INTERNATIONAL ENERGY AGENCY

Sectoral Approaches in Electricity

Building Bridges to a Safe Climate

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Building Bridges to a Safe Climate

Addressing climate change requires nothing short of an energy revolution. Electricity, mostly generated from fossil fuels, is at the core of this challenge, accounting for more than 40 % of global energy-related CO_2 emissions. This issue is most pressing for developing countries where growth in power demand is particularly high, fueling the risk of irreversible investment in CO_2-intensive capacity, the so-called "carbon lock-in".

Sectoral Approaches in Electricity: Building Bridges to a Safe Climate shows how the international climate policy framework could effectively support a transition towards low-CO_2 electricity systems in developing countries. Sectoral approaches are intended to address sectors that require urgent actions, without waiting for countries to take nation-wide commitments.

Once built, power generation capacity lasts for decades. Investing massively in CO_2-intensive technologies to meet surging electricity demand will either make it impossible or overly costly to stabilise CO_2 concentrations at sustainable levels. The technology mix needed to avoid such a development is clear: higher generation efficiency, CO_2 capture and storage, nuclear and renewables. Earlier IEA publications have extensively reviewed developed countries' efforts to steer generation away from carbon-intensive production modes, from dedicated support to low-carbon technologies to, increasingly, the reliance on CO_2 pricing via emissions trading. Following the same logic, there are proposals seeking to use the international carbon market to drive changes at sectoral level in developing countries. This publication illustrates the pros and cons of such an approach in a few key emerging economies. It also asks how international climate policy could support and enhance ongoing efforts on end-use energy efficiency - an essential piece of the climate change/electricity puzzle.

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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.

It carries out a comprehensive programme of energy co-operation among twenty-eight of the thirty OECD member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on international oil markets.
- To provide data on other aspects of international energy markets.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- 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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The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

International Energy Agency (IEA)
9 rue de la Fédération, 75739 Paris Cedex 15, France

Foreword

In L'Aquila, Italy on 9 July 2009, 17 heads of industrialised and non-industrialised countries participating in the Major Economies Forum on Energy and Climate set a clear goal for international climate policy: the increase in global temperature above pre-industrial levels ought not to exceed 2°C. This confirms the need for a rapid change of our energy systems globally, as energy remains the major source of greenhouse gases (GHG) from human activities.

The electricity sector presents both a challenge and an opportunity in the fight against climate change. It is the largest and fastest growing source of GHG emissions globally, with 41% of energy-related carbon dioxide (CO_2) emissions in 2007, and a 60% increase since 1990. At the same time, all projections, including those in the IEA *World Energy Outlook* and *Energy Technology Perspectives*, indicate the potential for significant emission reductions in electricity. The strategy for achieving these reductions is clear: a combination of aggressive savings in the electricity end-uses and the decarbonisation of generation.

IEA member countries have started taking measures to curb power generation emissions, from emissions trading to specific support for low-carbon technologies. Energy efficiency has become a priority even if more efforts are needed, as illustrated by the IEA report *Progress with Implementing Energy Efficiency Policies in the G8*. The rapidly growing economies of the developing world are now essential to curbing CO_2 emissions from electricity. They will host the lion's share of the growth in power generation between now and 2030, adding generation capacity equivalent to today's capacity in the United States, the European Union and Japan combined. The current economic crisis has triggered only a temporary pause in electricity growth. If developing countries resume investment in power generation along the lines of the past decade, they could lock in enough carbon in the global energy system to make the 2°C goal impossible to attain. The global community must act collectively against this risk.

This book presents what could be a comprehensive sectoral approach to electricity-related CO_2 emissions in the developing world. It considers options for sectoral market mechanisms, and support for energy efficiency policy. It also presents policy efforts to date in China, India, Mexico and South Africa. These dynamic economies, now at various stages of economic and energy development, illustrate the need for tailor-made policy solutions. Their current policies and capacities should be used as stepping stones. With the active participation of developed countries, developing countries can make a major contribution to solving global climate change.

Published three months ahead of the UNFCCC Copenhagen negotiation in December 2009, this book is a timely contribution to the discussions on the post-2012 climate policy framework. Its messages, however, should be heeded long beyond that point, if the energy sector is to make the 2°C goal possible.

Nobuo Tanaka
Executive Director
International Energy Agency

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We also express our gratitude to our colleagues of the OECD Environment Directorate and the delegates of the OECD/IEA Annex I Expert Group on the UNFCCC for many years of work and debates on sectoral approaches, much of which is reflected here.

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Executive summary

In L'Aquila, Italy on 9 July 2009, 17 heads of industrialised and non-industrialised countries participating in the Major Economies Forum on Energy and Climate set a clear goal for international climate policy: the increase in global temperature above pre-industrial levels ought not to exceed 2°C. This implies that global greenhouse gas (GHG) emissions should peak soon and fall below half current emission levels by the middle of this century. Yet the reality is that existing policy efforts would not prevent energy-related CO_2 emissions from rising for decades to come.

Electricity at the core of the climate stabilisation challenge

Lowering global CO_2 emissions to address climate change requires nothing short of an energy revolution. Electricity, because it is mostly generated from fossil fuels, is at the core of this challenge. It accounts today for more than 40% of global energy-related CO_2 emissions and its emissions will grow by 58% globally by 2030 unless new policy measures are introduced. Many OECD member countries have started implementing ambitious policies to guide electricity generation and uses on the path to lower emissions – CO_2 pricing through cap-and-trade, support for renewable and nuclear energy, subsidies for the deployment of breakthrough technologies such as carbon capture and storage (CCS), and a range of energy efficiency policies.

This issue of electricity-related CO_2 emissions is, however, most pressing for developing countries, where electricity demand growth is particularly high. If these countries invest in conventional CO_2-emitting generation capacity, there is a serious risk of so-called "carbon lock-in", as power plants are used over decades. According to the IEA *World Energy Outlook 2008* scenarios, unchecked growth in fossil fuel-based electricity outside the

OECD region could lead to a doubling of emissions by 2030. Electricity-related emissions in developing countries would then be equivalent to half of the level of global emissions required to stay on track with stabilisation of GHG concentrations at 450 ppm of CO_2 equivalent – the 450 Policy Scenario in *WEO 2008*. In other words, without additional measures, CO_2 emissions from electricity in non-OECD countries would make it impossible to keep the world on a sustainable climate path. Any global strategy to fight climate change must make the electricity sector a priority for action, with developed countries taking a strategic role in helping developing countries establish new, more effective approaches to emission mitigation.

This publication examines the issue of electricity and climate change in developing countries, with a focus on the next two decades. It is framed by the current debate on sectoral approaches (SAs), put forward in the negotiations of the UN Framework Convention on Climate Change (UNFCCC). A sectoral approach assumes that while some developing countries may not be in a position to adopt a comprehensive, legally-binding emission objective in the coming phase, they may commit certain sectors to ambitious GHG emission mitigation. Sectoral approaches of various types have been proposed by Parties to the UNFCCC. These include: sector-specific objectives for developing countries; new market mechanisms based on sectoral crediting or sectoral caps; and international support for sharing best technology and best policy practice in priority sectors.

A two-tiered approach to curbing CO_2 from electricity in emerging economies

An effective strategy to curb CO_2 from electricity rests on three pillars:

- Significant improvements in the energy efficiency of electricity end-uses, which will alleviate the pressure on building more capacity in the next two decades. Most of these improvements can be of a win-win-win nature – reaping benefits for energy security, economic performance and the environment.

- Policy incentives to move towards a decarbonisation of power supply, which will come at additional cost, either through a price on CO_2 emissions or subsidies for the deployment of low-carbon technologies not yet competitive with fossil fuel-based generation.
- Enhanced R&D in low-carbon generation technologies, a critical element for the long-term response. This publication addresses only the first two pillars.[1]

The cost of decarbonisation is such that unmanaged electricity demand growth would greatly undermine our economic ability to introduce low-carbon generation technologies at scale. Ambitious energy efficiency policies are essential to deliver a less costly transition to a different, more expensive power supply system.

A positive point is that we are not starting from scratch in these policy areas: the international policy framework includes measures that have achieved a degree of success in moving towards reducing electricity emissions. The Kyoto Protocol's Clean Development Mechanism (CDM) has encouraged the deployment of some clean generation technologies on a project-by-project basis, but has had limited effects on the efficiency of plants globally. The CDM has shown less success in the area of end-use energy efficiency.

There is, thus, clearly a need for the international community to shift to a higher gear in supporting energy efficiency in developing countries. This is an area of possible mutual interest in developed and developing countries, given the benefits from energy security, energy cost savings, economic performance, reducing local pollution, and lowering CO_2 emissions. As an example, the retrofitting of coal-based power generation units that operate at conversion efficiency levels much lower than their original design should be a priority for a least-cost strategy. The IEA

1. See IEA (2008d), *Energy Technology Perspectives,* for a presentation of technology solutions for long-term mitigation strategies, including in power generation.

made practical recommendations on this front in its report to the G8 in Hokkaido, which could be endorsed by the climate community.

A two-tiered international approach is recommended. On the demand side, urgent policy support is needed in energy efficiency. On the supply side, strong economic signals are needed to encourage low-CO_2 generation technologies, from high efficiency plants to renewables, nuclear and CCS. Market mechanisms, if acceptable, would bring economic benefits by ensuring a least-cost mitigation effort.

Sectoral market mechanisms: a radical departure from CDM

Under sectoral market mechanisms, credits for emission reductions would be issued once a country reports performance that exceeds an agreed sectoral emission objective, the so-called baseline. Baselines would differ across countries, especially for power generation, reflecting the fact that generation fuel mixes, resources and access to technology still differ greatly from region to region.

The crediting of sector-wide CO_2 reductions in electricity needs to address some issues raised by CDM, however. The Kyoto Protocol's CDM helps to lower the cost of compliance with emission targets of developed countries; however, it is a zero-sum game for the environment. Credits from CDM projects are mere offsets for emissions in countries whose GHG emissions are above target. Crediting all reductions on a sectoral basis is not politically acceptable as it would require more ambitious goals for developed countries, only to be achieved by more offsets: developed countries would still carry the full burden of global mitigation. To be politically plausible, crediting on a sectoral basis will, therefore, require setting ambitious emission baselines in order to deliver global CO_2 abatement, and to ensure that the supply of credits does not overwhelm demand. Developing countries would first reduce emissions to meet the baseline – their contribution to global mitigation – and only be credited for reductions that surpass the baseline.

This book proposes design options for electricity baselines that would meet the above concerns and requirements, and could facilitate negotiations over ambitious baselines. Baselines could, for instance, evolve during the crediting period to reflect the improved performance of new plants.

A key message is that sectoral crediting will require a robust energy policy framework to create actual incentives for investors in the electricity sector in countries. An agreement to a baseline at sectoral level will not be enough to drive change at plant level – one company's effort to reduce emissions may be annihilated by other companies' failure to reduce their own. In light of this barrier, the carbon finance community must start working with electricity policy makers in developing countries to determine how sectoral mechanisms can effectively send a carbon price signal to investors in power generation.

This represents a sea-change from the CDM, in which investors could seek credit revenues at the level of an individual project. Sectoral crediting would lead to the issuance of credits for performance aggregated at country level. One possibility, although not politically attractive for many developing countries, is the introduction of domestic cap-and-trade systems as means to exceed the sectoral baseline. An enforceable cap on emissions, with emission allowances to domestic sources and a price on CO_2, would encourage change at the level of individual sources. These domestic systems could pave the way for a global carbon price in the future, via the linking of regional emissions trading systems.

Within the sectoral approach, technology deployment goals are also proposed as commitments for which developing countries could seek international assistance, and which could also contribute to meeting a sector baseline. Care should be taken to ensure that the targeted technologies do not lock countries into irreversible choices, and undermine a least-cost mitigation strategy. In light of policy experience in all these areas, the sharing of best policy practice ought to be a mutual priority for both developed and developing country governments.

The two-tiered approach to curbing CO_2 from electricity in emerging economies can be summarised as follows. Energy efficiency measures would be best supported by targeted policy assistance. Developing countries' generally high interest in this area, and the important local benefits, should make carbon credits superfluous. The carbon market ought to focus on more expensive mitigation options, in generation, for which change will require a premium on carbon reductions. In the case of electricity, this two-tiered approach can help to maximise abatement at least cost for the international community.

Existing policy efforts as stepping stones

In seeking to support additional action in developing countries, the international community needs a sound basis of information on ongoing and planned efforts. This book considers four countries from this standpoint: China, India, South Africa and Mexico (an OECD member country). Without the introduction of additional measures, all would experience considerable growth in CO_2 emissions from electricity generation in the coming decades. While all have national climate change plans, not all translate their efforts in country-wide emission schedules. The IEA *World Energy Outlook 2009* will shed further light on this, with possible country roadmaps for climate policy in major emerging economies.

