (2007), *Current Status and Progress of Construction CALS in Korea*, presentation, August 2007.

United States

ACEEE (2007), *Appliance Efficiency Standards in the 2007 Energy Bill, Key Facts*, December 2007, http://www.aceee.org/energy/national/Standards_summary_2007energybill.pdf, accessed January 2008.

ASE (2005a), *FY 2005 Proposed Budget for Energy Efficiency Programs: Overall funding cut slightly for third year in a row*, Fact Sheet.

ASE (2005b), *California Statewide EE Policies - Public Benefits Fund*, http://www.ase.org/content/article/detail/2546, accessed January 2008.

ASE (2007a), *Idaho Statewide EE Policies*, http://www.ase.org/content/article/detail/2554.

ASE (2007b), Federal Budget, http://www.ase.org/section/_audience/policymakers/fedbudget/ – Budget Alert for FY '07, accessed December 2007.

ASE (2008), State Standards Appliance Standards Awareness Project (ASAP), http://www.standardsasap.org/state.htm, accessed July 2008.

CEC (2007), *2007 Appliance Efficiency Regulations*, California Energy Commission October 2007.

CEE (2007), *Consortium For Energy Efficiency: Residential Sector*, http://www.cee1.org/resid/rs-ce/rs-ce-main.php3, accessed December 2007.

CGUS (2006), *US and Indian Cooperate of Energy Efficiency Technology*, Consulate General of the US, press release, 2 May 2006.

Cockburn, J.(2007), *North American Energy Working Group*, presentation to standby power consumption workshop, Mexico, September 2007.

CRS (2006), *Energy Efficiency Policy: Budget, Electricity Conservation, and Fuel Conservation Issues*, CRS Report for Congress, 8 August 2006

DESIRE (2007a), *Financial Incentives for Energy Efficiency* http://www.dsireusa.org/summarytables/FinEE.cfm?&CurrentPageID=7&EE=1&RE=0, accessed, December 2007.

DESIRE (2007b), *Appliance Efficiency Regulations*, 19 October 2007, http://www.dsireusa.org/library/includes/incentivesearch.cfm?Incentive_Code=CA48R&Search=TableType&type=Appliance&CurrentPageID=7&EE=1&RE=0, accessed Jan 2008.

© OECD/IEA, 2009

DNREC (2008), *Delaware Energy An$wers Program*, Delaware Department of Natural Resources and Environmental Control, http://www.delaware-energy.com/energy_an$wers_program-for-home-Appliances.htm

DOE (2006a), *Energy Conservation Standards Activities*, Department of Energy report to Congress, January 2006.

DOE (2006b), *DOE kicks off National "Change a Light, Change the World" Campaign*, press release: 4 October 2006.

DOE (2006c), *DOE Assistant Secretaries in China to Discuss Energy Cooperation*, press release, 14 September 2006.

DOE (2007a), *Department of Energy Finalizes Regulations to Increase Energy Efficiency in New Federal Buildings by 30%,* news release, 21 December 2007, http://www.energy.gov/news/5790.htm, accessed January 2008.

DOE (2007b), *What Are Building Energy Codes Projects in the States?* State Energy Program, http://www.eere.energy.gov/state_energy_program/topic_definition_detail.cfm/topic=104, accessed December 2007.

DOE (2007c), *Implementation Report: Energy Conservation Standards Activities*, Department of Energy report to Congress, August 2007.

DOE (2007d), *Fact Sheet: Federal Energy Management Program*, March 2007.

Egan (2008), *S&L Compliance Frameworks Around the World: What Lessons Can be Learned?*, presentation to IEA workshop: Meeting Energy Efficiency Goals, Paris, February 2008.

EIA (2008), *Annual Energy Outlook*, Report DOE/EIA-0383 (2008), 2008.

EPA (2006), *Annual Report: ENERGY STAR and Other Climate Protection Partnerships*, September 2007.

EPA (2007a), *US and China Seek Uniformity in Energy Efficiency*, press release 20 March 2007, http://yosemite.epa.gov/opa/admpress.nsf/e87e8bc7fd0c11f1852572a000650c05/1164a5b8530e34b0852572a4004d0c24!OpenDocument, accessed December 2007.

EPA (2007b), *Utility Energy Efficiency Vision Can Save Billions of Dollars While Fighting Climate Change*, news release, 13 November 2007.

EPA (2007c), *National Action Plan for Energy Efficiency*, accessed at http://www.epa.gov/cleanenergy/energy-programs/napee/index.html.

EPA (2007d), *ENERGY STAR Overview of 2006 Achievements*, 2007.

EPA (2008a), *National Awareness of Energy Star for 2007: Analysis of CEE Household Survey*, 2008.

EPA (2008b), *Energy Star overview of 2007 Achievements*, 2008.

EPA (2008c), *New Product Specifications in Development*, http://www.energystar.gov/index.cfm?c=new_specs.new_prod_specs, accessed March 2008.

© OECD/IEA, 2009

EPA (2008d), *Fact Sheet: Building Codes for Energy Efficiency*, http://www.epa.gov/cleanenergy/pdf/buildingcodesfactsheet.pdf, accessed February 2008.

FTC (2007a), *US Federal Trade Commission Concluding Two-Year Rulemaking: FTC Announces New EnerGuide Label*, press release, 7 August 2007.

FTC (2007b), *US Federal Trade Commission Federal Register, 16 CFR Part 305, Rules Concerning Disclosures Regarding Energy Consumption and Water Use of Certain Home Appliances and Other Products Required Under the Energy Policy and Conservation Act ("Appliance Labeling Rule")*, Final Rule, 29 August 2007.

LBNL (2005), *The Standard Setting Process*, http://ees.ead.lbl.gov/node/2, accessed December 2007.

LOMPOC (2007), *Let the City help you save time and $$$*, City of Lompoc, California, http://www.cityoflompoc.com/splash/utilprograms.htm.

MEA (2005), *Maryland Energy Efficiency Standards Act, Questions and Answers*, 10 February 2005, Maryland Energy Administration, http://www.energy.state.md.us/policy/standards/050210-qa.pdf, accessed July 2008.

Meyers, S., J. McMahon and M. McNeil (2005), *Realized and Prospective Impacts of U.S. Energy Efficiency Standards for Residential Appliances: 2004 Update,* May 2005.

Mufson, S. 2007, *In Energy Conservation, Calif. Sees Light*, Progressive Policy Makes It a Model in Global Warming Fight, Washington Post, 17 February 2007.

Nadel, S. (2005), *The Federal Energy Policy Act of 2005 and it's implications for Energy Efficiency Program Efforts*, American Council for an Energy-Efficient Economy (ACEEE), September 2005.

Nadel, S., Andrew deLaski, Maggie Eldridge, and Jim Kliesch (2006), *Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards*, ACEEE, March 2006.