The case studies in this book provide a wide-ranging policy experience, both on end-use and generation. Policies in place or envisioned cover a broad range, from voluntary agreements with industry to standard energy efficiency measures, energy-service companies, various support for renewables (including with CDM contribution), and technology goals. In the case of Mexico, efforts include a plan for a multi-sectoral CO_2 cap-and-trade system. The case studies also highlight some gaps that would need to be addressed if countries were to pledge sector-level goals to the UNFCCC. These gaps include: regulatory frameworks and incentives to maximise and maintain plant efficiency; national-level data for electricity production and CO_2; and the role of local governments in relaying national policies.

Identifying policy needs and agreeing on support measures will require an extensive dialogue between developed and developing countries, and the formulation of sound energy and climate strategies in the latter. South Africa has completed such a multi-stakeholder national process to explore the country's strategies to fight climate change, an exercise that could be usefully replicated by other countries. Beyond such processes to elaborate national strategies, there is also a need to identify and promote best practice in energy and climate policies and to provide advice to countries seeking to increase their efforts in this area. Such work is underway in a number of industry and government fora, also described in this book.

Regardless of whether or not sector-specific discussions are brought to the table of the UNFCCC by the next climate policy framework, electricity generation and end-use should be priority areas for climate stabilisation. An expert group on electricity and climate should be established to monitor international progress on decarbonising generation and curbing demand growth, and to indicate areas where improvement is necessary. The IEA is ready to contribute its expertise to this important task.

Introduction

The electricity sector plays a unique role in climate change. Power generation is the single largest, fastest growing source of electricity. The reasons are now well known: electricity is an incredibly versatile energy, which provides unique services (light, appliances, heating, cooling) and is also in a position to compete with the final uses of fossil fuels (electric cars). The world consumes ever-growing quantities of electricity, and most regions rely on domestic, readily available resources to produce this electricity: predominantly coal (42% of generated power globally in 2007), followed by gas (21%), hydro (16%), nuclear (14%), oil (6%) and non-hydro renewables (2%).

The IEA and others have demonstrated that tackling climate change requires a quasi-decarbonisation of the power generation sector, which should be well under way by 2050. This is a striking challenge when close to 70% of today's power is supplied by fossil fuels. The wide policy apparatus that can trigger these changes should be implemented soon globally for the world to stand a chance of preventing catastrophic climate change.

This book focuses on one essential aspect of this issue, the rapid growth of CO_2 emissions from the power sector in developing countries, and how to curb this trend in the next 10 to 20 years. It is legitimate to ask how developed countries are aiming to reduce emissions from power as well; this has been the topic of much earlier work by the IEA on both policy instruments and technologies, recently covering topics as diverse as cap-and-trade, clean coal technologies, best policy practice for renewable energy deployment, and issues in the development and diffusion of carbon capture and storage.[2] The IEA has also stressed repeatedly that there is a vast potential for end-use efficiency improvements that would

2. See for instance: Reinaud (2003, 2007) and IEA (2005, 2007a) on issues related to cap-and-trade in power generation, IEA (2008d) on principles for effective deployment of renewables, CIAB (2008) on the clean coal deployment, IEA (2008a) on CO_2 capture and storage.

save the need for more new capacity in generation.[3] Not all answers have been provided in the context of developed countries, and indeed stronger action is needed to effectively curb the trend of CO_2 emissions from electricity. The building blocks are available, however, and now is the time for implementation.

One could argue that these same approaches could be applied in developing countries. They have not, so far, embraced ambitious climate change targets, even if some have adopted policies to foster the deployment of renewable energy in particular, and energy efficiency is a growing priority for these countries as well. Developing countries have had other, entirely legitimate priorities for their electricity sector: broadening access of populations to low-cost electricity, but also solving electric system reliability issues – the reduction of black-outs. Market reform is also underway in some countries to make the sector more economically viable, a process that proves challenging. These issues cannot be brushed away just because of climate change concerns; however, developing countries are responsible for the vast majority of emission growth in electricity globally, in quantities that could seriously threaten the world's ability to address climate change.

This book asks how the international policy framework can encourage developing countries to account for climate change concerns in their choice of electricity development. The book is firmly based on the assumption that developed countries will take the lead in reducing global emissions, a key principle of the United Nations Framework Convention on Climate Change (UNFCCC).

The book first makes the case for addressing power generation in developing countries as a major source of CO_2 accumulation in the atmosphere, and lays out a strategy that rests on supply-side decarbonisation and ambitious improvements in end-use energy efficiency.

3. For a discussion of potentials and policies to improve end-use electricity efficiency, see IEA (2009c) on consumer electronics and IEA (2006) on lighting in particular. See also IEA (2008b) for policy recommendations on energy efficiency across all sectors, that also include electricity use.

As a next step, lessons are drawn from the Clean Development Mechanism (CDM) in supply and demand-side abatement in electricity. The book considers new policy options to enhance developing countries' mitigation, currently on the UNFCCC negotiation table, as well as existing international initiatives in the power sector. This portfolio could be the basis for a sectoral approach to reduce CO_2 from electricity in developing countries.

The potential role of sectoral crediting, an option widely discussed internationally, is critically reviewed as a possible driver for change in the power sector of developing countries. Various design options are discussed, with some numerical analyses based on scenarios from the *World Energy Outlook 2008* (IEA, 2008g, referred to as *WEO 2008* hereafter).[4]

The picture would be incomplete without a review of the electricity sector and policies in place in key emerging economies. Four case studies consider the situations in China, India, Mexico and South Africa. The studies combine country data and information on current policy efforts, including in energy efficiency, with climate policy projections from the *WEO 2008*.

The book finishes on how to move forward internationally with the various elements described here. Developing countries have the opportunity to change the unsustainable energy path on which the world has proceeded so far. International policy solutions are now essential to trigger the necessary changes and to assist the developing world in this unprecedented energy challenge.

4. While this book uses the quantitative insights of *WEO 2008* scenarios, the policy mechanisms and definitions of sectoral approaches discussed here are not identical to those modelled in *WEO 2008*.

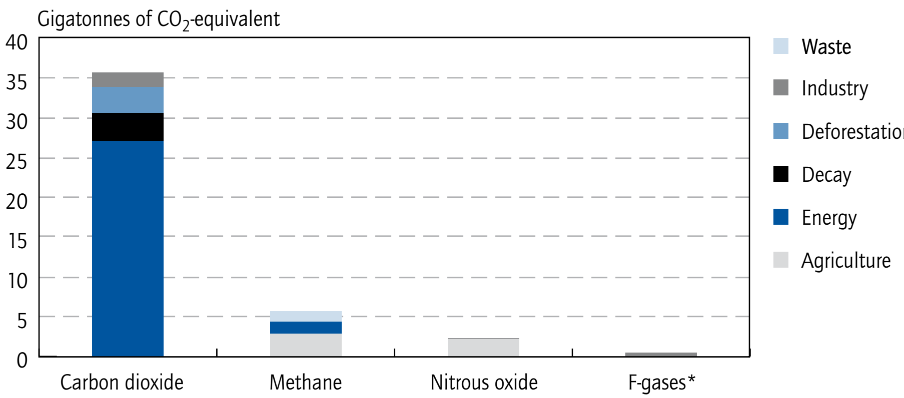
TACKLING CLIMATE CHANGE IN THE ELECTRICITY SECTOR

Emission trends and energy realities

The energy sector accounts for 82% of greenhouse gas (GHG) emissions in OECD countries, and 59% in non-OECD countries (see Figure 1). Energy-related emissions, largely carbon dioxide (CO_2), but also nitrous oxide (N_2O) and methane (CH_4) have been rising rapidly since 1990 (+33%), driven by the rapid economic growth of emerging economies and abundant use of fossil fuel resources. This is especially visible with the growing use of coal in power generation: CO_2 emissions from coal use in electricity have grown by some 76% between 1990 and 2007 worldwide, leading to a staggering 8.7 billion tons (Gt) of CO_2 emitted in 2007.

Figure 1

World anthropogenic greenhouse gas emissions by source, 2005



Notes: *F gases include HFCs, PFCs and SF_6 from several sectors, mainly industry. Industry CO_2 includes non-energy uses of fossil fuels, gas flaring and process emissions. Energy methane includes coal mines, gas leakages, and fugitive emissions. Nitrous oxide emissions from industry and waste amount to 0.12 $GtCO_2$-eq.
Sources: IEA, 2008g; EPA data provided to the IEA; IEA statistics; IPCC, 2007; OECD, 2008.

KEY MESSAGE

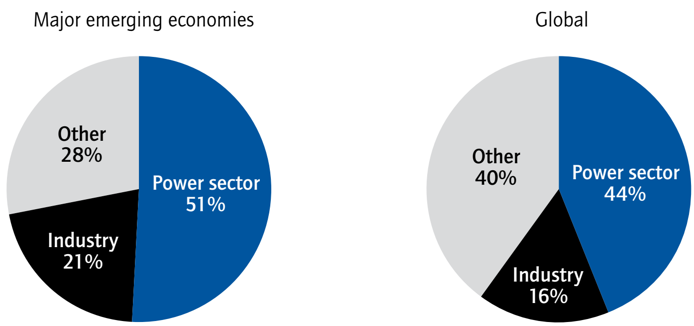
CO_2 from energy represents the bulk of global greenhouse gas emissions associated with human activities.

Global energy-related CO_2 emissions are expected to constitute the main share of emissions, reaching 36.4 $GtCO_2eq$ in 2020, with power and industry accounting for the lion's share – 44% and 16% of the total energy-related CO_2 respectively by that date. Almost half of the 2020 energy-related CO_2 emissions are expected to be emitted by the major emerging economies, where the power sector (51%) and industry (21%) play an even larger role (IEA, 2008g).[5]

Against this background, the importance of a few regions, (*e.g.* the OECD countries as well as the major emerging economies) and of a few sectors, (*e.g.* the power sector and heavy industry) becomes clear. The risk of carbon lock-in is particularly high in the power generation sector.

FIGURE 2

Energy-related CO_2 emissions by 2020 in the Reference Scenario



Note: The *WEO 2008* Reference Scenario indicates what would happen if no new energy policy measures were introduced by governments from 2008 onward.
Source: IEA, 2008g.

KEY MESSAGE

In the Reference Scenario, assuming no new policies and measures, the power sector would account for half of energy-related CO_2 emissions in major emerging economies by 2020.

There is growing consensus that, if left unchecked globally, electricity alone could greatly reduce the chances of stabilising the world's climate at a sustainable level. Under the *WEO 2008* Reference Scenario, which assumes no new policies

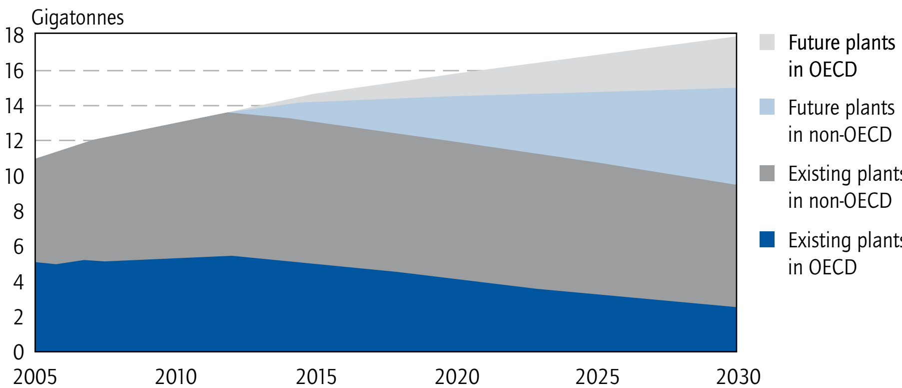
5. In *WEO 2008* scenarios, Other Major Economies include Brazil, China, India, Indonesia, Russia and Saudi Arabia.

and measures to curb CO_2, power generation emissions would reach some 12.6 $GtCO_2eq$ in non-OECD countries in 2030, against 6.8 $GtCO_2eq$ today. Developing countries are under pressure to develop their electricity infrastructure, and the resulting growth in emissions from power accounts for about half the growth in total emissions in the Reference Scenario.