NYS (2007), *Energy Conservation Improvements to Certain Residential Premises:Exemption Administration Manual* – Part 1, Residential – Other Than Multiple Dwellings, Section 4.01 – RPTL Section 487-a, Office of Real Property Services, New York State, http://www.orps.state.ny.us/assessor/manuals/vol4/part1/section4.01/sec487-a.htm, accessed December 2007.

ODE (2007), *Residential Energy Tax Credits*, Oregon Department of Energy – Conservation Division, http://egov.oregon.gov/ENERGY/CONS/RES/RETC.shtml, accessed January 2008.

SOC (2007), *2007 Legislation Affecting the Sales Tax on Home Weatherization Products*, State of Connecticut Department of Revenue Services, http://www.ct.gov/drs/cwp/view.asp?a=1514&q=384952, accessed April 2008.

TIAP (2006), *Builders & Manufacturers Incentives*, The Tax Incentives Assistance Project, http://www.energytaxincentives.org/builders/new_homes.php, accessed December 2007.

© OECD/IEA, 2009

TIAP (2007), *Consumer Tax Incentives, Home Heating & Cooling Equipment*, http://www.energytaxincentives.org/consumers/heating-cooling.php, accessed December 2007.

UCS, (2005), *President Bush's Fiscal Year 2005 Budget: New Priorities Needed*, Union of Concerned Scientists, 10 August 2005, http://www.ucsusa.org/news/positions/president-bushs-fy-2005-budget.html?print=t, accessed July 2008.

Witkowski (2008), *Rulemaking and Compliance Overview*, U.S. Department of Energy Energy Conservation Program for Consumer Products and Commercial and Industrial Equipment, presentation to IEA workshop: Meeting Energy Efficiency Goals, Paris, February 2008.

Brazil

CariPress (2008), *First Mandatory Standby Power Label for TVs in LAC, 11 August 2008*, available from http://caripress.com/2008/08/first-mandatory-standby-power-label-for-tvs-in-lac.html, accessed September 2008.

CLASP (2000), *Overview of Existing Legislation in the Region*, CLASP Workshop, Argentina, March 2000.

De Almeida, Edmar L. Fagundes (2005), *Rationing Electricity and Other Strategies: How Brazil Cut Demand in 20%*.

Electrobras (2007), *Pesquisa de Posee de Equipamentos e Habitos, ano base 2005, classe residencial relatoria Brazil*, July 2007.

Guerreio, A. (2006), *Special Topics of Brazilian Energy Sector*, presentation to IEA Workshop, May 2006.

Hollauer, G. (2008), *National energy Outlook 2030 in Brazil and Trends*, Mines and Energy Ministry.

IAEA (2003), *Brazil: A Country Profile On Sustainable Energy Development*, International Atomic Energy Agency with the Graduate School of Engineering (COPPE), Federal University of Rio de Janeiro(UFRJ), Brazilian Reference Centre on Biomass (CENBIO) and United Nations Department of Economic and Social Affairs(UNDESA).

Leonelli, P. (2007), *Energy Efficiency in Brazil*, Brazilian Ministry of Mines and Energy, presentation to IEA NEET Workshop, 20 November 2007.

Menandro, M. & Hamilton Pollis (2007), *PROCEL National Electricity Conservation Program*, presentation, Rio de Janeiro, Brazil, 22 November 2007.

Novgorodcev, Alexandre (2008), *Standby Labeling and Procel Seal on TVs: The Brazilian Experience*, presentation to the International Standby Power Conference, New Delhi, April 2008.

Pinto Junior, Ary Vaz (2007), *Demand-Side Management in Brazil*, CEPEL, NEET Workshop, Brasília, 20 November 2007.

© OECD/IEA, 2009

Poppe, Marcelo Khaled (2007), *Renewable Energy And Energy Efficiency in Brazil*, Secretary for Energy Development, Ministry of Mines and Energy.

Souza, L. R. and L. J. Soares (2007), *Electricity rationing and public response*, published in Energy Economics 29 (2007) 296–311.

World Bank (2008), *Financing Energy Efficiency, Lessons from Brazil, China, India, and Beyond,* World Bank 2008.

Zimmerman, M. P (2006), *Eficiência Energética: um desafio estratégico para o MME*, Plano Nacional de Energia 2030, 13 July 2006.

China

CCCIN (2007), *China begins compulsory procurement of energy-saving items*, China Climate Change Info-Net, 13 December 2007,
http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=10269, accessed April 2008.

CECP (2008), *Extract from CECP English Website*,
http://www.cecp.org.cn/englishhtml/introduction.asp, accessed April 2008.

CG (2006), *Nation sets emission reduction goal*, 29 March 2006,
http://english.gov.cn/2006-03/29/content_238984.htm, accessed June 2008.

CLASP (2007a), *Impacts of China's Current Appliance Standards and Labelling Program to 2020*, Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, March 2007

CLASP (2007b), *Creating and Implementing a Regularized Monitoring and Enforcement System for China's Mandatory Standards and Energy Information Label for Appliances*, March 2007

CNIS (2003), *Project of Energy conservation Potential Analysis of Primary Energy-Using Goods in China*, China National Institute of Standardisation, Beijing, 2003.

CSEP (2008), *China Sustainable Energy Program*,
http://www.efchina.org/FNewsroom.do?act=detail&newsTypeId=1&id=107, accessed in March 2008.

EL (2007), *China To Phase Out Incandescent Light Bulbs*, Environmental Leader, 3 October 2007,
http://www.environmentalleader.com/2007/10/03/china-to-phase-out-incandescent-light-bulbs, accessed May 2008.

HKTDC (2008), *Green Building Rating Standards to Take Effect on 1 June*, Hong Kong Trade Development Council,
http://gbcode.hktdc.com/gb/www.hktdc.com/alert/cba-e0605news3.htm, accessed June 2008.

IEA (2006), *Market Transformation Programme – Partnership with the UK*, IEA Energy Efficiency Policies and Measures database,
http://www.iea.org/Textbase/pm/?mode=pm&id=2526&action=detail, accessed April 2008.

© OECD/IEA, 2009

IEA (2008), *National Climate Change Program*, IEA Energy Efficiency Policies and Measures database,
http://www.iea.org/textbase/pm/?mode=pm&id=3834&action=detail, accessed March 2008.

Jin, M & Li, A. (2006), *The Implications and Impacts of China's Energy Label*, China National Institute of Standardisation (CNIS), 2006.

Langer, K. & Watson, Robert (2008), *The Greening of China's Building Industry*, China Business Review, http://www.chinabusinessreview.com/public/0411/langer.html accessed June 2008.

Li, Aizhen (2008), *pers com*., 29 March 2008.

Li, Tienan (2006), *Energy Efficiency (S&L) in China*, CSC Presentation, Brazil, November 28, 2006.

McElwee, Charles R. (2008), *China's Energy Conservation Law* (Introduction), 24 March 2008, http://www.chinaenvironmentallaw.com/?p=105, accessed April 2008.

MoF (2004), *Implementation of Government Energy Efficiency Procurement*, Treasury Document [2004] no. 185, Ministry of Finance & National Development and Reform Commission, People's Republic of China. 17 December 2004.

NLTC (2008), *Experiences and Challenges in China*, presentation Shuming Hua and Jiayang Li, National Lighting Test Center (NLTC), to the IEA Workshop: Meeting Energy Efficiency Goals, China Energy Group and the Lawrence Berkeley National Laboratory, Paris, February 2008.

NSM (2007), *Issue 2614 of New Scientist Magazine*, 25 July 2007, pp8-10, by Jim Giles.

Pan et al. (2006), *Rural Electrification in China 1950-2004, Working Paper #60,* Pan Jiahua, Peng Wuyuan, Li Meng, Wu Xiangyang, Wan Lishuang, Hisham Zerriffi, Becca Elias, Chi Zhang and David Victor. Center for Environmental Science and Policy, Stanford University CA. December 2006.

PDO (2004), *China outlines ten programs for energy efficiency*, People's Daily Online, 9 December 2004,
http://english.people.com.cn/200412/09/eng20041209_166706.html, accessed March 2008.

REN21 (2008), *Renewable Energy Policy Network for the 21st Century*,
http://gsr.ren21.net/index.php?title=5._Rural_(Off-Grid)_Renewable_Energy, accessed in June 2008.

Reuters (2008), *China lights way for huge efficient bulb subsidy,* 22 April 2008,
http://www.reuters.com/article/latestCrisis/idUSPEK299439, accessed June 2008.

UNDP (2005), *China Green Lights*,
http://www.undp.org/gef/05/portfolio/writeups/cc/greenlights.html, accessed May 2008.

© OECD/IEA, 2009

XNA (2008), *More gov't investment on energy efficiency*, Xinhua News Agency 25 March 2008, http://www.china.org.cn/environment/policies_announcements/2008-03/25/content_13486138.htm, accessed May 2008.

Zhou, N. (2008), *Experiences and Challenges in China*, presentation to the IEA Workshop: Meeting Energy Efficiency Goals, China Energy Group and the Lawrence Berkeley National Laboratory, Paris, February 2008.

India

BEE (2008a), *Bureau of Energy Efficiency Website*, http://www.bee-india.nic.in/

BEE (2008b), *Information on Indian Energy Efficiency Standards and Labelling Programme*, http://www.energymanagertraining.com/Standards_Labeling/main.htm

BEE (2008c), *International Standby Power Conference*, New Delhi, April 2008. http://www.energymanagertraining.com/StandbyPower/main.htm

Dey, D. (2007), *Energy Efficiency Initiatives: Indian Experience,* ECEEE 2007, Summer Study.

Dube, S. (2008), *Presentation at the International Standby Power Conference*, ICF International New Delhi, India, April 2008.

GTZ (2008), *Indo-German Energy Programme*, http://www.gtz.de/en/weltweit/asien-pazifik/indien/9521.htm, accessed March 2008.

Government of India (2006), *Integrated Energy Policy: Report of the Expert Committee,* Planning Commission, New Delhi, August 2006.

IEA (2007), *Energy Efficiency in China and India*, note by the Secretariat to the Standing Group on Global Dialogue. Paris, October 2007.

Kumar (2008), *pers.com*., 26 August 2008.

Modi, V. (2005), *Improving Electricity Services in Rural India*, CGSD Working Paper No. 30. December 2005.

MoP (2008a), *Power: The building block of the economy*, Ministry of Power Annual Report, 2007/08.

MoP (2008b), *Ministry of Power website*, http://www.powermin.nic.in/

NSSO (2001), *Consumption of some important commodities in India,* report No. 461, NSSO 55th Round 1999/2000, National Sample Survey Organization, Department of Statistics, Government of India, New Delhi, March 2001.

OECD/IEA (2007), *World Energy Outlook 2007*, International Energy Agency, Paris.

© OECD/IEA, 2009

Pandian, G. (2008), *Presentation at the International Standby Power Conference*, New Delhi, April 2008.

Singh, Devender (2008), *Sustainable Rural Energization in India*, presentation to IEA Workshop, Paris, 28 May 2008.

Tathagat, T. (2007), *India Labeling Program Impacts: Case Study*, published by the Collaborative Labeling and Appliance Standards Programme, March 2007.

World Bank (2008), *Financing Energy Efficiency, lessons from Brazil, China, India and beyond*.

Mexico

CONAE (2007), *Taller de Consuma de Energia en Espera,* Presentaciones del 25 de septiembre de 2007, http://www.conae.gob.mx/wb/CONAE/CONA_taller_energia_espera, accessed November 2008.

CONAE (2008a), *pers com*, Maria Elena Sierra, CONAE, 25/2/2008and 10/7/2008.

CONAE (2008b), *Proyectos NOM, Proyectos de Normas Oficiales Mexicanas*, http://www.conae.gob.mx/wb/CONAE/CONA_739_proyectos_de_nom, accessed November 2008.

IEE (2006), *Assessment of the Impact of Standards and Labelling Programs in Mexico (Four Products)*, Report No. 12933ITF FN LBNL 001, January 2006.

INEGI (2008), *Bases de Datos de la Encuesta Nacional de Ingresos y Gastos de los Hogares para 2000, 2002, 2004, 2005 y 2006,* published by the Instituto Nacional de Estadística, Geografía e Informática (INEGI),
http://www.conae.gob.mx/wb/CONAE/CONA_739_proyectos_de_nom

NAEWG (2002), *North American Energy Efficiency Standards and Labelling*, available from http://oee.nrcan.gc.ca/NAenergyefficiency/tableofcontent.cfm.

NRCAN (2008), *The Process and Institutional Context for Energy Efficiency Standards and Labels in Each Country*, http://oee.nrcan.gc.ca/NAenergyefficiency/II.cfm, accessed January 2008.

SENER (2006), *Prospective del sector electric 2006-2015, Dirección General de Planeación Energética*, issued by the Secretaría de Energía.

SENER (2007), *Prospective del sector electric 2007-2016, Dirección General de Planeación Energética*, issued by the Secretaría de Energía.

SEPCO (2008), *Efficiency Standards for Appliances in Mexico*, http://www.ises.org/sepconew/Pages/Efficiency_Standards_MX/0.html, accessed November 2008.

World Bank (2004), *Energy Policies and the Mexican Economy*, ESMAP January 2004.

© OECD/IEA, 2009

South Africa

B.G Bredenkamp *et al.* (2006), *Balancing the need for, and hurdles associated with implementing 'Energy Efficient Appliance Labeling in the South African Context*, Eskom Holdings Ltd and the Department of Minerals and Energy, 2006.

DEAT (2005), *South Africa Country Report: 14th Session of the UN Commission on Sustainable Development*, Department of Environmental Affairs and Tourism, September 2005.

DME (2003), *Capacity Building in Energy Efficiency and Renewable Energy – Energy Efficiency Appliance Labeling Study*, February 2003.