These magnitudes give a sense of the urgency to act now to avoid greenhouse gas (GHG) accumulation through fossil-fuel based power generation. Another factor reinforces this urgency. The energy sector has a relatively slow rate of capital replacement, and the rate of capital-stock turnover is particularly slow in the power sector. The power sector is at a turning point, partly because of the current economic crisis, but also because it is on the verge of major new capital investment to replace old plants. Under the *WEO 2008* Reference Scenario, some 4 530 GW of new power generation capacity would need to be installed between now and 2030. Of this total, about 3 350 GW of capacity addition is expected to take place in non-OECD countries, of which around 1 170 GW before 2015 (Figure 3).

FIGURE 3

CO_2 emissions from existing and new power plants in the Reference Scenario



Source: IEA, 2008g, IEA analysis.

Note: Due to the timescales associated with planning and building new plants, all emissions up to 2012 are assumed to be locked-in.

KEY MESSAGE

Without new policies to curb CO_2, the coming decades will see a significant increase in emissions from new power generation capacity in non-OECD countries.

The investment needs, in the Reference Scenario alone, are substantial with some USD 3.3 trillion to be invested in non-OECD countries for power generation until 2030. Policy measures can be introduced to steer such investment towards low-carbon generation. The alternative is a lock-in of carbon-intensive generation capacity that would be costly to retire early; more likely, the capital stock inertia would commit the world to fairly high emission levels from this sector.

Climate change stabilisation and electricity

To contain global warming within the range of 2°C to 3°C, GHG emissions should peak in the next 10 to 15 years and reach 50% of their 2000 level by 2050; further reductions would be needed thereafter (IPCC, 2007). Efforts to date are far from enough to put the world on the path required to stabilise our climate. The *WEO 2008* Reference Scenario indicates that energy-related CO_2 emissions would reach 40.5 $GtCO_2$ by 2030, if no additional measures are taken. This would put CO_2 concentrations on a catastrophic path.

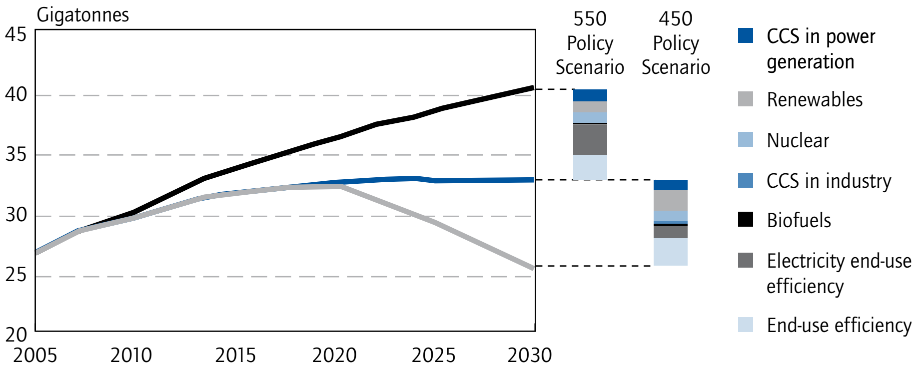
To preserve a 450 ppm concentration goal, consistent with a 2°C to 3°C range, IEA analysis shows that global energy-related CO_2 emissions need to be lower than today's levels by 2030 (25.5 $GtCO_2$), and on a rapidly declining path thereafter. With emissions of 12.6 $GtCO_2$ in the Reference Scenario, electricity generation outside OECD would represent roughly 50% of the global emission level allowed to reach 450 ppm. Fortunately, there is a wide array of technologies and policy options that enable electricity to contribute adequately to GHG mitigation globally.

With proper policy measures – including a carbon cost on emissions and much enhanced RD&D – the 450 Policy Scenario projects that emissions from electricity could be reduced to 2.1 $GtCO_2eq$ in OECD and 6.2 $GtCO_2eq$ in non-OECD countries, a 60% and 50% reduction from the Reference Scenario, respectively.[6]

6. By 2030, in the 450 Policy Case, total CO_2 emission levels would be 37% below their current levels in OECD countries, and 17% higher than current levels in other regions. On both sides, however, emissions would be on a downward trend, with non-OECD reaching their peak later than OECD.

Figure 4

Reductions in energy-related CO_2 emissions in IEA climate policy scenarios



Source: IEA, 2008g.

KEY MESSAGE

A major potential for global CO_2 emission reductions is found in the generation and use of electricity.

Figure 4 indicates the main components of the energy sector transformation needed to meet the global challenge imposed by climate change. Two broad areas stand out as requiring significant effort:

- Energy efficiency improvements across all end-uses: transport, heating, electricity uses, etc., to lower the demand for primary, carbon-intensive fuels. With proper policy instruments in place, energy efficiency could deliver more than half of the total required reductions.
- Decarbonisation of the supply side, especially in the power sector, through growing use of renewable energy sources (including hydro), nuclear power and carbon capture and storage (CCS) from fossil-fuel based electricity generation. Much technology development and targeted support is needed for these technologies to become viable and to penetrate the market. In the end, these changes can only occur with a significant price signal on CO_2 emissions, calculated as USD 180/tCO_2 in 2030 for the 450 Policy Scenario.

The importance of demand-side efficiency improvements

Climate policy costs: an overview

While efforts to stop climate change are fully justified to avoid damage to our societies and economies, they will require diverting resources towards more costly energy supply technologies than those that would otherwise be used. The IEA estimates that cutting CO_2 emissions by 50% from current levels by 2050 would require capital expenditures of USD 14 to USD 15 trillion from 2005 to 2050, over and above what would be spent in a business-as-usual scenario (IEA, 2008d). A rising cost on CO_2 emissions – implicit or explicit – is needed to guide the whole energy system (supply and demand) towards cleaner, low-carbon technologies. The cost of carbon would reach USD 180/tCO_2 at the margin by 2030, and USD 200 to USD 500/tCO_2 – and possibly higher – by 2050 to achieve a 450 ppm concentration objective (IEA, 2008d, 2008g). Figure 4 shows the key roles played by end-use efficiency and the power sector in achieving the emission reduction targets. The marginal emission reduction cost for stimulating the decarbonisation of the power sector is estimated at USD 100 to USD 200/tCO_2 by 2050. In this particular exercise, electricity costs would double from the business-as-usual trend, in the 2030 to 2050 time frame (IEA, 2008d).

Box 1

The *World Energy Outlook 2008* scenarios

The World Energy Outlook 2008 *looks at three scenarios; one business-as-usual scenario and two policyscenarios. These scenarios paint three potential future developments of the energy sector.*

- ***The Reference Scenario.*** *This scenario describes what would happen if only existing government policies were to remain in place. Extrapolating the impact of policies and measures that were enacted or adopted by mid-2008, energy demand would grow by 45% between 2006 and 2030, triggering a 45% increase in energy-related CO_2 emissions (from 28 $GtCO_2$ in 2006 to 40.6 $GtCO_2$ in 2030).*

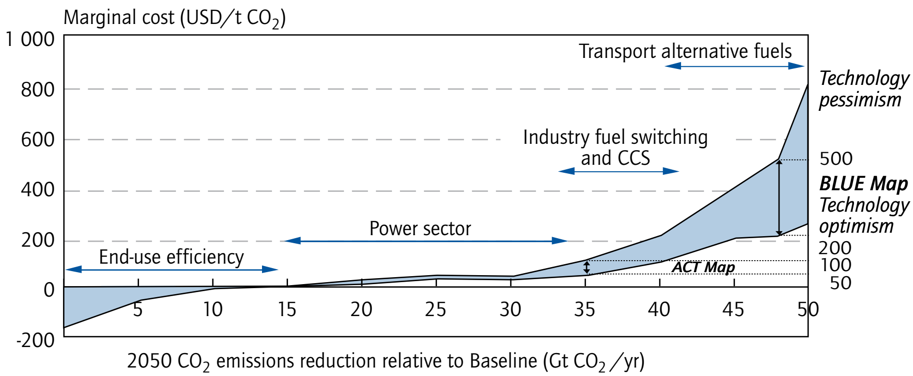
- ***The 550 and 450 Policy Scenarios.*** *These scenarios reflect international discussions that aim to reach a stabilisation level between 450 ppm and 550 ppm CO_2eq. Given different circumstances and preferences of different countries, both scenarios assume a hybrid approach that combines a cap-and-trade system with sectoral agreements and national policies and measures. In both instances, three distinct country groupings are applied: OECD+ (including EU countries currently not OECD member countries); Other Major Economies (including China, India, Russia, Indonesia, Brazil, and Saudi Arabia); and Other Countries. The 550 Policy Scenario reduces energy-related emissions to 33 $GtCO_2$ by 2030. OECD+ countries are assumed to adopt binding economy-wide emissions targets, with cap-and-trade schemes covering the power generation and industry sectors. They also participate in international sectoral agreements across the iron and steel, cement and transport sectors and undertake national policies and measures in the buildings sector. Other Major Economies also participate in the sectoral agreements in certain industries, and have the possibility to generate and trade emission credits. However, they are not assumed to adopt binding emission targets; instead they implement national policies and measures in the power generation, industry and buildings sectors. Other Countries are assumed to undertake national policies and measures across all sectors. In the 450 Policy Scenario, energy-related CO_2 emissions fall to 26 $GtCO_2$ by 2030. In this scenario, much stronger and broader policyaction is assumed. While the scenario outlined for the 550 Policy Scenario remains in principle the same, Other Major Economies now participate in the cap-and-trade scheme from 2020 onwards.*

In brief, both policy scenarios are markedly different from the Reference Scenario and require a transformation of the energy sector. The analysis that follows focuses on the 450 Policy Scenario, consistent with announcements by developed and developing country leaders at the Major Economies Forum on Energy and Climate in L'Aquila, Italy, on 9 July 2009.

Source: IEA, 2008g.

FIGURE 5

Marginal emission reduction costs for the global energy system, 2050



Source: IEA, 2008d.

KEY MESSAGE

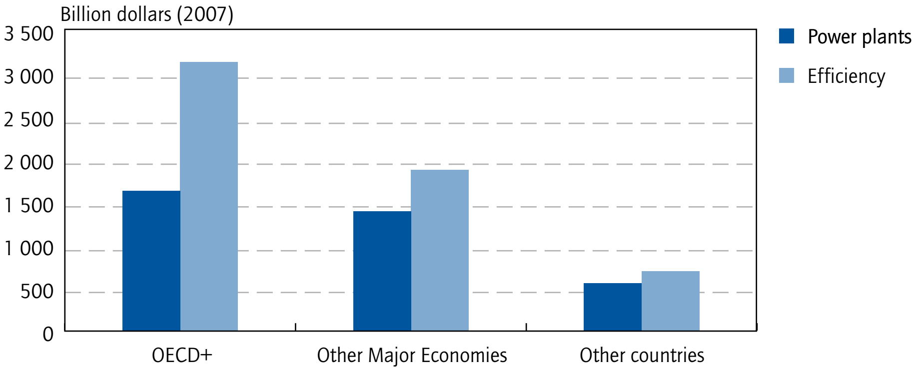
Cutting CO_2 to 50% of current levels requires a marginal cost of carbon ranging from USD 200 to USD 500/tCO_2 in 2050.

Standard macro-economic analyses of global CO_2 reduction scenarios project a small, yet positive GDP cost in the medium to long run – between 2.5% to 5.5% of GDP loss relative to the baseline level in 2050 (IPCC, 2007; OECD, 2008).

Looking at the power sector specifically (Figure 6), the additional investments in power plants under the 450 Policy Scenario by 2030 are estimated at some USD 1.6 trillion and USD 1.4 trillion in OECD+ and Other Major Economies, respectively. Taking into account the investment needs in demand-side energy efficiency, total investments represent about 0.55% of the global cumulative GDP over the period 2010 to 2030. Energy savings investment would, however, save USD 8.7 trillion in fuel costs over the same period.

FIGURE 6

Additional energy-related investment by region in the 450 Policy Scenario, relative to the Reference Scenario, 2010-2030



Source: IEA, 2008g.

KEY MESSAGE

Substantial investments are required in both OECD+ countries and Other Major Economies, not the least on the energy efficiency side.

Lowering exposure to cost: energy efficiency

Policy makers, especially in the energy sector, must accept the reality of increasing prices of energy delivered to consumers, as necessary to protect the global climate. They can, however, act pro-actively to lower such cost, by reducing the amount of energy that consumers require for the services that they need (light, communication and information technology services, heat and motion, as far as electricity is concerned). There is ample evidence of the large potential for energy efficiency improvements that would reduce energy requirements at no loss of service to consumers. The policy record is clear, but the remaining potential is still great, often hampered by market failures or barriers. In its recommendations to the 2008 G8 Summit in Hokkaido, the IEA proposed 25 best-practice policy measures in energy efficiency which, if applied globally, could help save more than 8 $GtCO_2$ by 2030 in a cost-effective fashion (IEA, 2008c).