DME (2005), *Energy Efficiency Strategy of the Republic of South Africa*, March 2005.

DME (2008a), *Appliance Labelling*, available at http://www.dme.gov.za/energy/app_std.stm, accessed February 2008.

DME (2008b), *Energy Efficiency*, available at http://www.dme.gov.za/energy/efficiency.stm – sited February 2008, accessed February 2008.

DME (2008c), *Projects (CaBEERE)*, available at http://www.dme.gov.za/energy/efficiency_projects.stm, accessed February 2008.

DME (2008d), *National Response to South Africa's Electricity Shortage*, Interventions to address electricity shortages, January 2008.

DPE (2006), *Capex Update*, presentation to the Portfolio Committee on Public Enterprises, Dept. Public Enterprises, 16 August 2006.

ESKOM (2005), http://www.wbcsd.org/DocRoot/NfXF9G0AejK4bqLFMf2u/poulton.pdf, accessed February 2008.

ELI (2008a), *Overview of activities: Street lighting*, available at http://www.efficientlighting.net/FormerELI/south_africa/overview_street.htm.

ELI (2008b), *South Africa*, available at http://www.efficientlighting.net/FormerELI/south_africa/south_africa.htm – sited February 2008.

GGN, (2007), National Parks to become more energy efficient, report 19 September 2007, available at: http://www.sagoodnews.co.za/environment/national_parks_to_become_more_energy_efficient.html, accessed February 2008.

Golding, T. (2008), *pers. com.* February 2008.

NAEC (2007), *Integrated National Electrification Programme (INEP) Plan to Achieve Universal Access to Electricity by 2012*, Masterplan/Business Plan, NAEC Meeting No. 2, 16 August 2007.

NERSA (2008), *NERSA Determination on ESKOM's Application for Price Increase*, Media Statement, 18 June 2008.

© OECD/IEA, 2009

Conclusions

IEA (2007), *Experience with Energy Efficiency Regulations for Electrical Equipment*, Information Paper, International Energy Agency, 2007.

IEA (2008), *Meeting Energy Efficiency Goals: Enhancing compliance, monitoring and evaluation*, Workshop report, 28-29 February 2008, International Energy Agency, Paris.

Chapter 4: The case of electronic appliances

EC (2008), *Addressing the challenge of energy efficiency through Information and Communication Technologies:* Communication from the Commission to the European Parliament, The Council, The European Parliament and the Committee of the Regions.

McKinsey (2007a), *A cost curve for greenhouse gas reduction*, The McKinsey Quarterly, February 2007.

McKinsey (2007b), *Curbing Global Energy Demand Growth: The Energy Productivity Opportunity*, May 2007.

Laitner, John A., and Karen Ehrhardt-Martinez (2008), *Information and Communications Technologies: The Power of Productivity: How ICT Sectors are Transforming the Economy While Driving Gains in Energy Productivity*, American Council for an Energy Efficient Economy, Washington, February 2008.

Sumita, T. (2008), *Green IT Initiative as a policy to provide a solution*, presentation to the workshop on ICTs and Environmental Challenges, OECD and the National IT and Telecom Agency (NITA), and Danish Ministry of Science, Technology and Innovation, Copenhagen, 22-23 May 2008.

OECD (2008), *Workshop Summary: ICTs and Environmental Challenges*, OECD and the National IT and Telecom Agency (NITA), and Danish Ministry of Science, Technology and Innovation, Copenhagen, 22-23 May 2008.

OECD/IEA (2003), *Cool Appliances: Policy Strategies for Energy-Efficient Homes*, Paris, 2003.

OECD/IEA (2005), *Act Locally, Trade Globally: Emissions Trading for Climate Policy*, Paris 2005.

OECD/IEA (2006), *Lights Labours' Lost: Policies for Energy-efficient Lighting,* Paris, 2007.

OECD/IEA (2007a), *Mind the Gap, Quantifying Principal-Agent Problems in Energy Efficiency*, Paris, 2007.

OECD/IEA (2007b), *World Energy Outlook 2007: China and India Insights*, Paris, 2007.

© OECD/IEA, 2009

OECD/IEA (2008), *Energy efficiency policy recommendations prepared by the IEA for the G8 under the Gleneagles Plan of Action*, Paris, 2008.

WWW 2008, *The Potential Global CO_2 Reductions from ICT Use: Identifying and assessing the opportunities to reduce the billion tonnes of CO_2*, World Wildlife Fund Sweden, May 2008.

Chapter 5: What's on TV?

Anandan, M. (2006), *LED Backlight: Enhancement of picture quality on LCD screen*, proceedings of ASID, New Delhi.

Ausmedia (2008), 2008 – *Laser TV Review and Future TV Technologies*, www.ausmedia.com.au/laser-tv-review.htm, accessed 13 May 2008.

DCE (2007), *Television Energy Rating Labels:The case, and proposal, for MEPS and Labelling Televisions*, Report 2007/10, Digital CEnergy, Australia.

Digital Trends (2007), *Price Drops Fueling LCD TV Sales,* 14 March 2007, http://news.digitaltrends.com/news-article/12465/price-drops-fueling-lcd-tv-sales, 20 accessed June 2008.

Displaybank (2006), *Price Trends of Global LCD TV Market, July 2005-June 2006,* compiled by FPDsiplay.com, http://www.fpdisplay.com/News_Info/Shtml/20060719_11774.htm, accessed 20 June 2008.

CNET (2005), *Flat-panel TVs can't topple tubes – just yet,* 14 January 2005, http://news.cnet.com/Flat-panel-TVs-cant-topple-tubes--just-yet/2100-1041_3-5473486.html, accessed 20 June 2008.

CNET (2008), *104 HDTVs' power consumption compared*, http://reviews.cnet.com/4520-6475_7-6400401-3.html?tag=txt, accessed 20 June 2008.

Electronic House (2007), *The Big View – TV Trends in 2007,* 2 January 2007, http://www.electronichouse.com/article/the_big_view/ accessed, 20 June 2008.

EICTA (2007), *EICTA's view on the reduction of Stand-by power Consumption for Consumer Electronics*, Wilfried Oppermann. German-French Expert Workshop on Stand-by Losses, 31 May 2007.

ENERGY STAR (2006), *Preliminary Market and Industry Research*, prepared for US EPA in support of the ENERGY STAR TV specification Revision, January 2006.

EST (2007), *The Ampere Strikes Back, How Consumer Electronics are taking over the World*. Energy Saving Trust.

Eurodata (2008), *Audience measurement developments and challenges as Digital TV is taking-off,* presentation by Jacques Braun, Eurodata TV, April 2008.

Fraunhofer (2007a), *EuP Preparatory Studies 'Televisions' (Lot 5), final Report on Task 4 "Technical Analysis",* compiled by Fraunhofer IZM and PE Europe, August 2007.

© OECD/IEA, 2009

Fraunhofer (2007b), *EuP Preparatory Studies 'Televisions' (Lot 5), final Report on Task 7 "Improvement Potential"*, compiled by Fraunhofer IZM and PE Europe, August 2007.

Fraunhofer (2007c), EuP *Preparatory Studies 'Televisions' (Lot 5), final Report on Task 1 "Definition",* compiled by Fraunhofer IZM, August 2007.

GfK (2006), *CE and IT – markets continuously driven by new technologies and by the development of a changing consumer approach*, presentation to EEDAL Conference, London by Jurgen Boyny, June 2006.

Greef, Pierre de and Hendriek Groot Hulze (2007), *Adaptive dimming and adaptive boosting backlight technologies for LCD-TV systems*, published in Energy Efficiency Times – India, November 2007.

ID (2007), *Revenue for Large-Sized LCD Panels to exceed $100 billion for first time in 2001*, available from
http://www.informationdisplay.org/newsarticle.cfm?newsArt=news81, accessed 25 March 2008.

iSuppli (2008), *Is there room for OLED in the TV market?*
http://www.engineerlive.com/in-our-opinion/19789/is-there-room-for-oled-in-tv-market.thtml, accessed 20 June 2008.

OECD (2007), *OECD Communications Outlook 2007,* Information and Communications Technologies, Paris, 2007.

OECD/IEA (2003), *Cool Appliances: Policy Strategies for Energy-Efficient Homes*, Paris, 2003.

OECD/IEA (2008), *Energy Efficiency Policy Recommendations*, In support of the G8 Plan of Action, Paris, 2008.

Pilotta, Joseph and Don Schultz (2005), *Simultaneous Media Experience and Synesthesia,* published in the Journal of Advertising Research, Vol 45, No. 1, March, 2005.

Rajar (2008), *Listening via platform – All Radio*. http://www.rajar.co.uk/index.php, accessed 20 June 2008.

Smith, Tony and James Sherwood (2007), *Telly vision: future display technologies,* 11 October 2007, http://www.reghardware.co.uk/2007/10/11/feature_future_display_tech/, accessed 26 March 2008.

Tech-on (2008a), *Sony: OLED Superior to LCD*, 22 May 2008,
http://techon.nikkeibp.co.jp/english/NEWS_EN/20080522/152138/, accessed 20 June 2008.

Tech-on (2008b), *Sony to Invest 22 Bn Yen in 20-inch Class OLED Panels*, 20 February 2008, http://techon.nikkeibp.co.jp/english/NEWS_EN/20080220/147729/, accessed 20 June 2008.

TV Basics (2008), *Media Trends Track*, Television Bureau of Advertising,
http://www.tvb.org/rcentral/mediatrendstrack/tvbasics/, accessed 9 March 2008.

TVtechnology (2004), *Lamps for Microdisplay Projection*,
www.tvtechnology.com/features/Tech-Coner/f_technology_corner-07.07.04.shtml, accessed 13 May 2008.

© OECD/IEA, 2009

Chapter 6: Computers and monitors

80 Plus (2008), *80 PLUS Reaches Major Milestone, Welcomes HP to Energy Efficiency Program*, News Release, 27 November 2006, available at http://80plus.org/documents/Pressrelease061127FINAL.pdf, accessed July 2008.

AP (2007), *Bye, bye, PC? PCs being pushed aside in Japan by array of gadgets with similar power, speed*, Associated Press, 5 November 2007, available at http://www.theglobeandmail.com/servlet/story/RTGAM.20071105.wjapanpcs1105/BNStory/PersonalTech/home, accessed August 2008.

Collins, R. (2007), *Analysis of the Potential for Minimum Energy Performance Standards for Computers and Monitors*, draft report prepared for Equipment Energy Efficiency Programme, Australia, September 2007.

Cremer et al. (2003), *Energy Consumption of Information and Communication Technology (ICT) in Germany up to 2010,* summary of the final report to the German Federal Ministry of Economics and Labour, January 2003.

Dealnews (2007), Price trends on 24" LCD monitors, 10 October 2007, available at http://dealnews.com/features/Price-trends-on-24-LCD-monitors/191172.html, accessed August 2008.

Displaysearch (2002), *DisplaySearch's Annual LCD Monitor Strategy Report Projects LCD Monitors to Overtake CRT Monitors in 2004*, 23 October 2002, available at http://findarticles.com/p/articles/mi_m0EIN/is_2002_Oct_23/ai_93202601, accessed August 2008.

Ecos (2008), *How Low Can You Go? A White Paper on Cutting Edge Efficiency in Commercial Desktop Computers*, prepared for Brad Meister, California Energy Commission Public Interest Energy Research Program (PIER), 20 March 2008.

EES (2006), *2005 Intrusive Residential Standby Survey Report*, prepared by Energy Efficient Strategies for E3, Australia, March 2006.

EE Times (2006), *10-inch+ LCD Q3 revenues up 9%, reports DisplaySearch,* 7 November 2006, available at http://www.eetasia.com/ART_8800440760_480200_NT_bb49d689.HTM, accessed August 2008.

EU (2008), *Regulation (EC) No 106/2008 of the European Parliament and of the Council of 15 January 2008 on a Community energy-efficiency labelling programme for office equipment (recast version)*, published in the Official Journal of the European Union, 13 February 2008.

EECJ (2007), *EDMC Handbook of Energy & Economic Statistics in Japan*, Energy Conservation Centre Japan, February 2007.

EGov (2005), *New Technologies Drive Growth in Teleworking*, National Statistics, 6 October 2005.

© OECD/IEA, 2009

Energy Star (2008), *Draft 1 Version 5.0 Displays Documents, Dataset Used to Determine Draft 1 Version 5.0 Displays Specification Levels*, available at http://www.energystar.gov/index.cfm?c=revisions.monitor_spec, accessed August 2008.

Gartner (2005), *Thriving Secondary PC Market Puts Old PCs to Good Use*, 23 August 2005.

Gidabyte (2006), *Russian IT Mosaic, Real Desktop PC Market Size in Russia is 6.1 million PC by the end of 2006*, available at http://www.gidabyte.com/it/122/, accessed August 2008.

Grochowski, E. and M. Annavaram (2006), *Energy per Instruction Trends in Intel Microprocessors*, Technology@Intel Magazine, March 2006.

Guardian (2006), *Surfers Glued to the Web for 11 Hours A Week*, 29 November 2006.

Harris, J., et al. (2005) *Public Sector Leadership: Transforming the Market for Efficient Products and Services*, presented at ECEEE Summer Study, 2005.

Hachman, M. (2007), *CRT Monitors Dying Off As LG, Samsung Mull Exit*, 10 September 2007, available at http://www.extremetech.com/article2/0,2845,2181410,00.asp , accessed July 2008.

IDC (2008), *Worldwide PC Monitor 2008 - 2012 Forecast and Analysis: Asia/Pacific's Rise to Prominence*, June 2008, available at http://www.mindbranch.com/Worldwide-PC-Monitor-R104-34029/, accessed August 2008.