Energy efficiency improvements appear best suited to satisfy multiple energy policy goals. Improvements in energy efficiency would:

- Lower the end-users' exposure to unit energy prices that are bound to grow as systems become decarbonised. In the nearer term, for some countries, this could accompany efforts to reform an energy sector often hampered in its attempts to charge cost-reflective prices.
- Lengthen the period of development and experimentation of a broad set of low-carbon technologies (technology development aspects are addressed only briefly in this book).
- Lower the overall investment needs in new, more costly, low-carbon supply technologies, or delay when these will have to be deployed to further lower emissions.
- Alleviate pressures on international energy markets.

The more efficient our end-use technologies, the lower the final energy required to deliver the same energy service, and the lower the cost increase for final consumers. The policy challenges to reap these benefits are many, but the expected benefits warrant serious policy resources.

An example is provided by recent analysis of residential electricity consumption (IEA, 2009c). Consumption of electricity in homes has been growing in all regions of the world at an average of 3.4% per annum since 1990 (Figure 7). 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 gaining access to electricity; however the majority is caused by the increased consumption of electricity by individual households.

In both OECD and non-OECD countries, the main source of the growth in residential end-use electricity consumption over the last five years has been information and communication technologies and consumer electronics devices. Looking ahead, it is likely that such devices will continue to be the main contributor to rising residential electricity demand. Global electricity use from these appliances could rise to 1700 TWh by 2030, or some 5% of total electricity output, in the Reference Scenario.

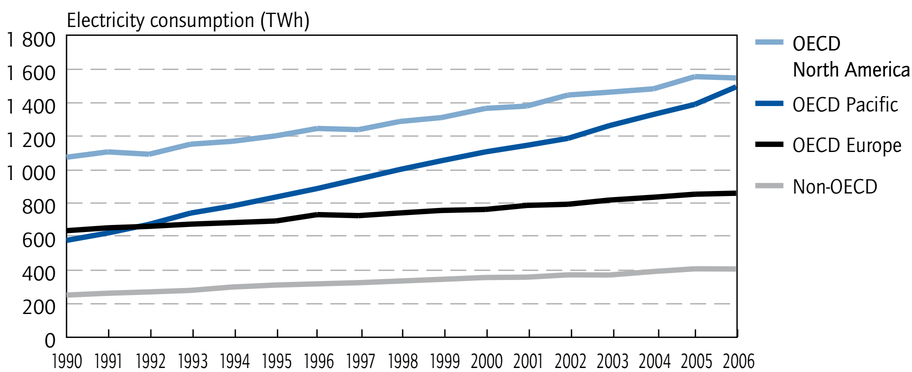
Switching to the best technologies currently available would save at least 40% of residential electricity consumption in most appliance categories (IEA,2009c).

Realising this potential is not straightforward, as it is disaggregated amongst many end-use consumers and potential end-use equipment. Other challenges include lack of information, low energy costs and principal-agent problems (IEA, 2007b). While it is clear that a carbon price will help in making energy efficiency measures more cost-effective, it will not be enough to overcome all barriers to a more rational use of electricity.

Effective energy efficiency policies, including scaling up successful existing policies, are therefore essential in energy strategies to cut CO_2 emissions from the power sector. Successful energy efficiency policies will deliver a less costly transition to a different, more expensive power supply system.

Figure 7

Residential electricity consumption, 1990-2006



Source: IEA, 2009c; IEA statistics.

KEY MESSAGE

Residential electricity consumption has risen steadily since 1990 in all world regions, although at a faster pace outside OECD.

Economic projections of future energy needs under a CO_2 constraint concur on the main technical and policy solutions. They combine a curb on rising demand for primary energy (particularly coal, oil, and gas) through enhanced energy efficiency and, possibly, conservation, as well as technology solutions to "decarbonise" the supply of energy.

A successful energy sector contribution to solving climate change must therefore have at its core a clear economic signal that encourages investment in the decarbonisation of the energy system along with enhanced investments in energy efficiency across end-uses, guided by sound policy approaches.

Summary

Growing electricity use worldwide is driving major growth in energy-related CO_2 emissions, especially in developing countries pursuing legitimate goals to broaden access to electricity as a secure, modern and versatile energy source. Under current trends, electricity-related CO_2 emissions in the developing world would be equivalent to half of the total global emissions allowed under the 450 ppm stabilisation goal in 2030. In other words, the world cannot afford such growth if ambitious global climate goals are to be met.

Solutions are well known – some technologies are available today to lower the CO_2 content of power generation, others are at various development stages. All will need an economic signal (an implicit or explicit price on CO_2) in order to divert investment decisions away from fossil fuel-based generation. Another essential component of the strategy to curb CO_2 from electricity is a rapid move to end-use efficiency improvements, to prepare for a more expensive energy supply system, and allow it the time to develop. The policy challenges are many, but the potential for success is significant. Chapter 2 considers how international policy proposals can drive this agenda in developing countries.

PRESENTING OPTIONS FOR INTERNATIONAL SECTORAL APPROACHES

The previous chapter laid two foundations for an effective strategy to reduce CO_2 from power generation: the decarbonisation of supply and ambitious improvements in end-use efficiency to tame the growth in electricity demand. This chapter presents options under discussion internationally to foster policy changes in developing countries. Much, in this discussion, hinges on two major uncertainties:

- What will be the main instruments for international action on mitigation?
- How will developing countries choose to apply these instruments in their domestic policy setting?

The timeframe for experimentation with policies in this sector is short, as the investment in generation over the next 20 years will prove essential in a global GHG mitigation strategy. Whatever policy portfolio is adopted internationally, it should help, not hamper, an appropriate development in power generation and electricity end-uses from a CO_2 mitigation viewpoint. It should also build from what countries have already put in place, and on existing regulatory and policy structures.

This chapter describes some international efforts underway to identify and share best policy and technology practice. Some companies in the power sector have taken responsibility for the GHG emissions of their activity and identified the critical components of an effective mitigation strategy.

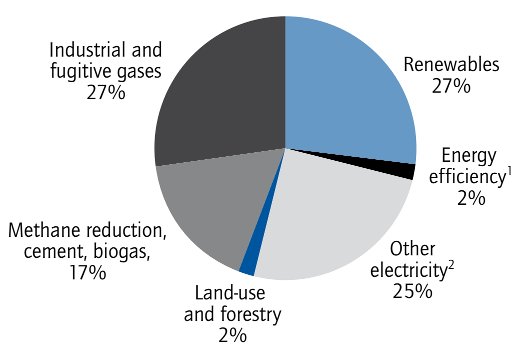
How do these initiatives and efforts fit with possible avenues for international co-operation and support on policies under the UNFCCC and elsewhere? This chapter first describes experiences with the Clean Development Mechanism (CDM), presents policy options in discussion internationally, including sectoral approaches, and reviews existing policy and power industry initiatives, with a focus on power generation and energy efficiency.

Electricity and climate in developing countries: lessons from the Clean Development Mechanism

The Clean Development Mechanism (CDM) is a market mechanism aimed at lowering mitigation costs in developed countries through the pursuit of least-cost mitigation options in developing countries. The establishment of the CDM created high expectations for the diffusion of renewable energy technologies and more efficient use of fossil-fuel resources and electricity, seen as major components of an international response to curb global CO_2 emissions.

FIGURE 8

Project types of issued and expected certified emission reductions from CDM until 2012



Note: The maximum amount of CERs that could be delivered by 2012 amounted to 2 931 $MtCO_2$ at the time of consultation of the UNEP database. [1] Demand side, transport, energy distribution. [2] Supply-side energy efficiency, biomass energy, fuel switch.
Source: UNEP Risø, CDM pipeline, consulted in May 2009.

KEY MESSAGE

Electricity supply projects account for an important share of the total expected supply of CERs by 2012. Energy efficiency projects remain underrepresented.

The CDM has managed to generate considerable reductions in GHG, in spite of what many describe as cumbersome and costly administrative procedures.[7] The majority of these reductions occurred in somewhat unexpected activities, where low-cost reduction potentials were able to generate important benefits, as well as significant reductions that could then be traded on the carbon market as so-called Certified Emission Reductions (CERs). However, it should be recognised that fairly small contributions have been recorded in electricity generation, or in end-use efficiency. The CDM should not be criticised for this, since it has been designed to encourage the emergence of least-cost GHG reductions, wherever they exist.

The following sections highlight the CDM results in the areas of electricity generation and end-use efficiency, and present some of the shortcomings of the CDM in a global mitigation strategy

Electricity generation in CDM: renewables and cleaner use of fossil fuels

The electricity sector contributes strongly to GHG reductions – and credits – under the CDM (Figure 8). Renewables in particular, because of their often high cost and their clear CO_2 benefits, have been quite successful. In China, recent wind plants have been systematically submitted to the CDM, generating concerns that the domestic policy goal may free-ride on international climate policy: wind plants that would have been installed anyway would enjoy additional revenues through the CDM. While rewards to cleaner energy are legitimate, the additional emissions that are allowed by the issuance of credits in such instances are not.

This is part of a broader debate on the risk that the project-based CDM would create perverse incentives for governments not to take policy measures that would benefit the global environment. A country that would benefit from CDM in a particular activity would hesitate to introduce a policy to curb emissions from this activity. The resulting emission trend would become part of its baseline, *i.e.* the reference from which emission reductions are calculated. A lower baseline would automatically mean fewer emission reductions and fewer potential benefits benefits from CDM. The CDM Executive Board has made a decision to avoid

7. These procedures, which may be streamlined, evolved from the need to ascertain the environmental integrity of the mechanism. The CDM certified emission reductions, or CERs, grant the right to Annex I Parties to emit GHG above their initial emission objectives; CERs must therefore correspond to real reductions, *i.e.* additional to what would have happened in the absence of the mechanism. Creating CERs, *i.e.* emission rights, for non-additional reductions would contribute to a net increase in emissions.

this perverse incentive by allowing projects to be submitted even when a policy has been introduced, if after a certain date. Projects that operate under a policy adopted earlier than this date would not be eligible.

At first focused on renewable energy, the CDM has recently moved into clean fossil-fuel burning in power plants, with methodologies allowing crediting for high-efficiency coal-based generation (CDM Executive Board, 2007). The approved methodology for such projects introduces a dynamic element in the baseline, which becomes more environmentally ambitious for the next CDM project, as new, high-efficiency plants have since come on line. It is conceivable that once many high-efficiency, coal-based generation projects have been replicated, a fairly minimal quantity of credits would be issued for new projects in this area. The CDM would then have achieved its goal of transforming an innovative cleaner technology into the baseline.

There is, however, a very large potential for lowering CO_2 emissions from existing power plants. The IEA made recommendations to the G8 Summit at Hokkaido on how to improve the efficiency of coal-based power generation. The implementation of IEA recommendations would reduce emissions from coal-based power by some 1.7 $GtCO_2$ annually (IEA, 2008h). This estimate includes the replacement of 300 GW, and retrofit of some 200 GW of older coal-fired power plant capacity (equivalent to the United States and European Union coal power capacities, respectively). In comparison, CDM projects in this area so far are expected to generate efficiency changes in 5 GW of capacity (see Table 1). The IEA recommended that full use be made of the CDM in this area, but indicated other actions to improve the situation, including:

- The replacement of all units of below 300 GW of capacity using sub-critical (low efficiency) technology and aged 25 years by larger units using supercritical or higher efficiency technology.
- Consider assessing for upgrading or replacement – preferably to 40%-efficiency – all subcritical units even less than 25 years old which have efficiencies of under 30%, subject to appropriate country-specific techno-economic assessment, including CCS readiness.
- Address financial gaps and lack of incentives for the replacement or upgrading of older units.
- Foster international co-operation to diffuse advanced technologies in developing countries to replace or upgrade older units. This co-operation

should also be extended to the adoption of best practice in power plant operation and should involve international financial institutions.

- Ensure coal quality control.

The IEA also recommended that countries consider establishing a dedicated funding mechanism to facilitate pre-financing of expenditure for capacity building and introduction of best practices, based on plant performance improvement programmes, including benchmarking and operation and maintenance practices. These programmes could be implemented by the IEA in collaboration with the private sector and financial institutions. The pre-financed expenditure could be repaid by the benefiting utilities from the savings made as a result of performance improvements (IEA, 2008h). Such a mechanism may be a useful component to an international approach to lowering CO_2 from electricity in developing countries, in an area where CDM has so far not delivered much improvement.