IHT (2008), *The rise of social networking for people who are all business*, International Herald Tribune, 18 June 2008.

Intel (2002), *PC Energy-efficiency Trends and Technologies, A closer look at energy consumption and emerging power-management technologies,* 2002.

ITAFE (2005), *IT Access for Everyone —Global Benchmarking Study*, January 2005.

IVL (2007), *Lot 3: Personal Computers (desktops and laptops) and Computer Monitors, Final Report (Task 1-8)*, for European Commission DG TREN, Preparatory studies for Eco-design Requirements of EuPs (Contract TREN/D1/40-2005/LOT3/S07.56313), prepared by IVF Industrial Research and Development Corporation, 27 August 2007.

IWS (2008), *The Internet Big Picture: World Internet Users and Population Stats*, available at http://www.Internetworldstats.com/stats.htm, accessed August 2008.

Kanellos, M. (2004), *A billion PC users on the way*, CNET News, 3 August 2004, available at http://www.zdnet.com.au/news/hardware/soa/A-billion-PC-users-on-the-way/0,130061702, 139155229,00.htm?omnRef=http://www.google.co.uk/search?hl=en, accessed August 2008.

Koomey, J. (2007), *Estimating Total Power Consumption by Servers in the US and the World*, Final Report, 15 February 2007.

METI (2008), *Developing the World's Best Energy-Efficient Appliances (Japan's "Top Runner" Standard), Revised Edition*, January 2008.

Metrics (2006), *Worldwide PC shipments to reach 334 million in 2010, with a value of US$271.1*

© OECD/IEA, 2009

billion, June 2006, available at
http://www.metrics2.com/blog/2006/06/16/worldwide_pc_shipments_to_reach_334_million_in_201.html, accessed August 2008.

MTP (2006), *Monitoring Home Computers*, Market Transformation Programme, September 2006.

Networkworld (2008), *IDC raises global PC shipment forecast*, IDG News Service, 12 June 2008, available at
http://www.networkworld.com/news/2008/061208-idc-raises-global-pc-shipment.html, accessed August 2008.

Nielsen (2008), *Nielsen Reports TV, Internet and Mobile Usage Amongst Americans*, News Release, 8 July 2008.

Nordman et al. (2007), *Improving the Energy Efficiency of Ethernet-connected Devices: A Proposal for Proxying*, Version 1.0, Ethernet Alliance, September 2007.

PC Retail (2008), *Western European PC market grows by 23 per cent*, 1 August 2008, available at http://www.pcretailmag.com/news/30271/Western-European-PC-market-grows-by-23-per-cent, accessed September 2008.

PPI (2007), *Facebook Added Its 30 Millionth Subscriber Yesterday*, Progressive Policy Institute, 11 July 2007, available at
http://www.ppionline.org/ppi_ci.cfm?knlgAreaID=108&subsecID=900003&contentID=254388, accessed August 2008

Reisinger D. (2008), *Why laptops will kick desktop PCs to the curb*, 10 August 2008, available at http://arstechnica.com/news.ars/post/20080810-opinion-why-laptops-will-kick-desktop-pcs-to-the-curb.html, accessed August 2008.

OECD (2007), *OECD Communications Outlook 2007,* Information and Communications Technologies, Paris, 2007.

OECD (2008), *Broadband Growth and Policies in OECD Countries*, Ministerial Background Report, Paris, 2008.

PEW Internet (2008), *Home Broadband Adoption 2008*, PEW Internet and American Life Project, Washington, July 2008.

Roth K., F. Goldstein and J. Kleinman (2002), *Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings, Volume I: Energy Consumption Baseline*, for Office of Building Equipment, Office of Building Technology State and Community Programs, DOE, January, 2002.

Roth K. and K. McKenney (2007), *Energy Consumption by Consumer Electronics in US Residences*, final report to the Consumer Electronics Association (CEA), January 2007.

Shibatani, Daisuke (2007), *Internet Penetration & Usage in Japan*, Internet Media Research Institute, Japan, July 2007.

© OECD/IEA, 2009

Souchon L., B. Aebischer, J. Roturier and F. Flipo (2007), *Infrastructure of the Information Society and Its Energy Demand*, presented to the ECEEE Summer Study, 2007.

Souchon L., S. Le Masson, F. Flipo and C. Gimenes (2008), *Quantitative Analysis and Modelling of ICT Energy Impact in France*, 2008.

TBA (2007), *TBA TV Basics: Personal Computers*, Media Track Trends.

TG Daily (2008), Large-screen monitor prices plummet as small monitors plateau, 26 March 2008, available at http://www.tgdaily.com/content/view/36629/118/, accessed August 2008.

TNO (2008), *LCD Pricing Update*, available from http://tech.norabble.com/2007/08/lcd-pricing-update.html, accessed August 2008.

USC (2004), *Census Bureau Releases Information on Home Workers*, News Release, 20 October 2004.

Wikipedia (2008), see http://en.wikipedia.org/wiki/Skype

ZDNET (2004), *Is Ballmer's $100 PC possible?,* 15 November 2004, available at http://www.zdnet.com.au/news/hardware/soa/Is-Ballmer-s-100-PC-possible-/0,130061702,139166674,00.htm, accessed July 2008.

ZDNET Asia (2007), *Asia Reports Strong PC Monitor Sales*, news report, 18 September 2007, available at www.zdnetasia.com/news/hardware/, accessed July 2008.

Chapter 7: Set-top boxes

ACNRE (2007), *Final Report, DVD Recorder Evaluation Standards Subcommitte*, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy, May 2007.

BOIS (2008a), *Preparatory Studies for Eco- design Requirements of EuPs, Lot 18 Complex Set-top Boxes, Task 2 Draft Report*, 7 May 2008.

BOIS (2008b), *Preparatory Studies for Eco- design Requirements of EuPs, Lot 18 Complex Set-top Boxes, Task 5 Report*, August 2008.

Bruniger, Roland (2008), *pers.com*., 3 September 2008.

Bruneger, Roland (2007), *The Swiss Agreement of Set-top-Boxes based on the European CoC*, provided to IEA workshop on Energy Efficient Set-Top Boxes & Digital Networks, Paris, 4-6 July 2007.

Chiao (2007), *Set-top Box Market in China & The Status of Energy Efficient STBS*, presentation by Morris Chiao , Skyworth Digital Tech to IEA workshop on Energy Efficient Set-Top Boxes & Digital Networks, Paris, 4-6 July 2007.

© OECD/IEA, 2009

Dube, Sanjay (2008), *Consumer Electronics Labeling Program to Address Standby Power in India*, presentation to the International Conference on Standby Power, New Delhi, India, 2 April 2008.

E3 (2007), *Consultation Regulatory Impact Statement: Minimum Energy Performance Standards and Alternative Strategies for Set-Top Boxes*, issued by the Equipment Energy Efficiency Committee under the auspices of the Ministerial Council on Energy, Report 2007/11, October 2007.

E3 (2008), *Fact Sheet - Digital TV Set Top Box: Minimum Energy Performance Standards*, issued by the Equipment Energy Efficiency Committee, August 2008.

EC (2008), *Code of Conduct on Energy Efficiency of Digital TV Service Systems, Version 7*, Ispra, 15 January, 2008.

ES (2008a), *ENERGY STAR Program Requirements for Set-top Boxes Version 2.0*, Washington, 2008.

ES (2008b), *ENERGY STAR Program Requirements for Cable, Satellite, and Telecom Service Providers*, Washington, 2008.

Guardian (2008), *Digital TV for a Tenner from Tesco*, 29th August 2007, available from http://www.guardian.co.uk/media/2007/aug/29/supermarkets.digitaltvradio, accessed June 2008.

Hu, Robert (2006), *Regulating Standby Power Activities in Taiwan*, presentation to the International Standby Power Conference, Canberra, Australia, 6-7 November 2006.

IEA (2007), *Summary Report: International Workshop on Energy Efficient Set-Top Boxes & Digital Networks*, IEA, Paris, 4-6 July 2007.

Kaplan, Katharine (2008), *pers. com*., 25 June 2008.

Li, Aizhen (2008), *pers com*. 29 March 2008.

Li, Tienan (2006), *Energy Efficiency (S&L) in China,* CSC Presentation, Brazil, 28 November, 2006.

NTIA (2007), *DTV Converter Box Coupon Program, Information Sheet for Manufacturers*, available from http://www.ntia.doc.gov March 2007.

MOCIE (2005), *e-Standby Program Application Regulation*, Notification No. 2006-39, Ministry of Commerce, Industry, Energy (MOCIE) and Korea Energy Management Corporation (KEMCO), 17 April 2006.

MVV (2007), *Preparatory studies for Eco-design Requirements of EuPs, Simple Digital TV Converters (Simple Set Top Boxes)*, Final Report, MVV Consulting GmbH, Freiburg, 17 December 2007.

NDRC (2007), *Results of NRDC/Ecos Consulting Study of Set-Top Box Power Use in the U.S.*, presentation by Noah Horowitz of the Natural Resources Defense Council to IEA workshop on Energy Efficient Set-Top Boxes & Digital Networks, Paris, 4-6 July 2007.

OECD (2007), *OECD Communications Outlook 2007,* Information and Communications Technologies, Paris, 2007.

© OECD/IEA, 2009

OECD/IEA (2007), *Mind the Gap, Quantifying Principal-Agent Problems in Energy Efficiency*, Paris, 2007.

OECD/IEA (2008), *Energy Efficiency Policy Recommendations*, In support of the G8 Plan of Action, Paris, 2008

SFOE (2007), *Measurement of the power consumption of set-top boxes, Final report*, Swiss Agency for Energy Efficiency (S.A.F.E.) in collaboration with HTW Chur (College of Science and Technology), 7 May 2007.

Sky, (2008), *Environment: Auto Standby*, available from: http://www.jointhebiggerpicture.com/HealthyEnvironment/Environment/WhatsSkydoing/SkyProducts/AutoStandby.aspx, accessed September 2008.

Chapter 8 and Chapter 9

External power supplies

BBC (2008), *Laptops set to out sell desktops*, BBC News, 21 March 2007, http://news.bbc.co.uk/2/hi/technology/6474581.stm, accessed July 2008.

BIO IS (2007), *Preparatory Studies for Eco-design Requirements of EuPs, Lot 7: Battery chargers and external power supplies*, Final Report, prepared by Bio Intelligence Service for European Commission DG TREN, 23 January, 2007.

DOE (2006), *The Current and Projected Future Market for Battery Chargers and External Power Supplies*, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Building Technologies Program, December 2006

E3 (2008), *Australian and New Zealand Energy Performance and Marking Requirements for External Power Supplies, Minimum Energy Performance Standards (MEPS) FACT SHEET,* May 2008.

Ellis, M., Peter du Pont and Kevin Lane (2006), *Communities of Practice: A new approach for co-ordinating energy efficiency standards and labelling programmes*, presented to EEDAL 2006, June 2006.

Energy Star (2008), *ENERGY STAR Program Requirements for Single Voltage External Ac-Dc and Ac-Ac Power Supplies, Eligibility Criteria (Version 2.0)*, Final.

EPS IEMP (2005), *External Power Supply International Efficiency Marking Protocol Vs 1.1*, September 2005.

Global Europe (2008), *Mobile phone market growing at fastest rate for five years*, 25 March 2008, http://www.mobileeurope.co.uk/news_wire/113745/Mobile_phone_market_growing_at_fastest_rate_for_five_years.html, accessed July 2008.

GSMA (2007), *Mobile Business Briefing: 20 facts for 20 years of mobile communications*, http://www.gsmworld.com/documents/20_year_factsheet.pdf accessed July 2008.

© OECD/IEA, 2009

iSuppli (2007), *Competition Heats Up in the PMP/MP3 Controller Chip Market: Actions maintains competitive lead in 2006,* 30 April 2007, http://www.isuppli.com/news/default.asp?id=7880, accessed July 2008.

ITBE (2008), *Competitive Developments in the Global Notebook Market*, IT Business Edge, 1 February 2008.

IVF (2007), *Preparatory studies for Eco-design Requirements of EuPs, Lot 3: Personal Computers (desktops and laptops) and Computer Monitors*, Final Report (Task 1-8), prepared by IVF Industrial Research and Development Corporation for European Commission DG TREN, August 2007.

MEA (2004), *Analysis of Potential for Minimum Energy Performance Standards - External Power Supplies*, NAEEEC Report, Mark Ellis & Associates.

OECD/IEA (2001), *Things That Go Blip in the Night, Standby Power and How to Limit it*, Paris.

OECD/IEA (2007), *Mind the Gap, Quantifying Principal-Agent Problems in Energy Efficiency*, Paris 2007.

Punchline (2007), *Consultation Regulatory Impact Statement, Minimum Energy Performance Standards and Alternative Strategies for External Power Supplies*, Report No 2007/02, prepared for the Australian Greenhouse Office by Punchline Energy, February 2007.

SA (2008a), *AS/NZS 4879.1:2008: Performance of transformers and electronic step-down convertors for ELV lamps - Test method - Energy performance*.

SA (2008b), AS/NZS 4879.2:2008 (int): *Performance of transformers and electronic step-down convertors for ELV lamps - Minimum Energy Performance Standards (MEPS) requirements*.

Times (2006), *Phone revolution makes Africa upwardly mobile*, Times Online, 4 March 2006.

US Congress (2007), *New Direction for Energy Independence, National Security, and Consumer Protection Act* and the *Renewable Energy and Energy Conservation Tax Act of 2007*, 110TH Congress 1ST Session H. R. 3221.

Standby Power

ANRE (2006), *Report of the Survey of Standby Power, FY 2005*, Agency for Natural Resources and Energy, Japan, March 2006.