In current negotiations, some critical questions are left open on the future role of CDM in electricity supply. In particular, the UNFCCC Parties have so far not agreed to make nuclear and CCS eligible for crediting, while any Annex I Party relying on these technologies would take full account of their contribution to

Box 2

CDM and plant retrofits

Under the CDM, several baseline and monitoring methodologies have been approved for projects aiming to retrofit or improve the efficiency of existing power plants (Table 1). In addition to the large-scale methodologies listed here, there are also several small-scale CDM methodologies approved and projects registered for energy efficiency in existing power plants. Several of the approved methodologies have also been used for energy efficiency projects for direct power generation in industrial and manufacturing plants.

The number of CDM projects in this area to date is small, but it is clear that CDM could encourage efficiency improvements in existing power plants. Having the CDM continue to serve as a market mechanism for energy efficiency measures in existing plants could allow a sectoral approach in the electricity sector to, at least initially, focus only on new plants. Support for plant refurbishment, other than CDM, could also be envisioned, as illustrated by the task force on power generation under the Asia-Pacific Partnership.

Table 1

Examples of approved CDM methodologies for retrofitting or improving efficiency of power plants

CDM Methodology	Description	Number of projects approved or under validation	Capacity pre-project (MW)	Capacity post-project (MW)	1000 tCO_2 by 2012
ACM0007	Conversion of existing grid connected single-cycle plants to combined cycle operation	11	2 582	3 621	11 811
ACM0012	GHG emission reductions from waste energy recovery projects	2	1 554	1 554	783
AM0054	Energy efficiency improvement of a boiler by introducing oil/water emulsion technology	0			
AM0061	Methodology for rehabilitation and/or energy efficiency improvement in existing power plants	1	200	240	462
AM0062	Energy efficiency improvements of a power plant through retrofitting turbines	1	660	720	781
Total		15	4 996	6 135	13 837

Source: UNEP/Risø CDM pipeline, 2009.

lowering its emissions. A move from the project scale to the sectoral scale may remove this difference of treatment of technologies across Parties.

Relatively speaking, the power generation sector has had some success under the CDM, notwithstanding usual concerns about transaction costs, and the difficulties in setting the baseline and proving additionality. Areas that are underdeveloped include generation efficiency, which may require a more holistic approach – at present, only individual methodologies exist, *e.g.* for more efficient coal-use in generation. In all, the expected reductions fall far short of that needed to meet global stabilisation goals. The cumulative CDM emission reductions of 1.5 $GtCO_2$ in the power sector over the 2000-12 period are unlikely to curb the trend of this sector, where emissions outside OECD were 3.2 $GtCO_2$ above their 1990 levels in 2007, and rising. Clearly, there is a need to scale-up efforts in this area, with this, or another, better suited mechanism.

Energy efficiency under the CDM

As of May 2009, roughly 15% of projects in the CDM pipeline were related to energy efficiency (UNEP Risø Centre, 2009). These projects are expected to deliver 12% of the cumulative CERs up to 2012. Thus CDM seems to perform quite well in encouraging energy efficiency. However, this category ranks highest in terms of rejected projects (33%). In addition, most energy efficiency projects focus on measures in industry. Almost 60% of the energy efficiency projects in the pipeline focus on the use of waste heat or waste gas for electricity production in industry; a further 27% promote end-use energy efficiency improvements in industry. End-use energy efficiency projects outside industry (*i.e.* related to households and services) lag behind, representing only 4% of total energy-efficiency projects.

Out of the total issued CERs, only 4% are related to energy efficiency, of which 97% were issued to projects aimed at energy efficiency improvements in industry. Demand-side energy efficiency projects also showed some underperformance. A lower than anticipated volume of CERs was issued as project developers and validators tended to overestimate the emission reduction potential of projects; on average 88% of the expected credits were realised.

CDM faces serious difficulties in overcoming the barriers to end-use energy efficiency improvements. A number of factors explain this: the small scale and scattered nature of demand-side projects; high upfront costs required by such programmes; difficulties with monitoring the energy savings/energy efficiency improvements; and the lack of knowledge on best practice as well as the lack of public education/capacity and acceptance. The CDM could have contributed to removing some of the barriers to energy efficiency, but has instead created an additional barrier through its complex institutional approach and the demanding methodological requirements, particularly related to monitoring.

The introduction of so-called programmatic CDM has addressed some of the above issues. Under programmatic CDM, a series of similar activities can be implemented in a particular sector, at different points in time, and these activities are registered under a single umbrella project. There are, however, higher requirements in terms of capacity on the ground, as all activities must be supervised by a so-called bundling agency that acts as the aggregator for all the separate activities under the umbrella project. There are 18 programmatic CDM projects at the validation stage at the moment; none have been approved yet.

Difficulties remain, particularly due to the challenge of financing energy efficiency projects and the requirement for robust measurement of emission reductions at the level of each project activity. This latter issue has been addressed by a methodological innovation. The so-called "deemed savings" methodology, which reduces unnecessary monitoring complexity, could lower the transaction costs of energy efficiency projects under the CDM. However, there appears to be resistance to allow for this approach on a broader scale by the CDM Executive Board.

Notwithstanding the increasing success of the CDM in leveraging clean energy investments,[8] the CDM contribution to changing energy production sources and use in developing countries remains limited, and is inadequate when considering ambitious mitigation scenarios. A recent study estimated CDM energy efficiency projects to deliver about 140 $MtCO_2$ by 2012 compared to a total delivery from the CDM of around 1.4 $GtCO_2$ to 1.8 $GtCO_2$ (Carbon Trust, 2009).[9] A comparison with the non-OECD countries' annual emissions of nearly 15 $GtCO_2$ in 2007 indicates that the CDM by itself is unlikely to initiate the necessary transformation of the energy system, or to leverage the potential offered by energy efficiency in developing countries.

8. Capoor and Ambrosi (2008) estimate that in 2007 alone CDM has leveraged USD 33 billion (EUR 24 billion) in investment in the field of clean energy (renewable energy, fuel switching and energy efficiency), or 63% of what has been leveraged in those same areas since 2002 (USD 52 billion or EUR 39 billion). Renewable energy account for two-thirds of the total capital leveraged, with hydro at 22% and wind at15% respectively.

9. Excludes an estimated 300 $MtCO_2$ by 2012 from projects not yet in the CDM pipeline.

These disappointing results prompt some observers to question the current project-based approach of the CDM for energy efficiency. It is triggering the question of whether CDM can evolve from its current project basis to a policy or sectoral basis, to enhance the coverage of the carbon market, lower transaction costs, and pave the way for broader participation by developing countries in the global mitigation effort. One alternative would be to provide direct funding for energy efficiency policies and measures. Whether or not the achieved reductions would be part of a broader, sectoral, crediting mechanism is open for debate.

How does the CDM contribute to mitigation: the offset issue

The CDM has proven the effectiveness of the carbon price incentive as a tool to develop emission reduction activities in countries without emission goals. Much has been said about the transaction costs imposed by the CDM, but these have not stopped entrepreneurs from conducting an impressive number of projects and registering them as CDM with the hope of receiving carbon market revenues.

The carbon price that drives all such activities results from the balance of supply and demand – in fact, the CDM *raison d'être* is to provide credits to facilitate the compliance of developed countries with their Kyoto Protocol targets, the demand side of this market. As such, the CDM does not deliver emission reductions beyond those agreed by Annex I Parties listed in Annex B of the Kyoto Protocol. Environmentally, the CDM is a zero-sum game, even if, economically, it facilitates the compliance of buyers. CERs from the CDM are pure offsets for emissions above target in an Annex I Party. It is, however, very profitable for developing country project developers, hence the interest in broadening the scope of the CDM in a future climate policy framework.

The offset nature of the CDM means an ever-expanding role for the mechanism is not politically plausible, as it assumes that developed countries shoulder all of the needed effort in global mitigation. In contrast, proposals have developed to attach global mitigation benefits to crediting mechanisms, as described below (Schneider, 2008; Baron, Buchner and Ellis, 2009).

Proposed policy approaches beyond 2012

The international climate policy challenge, viewed from the perspective of the electricity sector, is to develop policy instruments that can help address both electricity supply and demand. The Bali Action Plan, agreed by the Parties to the UNFCCC in 2007, established some basis for the elaboration of international policy co-operation, in addition to a call to enhance global mitigation. The main elements are listed in Box 3; the new notion of nationally appropriate mitigation actions (NAMAs) is the essential component of developing countries' contribution to global emission reductions.

Box 3

Essential elements related to GHG reductions in the Bali Action Plan

The Bali Action Plan contains several essential elements related to GHG mitigation that are of relevance for possible policies to address GHG emissions from electricity in developing countries:

- *Enhanced national/international action on mitigation:*
  - o *Measurable, reportable and verifiable (MRV) nationally appropriate mitigation commitments or actions by all developed countries.*
  - o *Nationally appropriate mitigation actions (NAMAs) by developing countries in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable reportable and verifiable manner.*
  - o *Co-operative sectoral approaches and sector-specific actions.*
  - o *Various approaches, including opportunities for using markets, to enhance the cost effectiveness and promote mitigation actions.*
- *Enhanced action on technology development and transfer to support action on mitigation, including:*
  - o *Ways to accelerate deployment, diffusion and transfer of affordable, environmentally sound technologies.*
- *Enhanced action on the provision of financial resources and investment to support action on mitigation and technology co-operation, including:*
  - o *Positive incentives for developing countries to enhance the implementation of NAMAs.*
  - o *Mobilisation of public- and private-sector funding and investment, including facilitation of carbon-friendly investment choices.*

Source: Bali Action Plan, UNFCCC, 2007

The Bali Action Plan is clear on the fact that NAMAs ought to be supported, presumably by other Parties – both actions and support are to be measured, reported and verified. The means for support identified in the Bali Action plan include financial resources and investment, as well as market mechanisms. The Bali Action Plan also mentions sector-specific co-operation activities.

After some months of negotiations on these elements, three major strands emerge from international discussions on GHG mitigation for developing countries:

- *Unilateral actions:* a developing country could pledge action, without support from the international community, to reduce emissions in specific areas.
- *Supported actions:* international support would be targeted to actions to implement a policy, acquire technology, or build institutional capacity to achieve mitigation.
- *Market-based actions:* drawing on experience with the Kyoto Protocol trading mechanisms, actions that deliver reductions beyond an emissions "baseline" could be rewarded by GHG credits, which could be sold on the international carbon market.

The notion of sectoral approaches can be used to underpin all three of these strands.

The rationale for sectoral approaches

The term "sectoral approaches" covers many meanings (see Baron *et al.*, 2007 for definitions). From the perspective of the electricity sector, a sectoral approach defines the appropriate scale of mitigation activities in developing countries, in opposition to the project-based approach of the CDM. The need for sectoral approaches has been motivated by the recognition that ongoing efforts to mitigate GHG emissions on a global scale are inadequate. The parallel observation is that few developing countries are in a position to adopt country-wide emission mitigation objectives. Sectors, which represent a more appropriate level for the implementation of NAMAs than projects, have therefore become the focus of international discussions.

When looking at important sectors and activities for curbing global emission trends, the previous chapter makes the case that electricity deserves priority, as far as the energy sector is concerned. Following the question of prioritisation, comes the issue of enhancement of mitigation activities in these sectors, to ensure that developing countries move away from their current practice and start adopting more climate-friendly practices.

Other motivations have been introduced, stemming from a bottom-up swell of concerns on the international dimensions of climate change policy. Most prominent among them, although maybe not the most significant in GHG terms, is the distortion of competitiveness that favours some industries operating in countries without emission objectives. Recently, this has been a pressing issue in discussions on the treatment of various activities under the European Union Emissions Trading System (EU ETS); the discussion of cap-and-trade systems in IEA member countries has also generated heated debates over the competitiveness and carbon leakage issue. Previous IEA analysis explored the possible role of sectoral approaches in the context of these trade-exposed, GHG-intensive activities; additional work looked at the competitiveness and leakage issue (Baron *et al.*, 2007; Reinaud, 2008a, 2008b). International sector-wide approaches to industry, to be successful, will need to grapple with the need to shift technology choices away from carbon-based fuels, the necessary economic incentives to achieve this shift, and the concerns about competitiveness inside and outside sectors (IEA, 2009b).

Beyond the competitiveness concerns, another important element from a design perspective was the earlier observation that the CDM is not able to trigger a shift in investment priorities in developing countries on the scale and with the speed necessary to avoid carbon lock-in. The question then became how can crediting be scaled up, with the double objective of:

- Fostering the needed change in the emission trends of developing countries;
- Diffusing the carbon price signal on a larger share of global emissions.

Based on these objectives, an array of policy proposals have been tabled by UNFCCC Parties, with different emphases on goals and instruments.

Sectoral approaches under the UNFCCC

A simple way to describe sectoral approaches to GHG mitigation is to distinguish between goals and instruments. Developing countries could commit, or pledge emission limitations goals for key sectors. The UNFCCC policy framework could then offer various instruments to support the implementation of these goals.

Sectoral mitigation goals

The intent of setting sectoral mitigation goals has been to use sector-level expertise to establish realistic yet ambitious mitigation goals across a range of activities. One possible advantage is the identification of best practice and the possibility to engage developing countries in a process that shares such experience and facilitates actions to reduce emissions. The other advantage is that, for certain sectors, emission reductions complement specific technology choices or policy measures; the required support for such measures may be more quickly identified. One disadvantage is that there is no guarantee that mitigation is achieved at least overall cost: different measures in different sectors are not likely to imply similar marginal abatement costs, without some form of co-ordination. This aspect is covered below.

A set of indicators that could be used to establish sector-by-sector commitments for developing countries has been proposed by Japan, reproduced in Table 2.

Table 2

Metrics for sectoral goals

Sector	Indicator
Iron and steel	kg CO_2 per tonne of crude steel
Cement	kg CO_2 or energy per tonne of cement or clinker
Aluminium	kg CO_2 equivalent per tonne of primary aluminium
Power generation	Coal-based power generation: thermal efficiency or CO_2 intensity per MWh
Road transport	gCO_2/km

Source: Government of Japan (2009).

This proposal is linked to specific support to facilitate policy implementation or technology diffusion in the appropriate areas, following possible voluntary national climate action plans by developing countries that would identify corresponding needs. Such support would need to be elaborated jointly between developed and developing countries.

Alternative, less direct formulations have also been used to establish sectoral goals to reduce GHG intensity. Instead of committing to a specific emission objective (absolute or relative), a country/sector may commit to the deployment of a climate-friendly technology. For example, a country could pledge a target for the penetration of renewable energy sources in the electricity supply mix – which is not necessarily easy to translate into precise CO_2 reductions – or a share of hybrid vehicles in the country's fleet of personal vehicles, or the mandated use of waste heat recovery in cement plants.

This technology-based sectoral approach seems to meet some interest, particularly in China (Duan, 2008; CCAP *et al.*, 2008), where there is a tradition of regulations based on technology or minimum performance levels (Wang, 2006). One drawback, already mentioned above, is the uncertain cost associated with mandated technology or performance, and the possible economic cost associated with applying uneven marginal costs of reduction across sectors. Put differently, a technology-based approach is an indirect, less efficient way to introduce a cost of carbon on sectors, but may be an effective interim step to trigger emission reductions in key areas, especially where there are barriers to a rational use of energy, or where energy pricing would be ineffective.

Sectoral mitigation instruments

The Bali Action Plan outlines various forms of support for NAMAs in developing countries. The most straightforward may be the direct support for policy implementation, based on countries' actual needs and existing capacities. Such support could range from training of policy officials and private sector personnel (plant managers, engineers), to concessional grants or loans to a specific activity/technology that contributes to lowering GHG emissions. Countries and multilateral development banks have accumulated some experience in this field, from project to policy-wide support. However, current global emission trends suggest that more is needed. The international process to identify policy and other needs, and match them with appropriate support, may be difficult and may require some criteria for prioritisation. Sectoral expertise would also be needed to ensure policy realism.

Probably as a result of the experience with the Kyoto Protocol emissions trading mechanisms, market-based approaches have received much attention as tools to engage entire sectors in mitigation. After many iterations and discussions, two broad options emerge (Schmidt, Lawson and Lee, 2004; Bosi and Ellis, 2005; Baron and Ellis, 2006; Baron, Buchner and Ellis, 2009; Schneider, 2008):

- *Sectoral crediting*. A crediting mechanism based on ambitious, negotiated mitigation goals at the sectoral level. The goals may be of a non-binding or "no-lose" nature: A country could commit one of its sectors to a target, generate emission reduction credits if it outperformed the target, but not be penalised otherwise (see *e.g.* Schmidt *et al.*, 2008; Philibert, 2000; IEA, 2002). The baseline can be expressed in absolute terms as a total amount of emissions, or in intensity terms as tCO_2-eq per unit of output.

- *Sectoral trading*. A country could adopt a sector-wide emission commitment. This would enable it to trade emission allowances internationally, even if the country were not covered by a country-wide emission goal. Note that a country adopting a cap at national level would not need a specific international instrument to allow its sectors to trade emission allowances – the EU ETS was developed by EU Member States without consultation of UNFCCC Parties.

Under crediting, credits would be issued after verification of performance of the sector as a whole. Under trading, the country/sector would be liable for compliance with the emission commitment and allowances could be issued *ex ante* (see Baron, Buchner and Ellis, 2009). This distinction has important implications for the way the carbon market could interact with sectors at country level. This dimension is explored in the next chapter. Under both options, the baseline would be set below business-as-usual, so that the host country – the country that commits to a sectoral goal – contributes to global mitigation; the intent is for these new mechanisms to go beyond emission offsets and enhance the contribution of developing countries to the global mitigation effort.

Both market mechanisms would require credible monitoring, reporting and verification mechanisms to ensure that any traded reductions correspond to actual reductions from agreed baselines. Countries that have already established an emissions trading scheme have expressed that they would only link with systems that have mechanisms to ensure their environmental integrity. There is much practical experience that can be shared across countries on this issue, but the institutional requirements of a proper monitoring, reporting and verification framework should not be underestimated.

If the two options for sectoral market mechanisms can be defined succinctly, much remains to be done to move them to implementation. In particular, the sector-specific elements of these discussions have not, so far, found a home in the UNFCCC regime (with forestry being the exception). In addition, agreeing to baselines for broader sector-wide efforts would require a dedicated negotiation framework, as ambitious baselines would define a level of effort by host countries, an issue that cannot be addressed from a purely technical perspective.

Different options for different policy areas

The electricity sector requires an approach that supports both fuel-switching and progressive decarbonisation on the supply side, and energy efficiency improvements on the demand side. On the supply side, the stakeholders are generators that seek to minimise energy cost and have shown interest in the CDM. Demand stakeholders range from equipment manufacturers that may not spontaneously search for highest energy efficiency options, and end-users that would benefit from these options but may not be cognisant of their electricity costs, nor informed about potential gains brought by more efficient equipment.

Power generation

On the power generation side, all policy scenarios concur on the need to implicitly or explicitly price CO_2 to guide investment towards more efficient, low- and no-CO_2 technologies. Even over the very first years of the EU emissions trading system there is evidence of CO_2 abatement in the power sector, through changes in operations and plants dispatch (McGuinness and Ellerman, 2008; Ellerman and Feilhauer, 2008). The experience with the CDM also speaks in favour of harnessing the carbon market to drive changes in generation choices. Hence the above-mentioned sectoral market mechanisms (crediting or trading) seem to be good candidates to foster change in generation. This is explored fully in Chapter 3.

Would the CO_2 price be enough? Domestic policy discussions in the European Union and the United States suggest that additional support is needed to prepare for the decarbonisation of power generation – particularly for CCS and renewables, as the CO_2 price may not be high enough to trigger the technology development and deployment needed to deliver this transition.[10] There is now much interest in engaging developing countries in international co-operation on low-CO_2 technologies, especially on CCS and on renewables. The recent creation of the GCCSI (Global Carbon Capture and Storage Institute) and IRENA (International Renewable Energy Agency) are evidence of this move.

The question of technology transfer would probably loom large in international co-operation on decarbonising power generation. A careful look is needed at the evidence on barriers to the transfer of technologies (Box 4), to identify possible remedies.

10. Although mid-term projections forecast a fairly high price tag on CO_2 to achieve ambitious mitigation objectives – USD 180/tCO_2 in the WEO 450 Policy Scenario – current carbon markets are not structured to translate this expectation into a clear price signal for current investors in clean technologies. This market failure alone justifies that some support be provided to technologies that are likely to play a role in solving climate change in the medium- to long-run.

Box 4

Intellectual property rights and barriers to transfer of low-carbon technologies

The issue of intellectual property rights (IPRs), as it relates to technology transfer to developing countries, has often been portrayed as a conflict between the desire to ensure economic benefits to innovators and that of maximising technology diffusion. Some observers argue that IPRs will be the catalyst for innovation and diffusion of low-carbon technologies; others claim that IPRs represent a potential barrier to widespread diffusion. Much of this debate has been on patenting rights for pharmaceuticals and the associated access to affordable medicine in developing countries. Certain features of low-carbon technologies and the electricity sector indicate that the issues surrounding IPRs and technology transfer in electricity differ from those of pharmaceuticals.

In the case of pharmaceuticals, the bulk of expenditure is at the R&D stage, while reproduction costs are very low (Tomlinson et al.*, 2008). As a result, IPRs and patents are essential to the industry, and the high cost of patents acts as a potential restriction to access in developing countries. Low-carbon technology does not necessarily share these characteristics, and patents typically represent a small percentage of energy project investment costs (WBCSD, 2009). Although the empirical evidence is somewhat limited, studies (Barton, 2007; Stern, 2007; OECD, 2005) indicate that patents are probably not a large factor in the diffusion of low-carbon technologies. Other factors may be of higher importance, such as the removal of trade restrictions and tariffs on low-carbon technologies. The OECD surveyed equipment exporters of low-carbon technologies in different sectors, including renewable energy, advanced coal technologies, and combined heat and power. Although results are based on a limited number of respondents, they show that import tariffs on most low-carbon goods in these sectors were below 10% in most OECD countries, while they varied greatly in non-OECD countries with tariffs in some countries, including China and India, often greater than 10%. The study found that non-tariff measures are also barriers to trade for some technologies. Such non-tariff measures include inadequate domestic IPR systems, as well as differences in technological standards or non-transparent procurement* *procedures (Steenblik and Kim, 2009; Steenblik and Serret, 2009). Another OECD study looking at IPRs and technology transfer in general, not only low-carbon technologies, found a general connection between IPRs and both technology transfers and local innovation (Park and Lippoldt, 2008). A statistical analysis on factors affecting the imports of renewable energy technology confirmed a negative correlation between tariffs on renewables technology and imports, and a positive link between registered patents and both imports and exports (Jha, forthcoming). The study concludes that patents could play an important role in facilitating exports of renewables components.*

A review of UNFCCC Parties' submissions on technology transfer finds that while there is a clear divergence between G77 countries and Annex I Parties on this issue, IPRs are not central to any country's proposal on technology. The review suggests that Annex I Parties' support of eligible NAMAs should cover any incremental costs associated with IPRs. Furthermore, to the extent that there are also non-cost related barriers from IPRs, some propose that the UNFCCC should make recommendations to the World Trade Organization (WTO) for addressing critical climate change mitigation technologies (Staley et al. *2009).*

There remains, however, a large array of low-carbon technologies for which analysis such as those mentioned above would be worthwhile. This leads some to conclude that it may be too early to draw any conclusion on whether or not IPRs represent a barrier to low-carbon technology diffusion. To the extent that IPRs represent a threat to technology diffusion, policy makers need to ensure the parallel goals of protecting IPRs and effective low-carbon technology transfer. Public-private partnerships and bi-lateral government agreements can be useful in this context (Tomlinson et al.*, 2008).*

Other typical non-trade related barriers to the transfer of low-carbon technologies to developing countries include higher up-front investment costs of newer technologies, lack of information about investment and technology alternatives, and lack of access to capital. Arguably, the CDM lowers several of these barriers (Schneider et al.*, 2008); roughly 36% of CDM projects, representing about 59% of total CERs, involve technology* *transfer (Seres, 2008). One study points out that while subsidies in the renewables sector have been important in generating a market for these technologies, such subsidies, as well as tariffs, should be phased out as the industry becomes more competitive and costs come down (Jha, forthcoming).*

Against this background, sector-focused approaches could further facilitate agreement on measures for increased technology transfer in certain key sectors. As mentioned, much can be achieved through increased international co-operation, and sectoral approaches could serve as a starting point for sector-specific discussions, not only on mitigation targets, but also on measures needed to ensure sufficient transfer of low-carbon technologies. Information sharing on alternative technologies and best practice is also useful in this context – especially as industry in one country may already have overcome barriers to technology adoption, and could share some of the solutions. However, it is also clear that mechanisms such as the CDM or sectoral approaches have no direct bearing on the international rules around IPRs and trade tariffs. Thus, if these issues were indeed significant hurdles to technology diffusion, other international mechanisms would be needed to ensure an international regime that fosters the effective diffusion of low-carbon technology.