BP (2008), *EGAT Sets New Standby Rule*, Bangkok Post, 5 August 2008, available from http://www.bangkokpost.com/050808_Business/05Aug2008_biz011.php, accessed August 2008.

Bush (2001), *Energy-Efficient Standby Power Devices,* US Presidential Executive Order 13221, 31 July 2001, available from http://www.ofee.gov/eo/eo13221.pdf

© OECD/IEA, 2009

Dube, Sanjay (2008), *Consumer Electronics Labeling Program to Address Standby Power in India*, presentation to the International Conference on Standby Power, New Delhi, India, 2 April 2008.

E3 (2006), *Order out of Chaos* – summary paper for the international standby power conference, Canberra, Australia, 6-7 November 2006.

EES (2001), *Quantification of Residential Standby Power Consumption in Australia: Results of Recent Survey Work*, Project for the National Appliance & Equipment Energy Efficiency Committee, 29 April 2001.

EES (2006a), *2005 Intrusive Residential Standby Survey Report*, March 2006.

EES (2006b) *Standby Power – Current Status: A report for the Equipment Energy Efficiency (E3) Committee which documents the state of standby power in Australia and New Zealand*, Report No 2006/10, October 2006.

EC (2005), *Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products*, In Official Journal of the European Union L191/29-58. Brussels. 22 July 2005.

EC (2008a), *Draft Proposal for a Commission Regulation implementing Directive 2005/32/EC with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment*, available from http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm

EC (2008b), *Reducing standby electric power consumption – guide*, EU Business, 9 July 2008, available from http://www.eubusiness.com/Energy/standby-power-guide

EnergyConsult (2008), *APP Alignment of National Standby Power Approaches Project: Early Data Outcomes*, prepared for the Energy Efficiency Branch, Department of the Environment, water, Heritage and the Arts, June 2008.

EO (1993), *Executive Order 12845 Requiring agencies to purchase energy efficient computer equipment*, US President William J. Clinton, 21 April 1993, see http://www.archives.gov/federal-register/executive-orders/1993-clinton.html

Fraunhofer (2007), *EuP Preparatory Study Lot 6 Standby and Off-mode Losses: Task 5 Definition of Base Case*, Final Report, Compiled by Fraunhofer IZM, Berlin, 2 October 2007.

G8 (2005), *The Gleneagles Communiqué*. http://www.g8.gov.uk. July 2005.

Harrington et al. (2007), *Standby Energy: moving to the next level,* L. Harrington, J. Brown, S. Holt, A. Meier, B. Nordman and M. Ellis, in proceedings of the 2007 ECEEE Summer Study, France.

Harrington et al. (2008), *Standby Power: building a coherent international policy framework,* L. Harrington, H-P. Siderius and M. Ellis, paper for the 2008 ACEEE Summer Study, Asilomar, United States.

Hu, Robert (2006), *Regulating Standby Power Activities in Taiwan*, presentation to the International Standby Power Conference, Canberra, Australia, 6-7 November 2006.

© OECD/IEA, 2009

IEA (2008), *IEA Standby Power Policy Summary,* International Energy Agency, France, available from http://www.iea.org/textbase/papers/2007/Standby_Summary.pdf.

KEMCO (2005), *Standby Korea 2010: Korea's 1 watt plan*. Korea Energy Management Corporation and the Ministry of Commerce, Industry and Energy, October 2005.

Kim, Yungrae (2008), *New Energy Efficiency Policy Tool: Standby Warning Label,* presentation to the International Conference on Standby Power, New Delhi, India, 2 April 2008.

Novgorodcev, Alexandre (2008), *Standby Labeling and Procel Seal on TVs: The Brazilian Experience*, presentation to the International Conference on Standby Power, New Delhi, India, 2 April 2008.

OECD/IEA (2001), *Things That Go Blip in the Night*, International Energy Agency, France, Paris. 1 April 2001.

Ohkuni, Kotaro (2006), *pers. com*., 15 December 2006.

Ohkuni, Kotaro (2008), *Standby Power in Japan,* presentation to the International Conference on Standby Power, New Delhi, India, 2 April 2008.

PIER (2004), *Developing and Testing Low Power Mode Measurement Methods*, prepared for the California Energy Commission, Public Interest Energy Research Program by Lawrence Berkeley National Laboratory, September 2004.

Siderius (2006), *Standby: The Next Generation*, Siderius, H-P., B. Harrison, M. Jäkel and J. Viegand, in proceedings of the EEDAL Conference, London, 21-23 June 2006.

U.S. DoE (2008), *Implementation Report: Energy Conservation Standards Activities*. Washington D.C., February 2008.

Digital networks

Banks R. (2007), *20 Years is a Long Time*, presented to IEA workshop, Energy Efficient Set-Top Boxes & Digital Networks, International Energy Agency, Paris, France, 4-6 July 2007, available at http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=285.

Christensen K., B. Nordman and R. Brown (2004), *Power Management in Networked Devices*, IEEE Computer, August 2004.

Economist (2007a), *Cutting the Cord: wireless energy makes wireless devices look easy*, 26 April 2007.

Economist (2007b), *A Sense of Things to Come: sensors can keep a remote eye on almost anything*, 26 April 2007.

Economist (2007c), *A World of Connections: new wireless technologies will link not just people but lots of objects too*, 26 April 2007.

Economist (2007d), *What the Mousetrap Said, Machines catch on to smart talk*, 26 April 2007.

© OECD/IEA, 2009

IEA (2007), *International Workshop on Energy Efficient Set-Top Boxes & Digital Networks Summary Report*, International Energy Agency, Paris, France, 4-6 July 2007, available at http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=285.

Meier, A., B. Nordman and M. Ellis (2007), *Buildings as Networks: Danger, Opportunity and Guiding Principles for Energy Efficiency,* presented to IEA workshop, Energy Efficient Set-Top Boxes & Digital Networks, International Energy Agency, Paris, France, 4-6 July 2007.

Nordman B. (2007a), *Necessary Design Infrastructure for Energy-Efficient Networked Buildings*, January 2008.

Nordman B. (2007b), *Energy Consumption of Networks,* presented to IEA workshop, Energy Efficient Set-Top Boxes & Digital Networks, International Energy Agency, Paris, France, 4-6 July 2007.

Nordman B., and K. Christensen (2007), *Improving the Energy Efficiency of Ethernet-Connected Devices: A proposal for Proxying*, Version 1.0, September 2007.

OECD/IEA (2008), *Energy Efficiency Policy Recommendations*, In support of the G8 Plan of Action, Paris, 2008.

SMH (2008), *Wireless power eliminates chargers*, 22 August 2008, available at http://www.smh.com.au/news/articles/wireless-power-eliminates-chargers/2008/08/22/1219262494935.html, accessed August 2008.

WWW 2008, *The Potential Global CO_2 Reductions from ICT Use: Identifying and assessing the opportunities to reduce the billion tonnes of CO_2*, World Wildlife Fund Sweden, May 2008.

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