There are differences in UNFCCC Parties' positions on the need for a new executive body and centralised technology fund under the UNFCCC for technology transfer. This structure is supported by G77 parties, while Annex I Parties generally prefer to make use of existing institutions and funding mechanisms, including bilateral agreements, regional accords, and public-private partnerships (Staley et al.*, 2009).*

As there is a clear cost of driving technology choices away from CO_2-intensive to other generation technologies, sectoral market mechanisms may be at the core of a strategy to engage developing countries in emission mitigation in power generation. In some cases, CO_2 credit revenues have proven effective in driving technology transfer to developing countries. There may, however, still be barriers to such transfer, and specific support may be needed in this area to ensure that countries are equipped to make the transition to low-CO_2 electricity supply.

Energy efficiency

Developed and developing countries alike are making energy efficiency a priority of their energy and environment policy strategies (Chapter 4 provides examples of current efforts in China, India, Mexico and South Africa). The benefits of energy efficiency have grown increasingly clear over the last few years:

- reduced exposure to rising international energy prices;
- energy cost savings for end-users;
- lower needs for expensive energy infrastructure;
- lower local pollution;
- lower CO_2 emissions.

In spite of these benefits, energy efficiency policies are not yet on par with the estimated cost-effective potential for energy savings. There is a clear deficit on the side of policies; the IEA has identified policy instruments that could avoid the emissions of 8.2 $GtCO_2$ by 2030, if implemented globally (Box 5). This is in line with the estimated CO_2 savings from energy efficiency between the *WEO 2008* Reference Scenario and the 450 Policy Scenario.

Box 5

Breaking the barriers to energy efficiency – the IEA 25 policy recommendations

The IEA recommended policy measures to the G8 Summits in 2006, 2007 and 2008. The consolidated set of recommendations from these summits covers 25 fields of action across seven priority areas: cross-sectoral activity; buildings; appliances; lighting; transport; industry and power utilities. If implemented, these policies could reduce global CO_2 emissions by some 8.2 $GtCO_2$/year by 2030.

The IEA recommends that governments and policy makers adopt and urgently implement its package of measures to significantly enhance energy efficiency. This package was developed under the Gleneagles G8 Plan of Action, which mandates the pursuit of a clean, clever and competitive energy future.

All of IEA recommendations in this package meet strict criteria. A recommendation is justified if it:

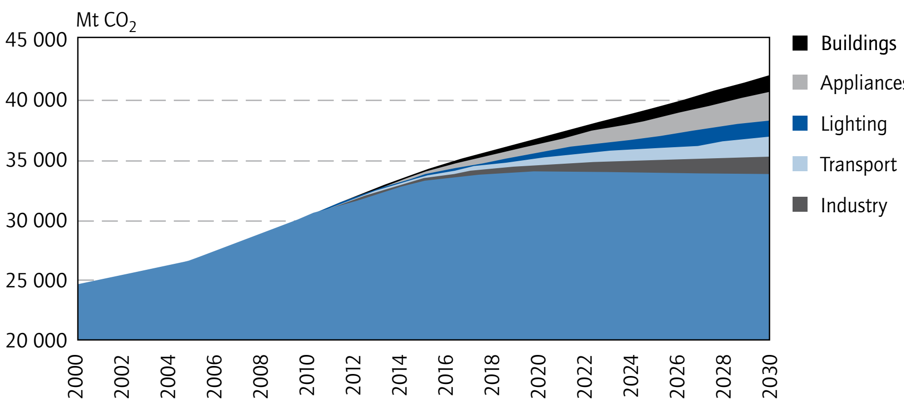
- *Is likely to save a large amount of energy at low cost;*
- *Addresses existing market imperfections or barriers;*
- *Addresses a significant gap in existing policy;*
- *Is supported by a degree of international consensus.*

A full description of the recommendations can be found at: www.iea.org/textbase/Papers/2008/cd_energy_efficiency_policy/index_EnergyEfficiencyPolicy_2008.pdf

Source: IEA, 2008c

Figure 9

Global CO_2 savings from IEA 25 concrete recommendations



Source: IEA, 2008c.

KEY MESSAGE

The global implementation of best policy practice in energy efficiency could save the world some 8 $GtCO_2$ by the year 2030.

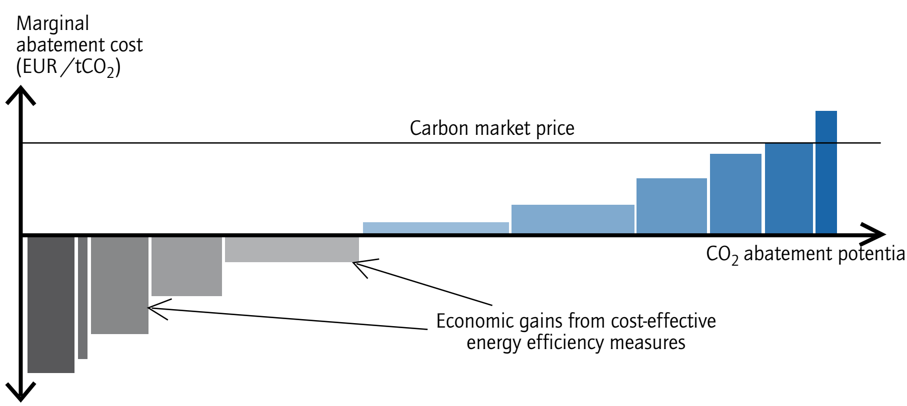
Considering the many benefits from energy efficiency for countries that would exploit this potential, it is widely considered a win-win proposition. At the same time, it is in the interest of the international community to have these potentials exploited swiftly. Where the policy deficit is clear, efforts should be made.

Two points argue against relying on the carbon market as the priority measure to promote energy efficiency on a broad basis:

- The lackluster experience of the CDM in this area, documented above. Energy efficiency must be moved to a larger scale, as is needed to address climate change. This cannot be achieved through a mechanism that is, by design, likely to reject measures with negative cost.
- The relatively high cost on developed countries (the purchase of emission reductions at carbon market price), in light of the important benefits for developing countries. This is illustrated in Figure 10.

Figure 10

Energy efficiency gains and the carbon market



KEY MESSAGE

The economic gains from energy efficiency justify action. Developed country support would ideally be in the form of assistance to energy efficiency policy development.

The exact mechanism whereby developing countries would seek support for policy implementation in energy efficiency has yet to emerge. There is clearly an up-front cost to be borne to implement policies that must be put in place in this area – an upfront cost that would be rewarded through higher energy security, lower energy costs for consumers, enhanced economic performance, lower pollution, etc. As developed countries may support the implementation of these measures, an additional payment through the carbon market would seem superfluous – notwithstanding the difficulty of getting the carbon market to work for energy efficiency.

International sectoral initiatives and fora related to electricity

The prominence of electricity (supply and demand) in climate change has prompted much international effort to formulate an adequate response to the problem, on the side of industry and governments alike. In Europe, Eurelectric has played a key role in gathering expertise on the role of the electricity sector in fighting climate change, illustrated by a recent declaration of European industry companies (Box 6).[11]

Box 6

Eurelectric – Decarbonising power generation by 2050 in Europe

Under the umbrella of Eurelectric, the chief executives of the European electricity sector signed a declaration whereby they commit to achieve carbon neutrality for their sector by 2050. They call on European policy makers to, inter alia, contribute to the deployment of a market-based approach to GHG mitigation; ensure that all carbon-free technologies can be used; increase R&D support, e.g. *on CCS; deliver an integrated market; promote energy efficiency and electricity use as solutions to mitigate climate change.*

Source: Eurelectric, 2009.

Reflecting the nature of the respective participants, some of these efforts are geared to identifying policy and technology solutions, while others provide advice that can be readily applied to lower emissions in plants. Some power sector utilities have worked together since 2000 under the umbrella of the World Business Council for Sustainable Development (WBCSD), and recently produced recommendations on mitigating GHG emissions in power generation. A running theme in these utilities' views is the different national circumstances with respect to regulatory frameworks and natural resource endowments, both of which should be taken into account in identifying best policy practice. The WBCSD provided a detailed review of policy support for various technology solutions, as well as general policy recommendations.

11. See, among others, IEA (2001) for a description of Eurelectric's early emissions trading simulations.

Box 7

Recommendations of the WBCSD Electricity Utilities Sector Project

Energy efficiency: encourage the use of flexibility mechanisms (emissions trading and crediting) for energy efficiency, especially for programmes of many small energy saving applications; provide an international platform for co-operation on energy-saving technology and policies; invest in international public-private partnerships for technology transfer; promote the protection of intellectual property rights.

Generation efficiency: provide platforms for the transfer of knowledge and best practice.

Solar power: set up a programmatic flexibility mechanism to support solar.

Hydropower: enhance opportunities for sustainable large hydropower projects.

Nuclear: collaborate on the development of the fourth generation (Generation IV) technologies; recognise nuclear in flexibility mechanisms.

Advanced coal: maintain eligibility under the flexibility mechanisms.

CCS: develop an international platform for national policy development; recognise CCS in flexibility mechanisms.

Source: WBCSD, 2008.

WBCSD recommendations show a focus on two elements: the need for international R&D and exchange of best practice; and the access of low-CO_2 energy solutions (on the demand and supply sides) to the flexibility mechanisms (*i.e.* emissions trading and crediting), including CCS and nuclear, so far not eligible as projects under the CDM.

On the energy efficiency side, an international policy movement has been initiated through the agreement on an International Partnership on Energy Efficiency Co-operation (IPEEC), signed in Rome on 24 May 2009. The Partnership signatories include: G8 countries, Brazil, China, South Korea, Mexico, the European Commission (as observer), with India, one of the founding members, to join soon.

Box 8

The International Partnership on Energy Efficiency Co-operation

IPEEC has been creatad to serve as a framework for international co-operation in promoting energy efficiency and energy savings. The overall objective of the partnership is to facilitate actions that yield high energy efficiency gains by providing a high-level forum for discussion, consultation and exchange of information. IPEEC does not aim to directly develop standards or efficiency goals for its members, however. Areas of co-operation within IPECC may include:

- *Support ongoing energy efficiency work in member states.*
- *Exchange information about measures to improve efficiency on sectoral or cross-sectoral bases, for example on: standards; methodologies for energy measurement; enabling environments to finance energy efficiency; public energy efficiency programmes; consumer awareness; policy evaluation; public-private partnerships; and dissemination of best practices.*
- *Develop public-private partnerships for improving energy efficiency.*
- *Enable joint R&D in energy-efficient technologies.*
- *Facilitate dissemination of energy-related products and services.*

The Asia-Pacific Partnership on Clean Development and Climate (APP) provides an example of an international co-operative sectoral approach geared to electricity supply, among other activities. Established in 2005 at the initiative of the United States, it promotes sector-specific co-operation among seven partner countries – Australia, Canada, China, India, Japan, South Korea and the United States, which together represent a very significant share of global GHG emissions (some 60%) as well as of the global GHG mitigation potential. APP is organised along eight public-private task forces: cleaner fossil energy; renewable energy and distributed generation; power generation and transmission; steel; aluminum; cement; coal mining; and buildings and appliances.

The task forces are technology oriented, and rely on a bottom-up approach. For instance, the iron and steel task force conducts data collection, estimates mitigation potentials through a common methodology combining the rate of diffusion of best available technologies and intensity benchmarking, and site visits to promote technology transfer based on performance diagnosis. It seeks to identify and overcome barriers to deployment and transfer of technologies. Clean technologies with environmental and energy saving benefits were compiled into 64 technologies, documented in a state-of-the-art clean technology handbook (SOACT). The iron and steel task force estimates a CO_2 potential reduction on the basis of 10 best available technologies and best practice at 127 $MtCO_2$ per year (Okazaki, 2009). Box 9 describes APP activities to date on electricity generation.

On paper, the best way to improve energy efficiency is to scrap old plants and build new plants with higher efficiency. While this process is ongoing, it is ineffective and too slow for putting developing countries on a lower emission pathway. Improving the efficiency of existing plants has the potential to affect emissions through technical capacity building in the near future, in a way that is also win-win for plant operators and for the environment. Further, it is essential that best practice in operation and maintenance is spread widely, as new plants, however high their design efficiency, could soon see it deteriorate without adequate maintenance. This requires well-trained operators and engineers. The APP task force in this sector clearly addresses this issue. These efforts could be replicated on a larger scale.

Box 9

Electricity generation activities under the Asia-Pacific Partnership on Clean Development and Climate

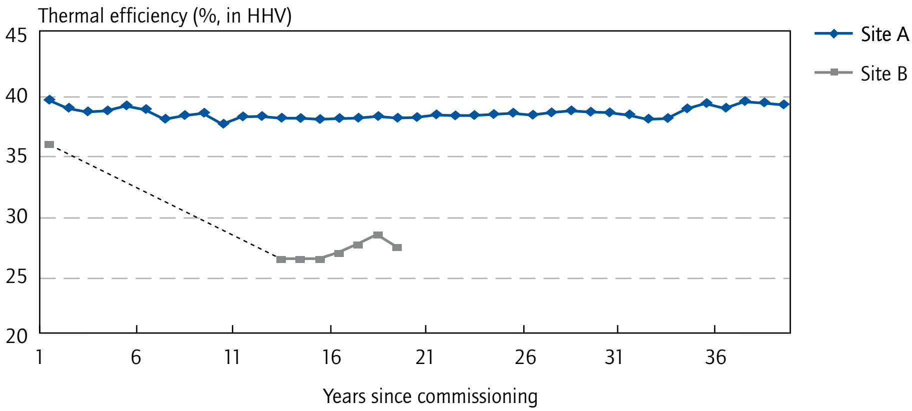
The power generation and transmission task force of the APP started in January 2006. Governments provide a platform, and coal-fired plant engineers from developed and developing countries exchange their views on the best practices in operation and maintenance. Peer review, a main activity under the task force, targets the minimisation of efficiency degradation so as to maintain thermal efficiency. It proceeds first with the gathering of data and analysis of plant specification and historical operation data, considering different loads. The peer review process developed a handbook, containing instructions on daily operation and maintenance technologies and practices. The handbook is being used among partners to enhance know-how and minimise efficiency losses. Other tools, such as a checklist and review sheets, were developed and implemented. These are usually followed by the identification of potential CO_2 reduction, based on improved operations and maintenance; the task force also develops a methodology to gather sample plant data for evaluation.

Source: APP, 2009.

Figure 11 illustrates an actual case of deterioration of plant thermal efficiency, from design level to actual operation; it also shows that new plants (site A) already operate at much higher efficiency and that, with proper operation and maintenance, efficiency can remain much closer to design level. The lower line on this figure (site B) shows that deterioration in conversion efficiency can be over 5 percentage points: in this particular case, the plant must burn some 24% to 27% more coal to generate the same quantity of electricity. This has negative implications for running costs and for the emission of CO_2 and local pollutants.

Figure 11

Evolution of plant thermal efficiency during years of operations



Source: The Federation of Electric Power Companies, 2009.

KEY MESSAGE

Thermal power plants can operate near design efficiency for decades with proper operation and maintenance. Their efficiency can deteriorate rapidly otherwise, which triggers higher energy input and cost, as well as unduly high CO_2 emissions for an identical level of electricity output.

A 1% to 1.5% recovery of thermal efficiency seems achievable among existing plants in APP countries; this would result in savings of more than 60 million tonnes of coal, amounting to a CO_2 saving of some 120 $MtCO_2$ annually (Maeda, 2009).

While the APP has not so far tackled the issue of a radical shift in the generation profile of countries, the generation and transmission task force has addressed an important, current challenge for power generators worldwide, *i.e.* the adequate maintenance and operation of existing plants. This issue is all the more important as new plants, regardless of their design, will also need improved maintenance if they are to deliver the expected reductions in CO_2 per unit of electric output.

The APP task forces contribute to sound policy-making through the gathering of information on a wide spectrum of technologies and best practices. They also provide a platform through which all countries can learn about best practice, and elaborate methodologies to gather relevant and comparable data. These best practices, if adopted by developing countries, could form the basis of measurable, reportable and verifiable actions under a future climate policy framework. All possible lessons from the bottom-up approach of the APP should be drawn as Parties consider whether to engage in international sector-specific discussions on mitigation.

Box 10

e8 climate change activities

e8 has prepared a compendium of good practices for development and deployment of different technologies. The compendium describes advances made by the e8 companies in a range of fields, including: energy efficiency measures (combined cycle gas turbine and other supply-side efficiency, energy efficiency in buildings); deployment of new technologies (CCS, improved nuclear reactors, combining thermal plants with solar fields, efficiency gains in coal plants); demand-side management (improved consumption monitoring and load curve services, energy-use diagnostics, diffusion of energy-efficient appliances); research and development (hydrogen, voltage regulation, energy storage technologies, wave power); and various partnerships (public-private partnerships on energy efficiency in construction projects, capacity building partnerships in developing countries). The e8 has also undertaken a number of innovative, not-for-profit capital projects to promote sustainable energy development and/or reduce greenhouse gas emissions worldwide.

See www.e8.org/index.jsp?numPage=46 for more information on e8 activities.

The above is by no means a comprehensive survey of efforts underway, as the following summaries indicate. e8, a group of large electricity producers operating in G8 countries, has contributed to GHG mitigation projects (sometimes registered under the CDM), as well as a range of analyses promoting cleaner electricity production (Box 10). The Committee on Power Generation Performance of the World Energy Council (2008) has developed tools to evaluate and compare power plant performance, with an aim to promote benchmarking. REN 21, the Renewable Energy Policy Network for the 21st Century, is another example of a global policy network that acts as a forum to promote renewable energy sources. The Renewable Energy & Energy Efficiency Partnership (REEEP) also fosters the development and the market of renewable energy and energy efficiency, with some funding for projects that seek to structure the regulatory and policy frameworks for further deployment of these technologies. Last, the previously mentioned IRENA and GCCSI reflect accelerated effort to co-ordinate policy in the RD&D of low-CO_2 supply technologies.

Conclusion

As countries envision their next steps to address climate change, a wide range of international policy approaches is on the table for their choice – especially in developing countries, where country-wide goals may not be agreed in the near future, and policy support may be needed to assist countries with meeting agreed sectoral goals. This chapter provided an overview of these options, to identify which sets of instruments are suited to address the problem of rising CO_2 emissions from power generation in developing countries.

The question for the current negotiations and future climate policy framework is how efforts will be shared to enhance emissions abatement in developing countries. The experience of the CDM, and the specificities of energy efficiency potentials and measures to exploit them, suggests a two-tiered approach:

- Energy efficiency on the end-use side could be supported through assistance to energy efficiency policy implementation and financing. The form and type of support would need to fit country capacities and policy frameworks. Some countries may be in a position to undertake these policies unilaterally as a contribution to international GHG abatement. Others may need more extensive policy support and financing.

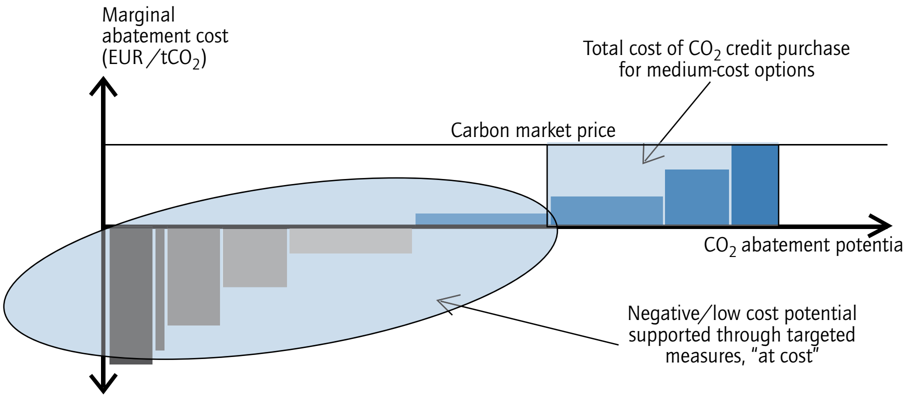
- Sectoral market mechanisms, on the basis of a "no-lose" target expressed in terms of CO_2 intensity, appear to be an option to start to diffuse a carbon price signal to the power generation sector in developing countries. Sectoral trading, with a cap on the sector emissions, may be interesting for more advanced economies.

This two-tiered approach may be an overly simplistic dichotomy: climate policy has taught policy makers about the fallacy of any "one-size-fits-all" approach. Whether on the end-use or supply-side of the equation, several different elements in the current climate negotiation can be brought to bear on efforts to reduce emissions from electricity. As will be presented in Chapter 4, some developing countries have elaborated domestic strategies to address CO_2 emissions from power generation, some of which may be enhanced by international support. However, situations differ in terms of: central and local government capacity; regulatory structures for power generation and energy efficiency policies; access to primary energy resources; access to technologies; and innovation frameworks.

The challenge for international climate policy-makers will be to design a streamlined approach to identify country needs, elaborate realistic and ambitious goals, and determine appropriate support in available finance and other mechanisms (see Kim *et al.,* 2009). In that respect, one advantage of the above two-tiered approach is that it would make it possible to support some measures – energy efficiency – at cost, while others could be more effectively financed via some new market mechanism, *i.e.* at carbon market price (Figure 12). The choice between approaches would have clear cost implications, a relevant question in light of heated discussions on finance in the UNFCCC.

Figure 12

An effective two-tiered approach to international mitigation support



KEY MESSAGE

Mitigation measures with clear economic and other benefits could be supported at cost. Others may rely on the carbon market, if practical. This strategy would come at lower cost than a full carbon market approach, in which all reductions would be acquired at carbon market price.

Chapter 3 explores further the policy options to encourage the power generation sector to adopt lower-carbon generation technologies, with a focus on how sectoral crediting may work in this specific context.

POLICY OPTIONS TO TRANSFORM POWER GENERATION

This chapter focuses on international instruments proposed to encourage low-carbon investments, which could be considered in power generation. Much of the discussion in international negotiations has focused on sectoral market mechanisms, meant to improve the competitiveness of low-CO_2 generation technologies. The study of these prospective sectoral market mechanisms reveals a number of features that are important for the success of any international effort to curb CO_2 from power generation in emerging economies.

Introduction

The power generation sector is on the verge of major new investment to replace its old capital stock while also meeting the surge in electricity demand – especially in developing countries. Developed countries have started implementing ambitious policy measures to lower the CO_2 content of their electricity generation, including emissions trading, renewable portfolio standards and feed-in tariffs, as well as various forms of support for nuclear power.[12] Efforts are also underway to develop the low-CO_2 technologies that could be deployed to further cut CO_2 – including CCS, large-scale solar plants, Generation IV nuclear, etc. All these measures will necessarily take some time to start curbing CO_2 emissions. Power generation capital stock turns over slowly and today's uncertainty in energy prices, CO_2 prices and other regulatory uncertainty seem to favour a "wait-and-see" approach; in Europe, this has prompted much investment in more modular, small-size natural-gas plants. While these are sometimes 50% less carbon-intensive than coal-based generation, they are only one small step towards a full decarbonisation of electricity.

Developing countries have a large potential to lower CO_2 emission growth in electricity. As chapter 4 will show, non-Annex I countries are taking measures towards that aim, although not at a pace consistent with the required action on global greenhouse gas emissions. The extent to which developing countries

12. Feed-in tariffs and certificate trading schemes are commonly used for the deployment of renewable energy. Other instruments have been used for the promotion of nuclear generation, *e.g.* loan guarantees by the Secretary of Energy for up to 80% of the eligible project costs, under Title XVII of EPAct 2005 (US DOE, 2009).

will undertake further efforts on their own, or require support for these, is up for negotiation in the UNFCCC.

The *WEO 2008* 450 Policy Scenario makes it clear that a significant price on CO_2 emissions is needed to trigger change in power generation – the 450 Policy Scenario illustrates this with a cap-and-trade system that would encompass power generation, but countries may adopt other measures to that effect, with a similar implicit price of CO_2. With USD 180/tCO_2, power generation emissions would be significantly reduced by 58% below 2006 emission levels in OECD countries in 2030, against a 4% reduction for the developing world – nonetheless a significant departure from business-as-usual trends. The 450 Policy Scenario also assumes significantly more efficient end-uses that lower demand for power, hence alleviating the cost of removing CO_2 at the generation stage.

The current situation is far from such a policy scenario. The question at this stage is about what would be a robust and realistic policy transition towards a global effort that resembles the 450 Policy Scenario of *WEO 2008*. The CDM is unlikely to impact the bulk of electric power investment choices, as shown by the growth in coal-based power generation in China and India since 2000. Curbing global CO_2 emissions growth requires moving to a broader, sectoral scale. In addition to difficulties related to CDM *per se*, there is pressure to expand crediting mechanisms coming from both developed and developing countries: first, developed countries wish to engage developing countries in mitigation activities on a bigger scale. This may be achieved by a broader coverage of the carbon market and a departure from the offset nature of the CDM. Second, developing countries are eager to develop more activities to benefit from carbon market revenues.

This chapter covers three important dimensions of sectoral market mechanisms, from the macro scale to the more specific domestic policy issues:

- What could be the amount of GHG credits generated by the power sector in developing countries? We address this question in the context of the 450 Policy Scenario.
- Market mechanisms require baselines from which credits would be determined: how could these baselines be defined?
- Domestic implementation: will carbon finance find its way to investors under a sectoral crediting mechanism?

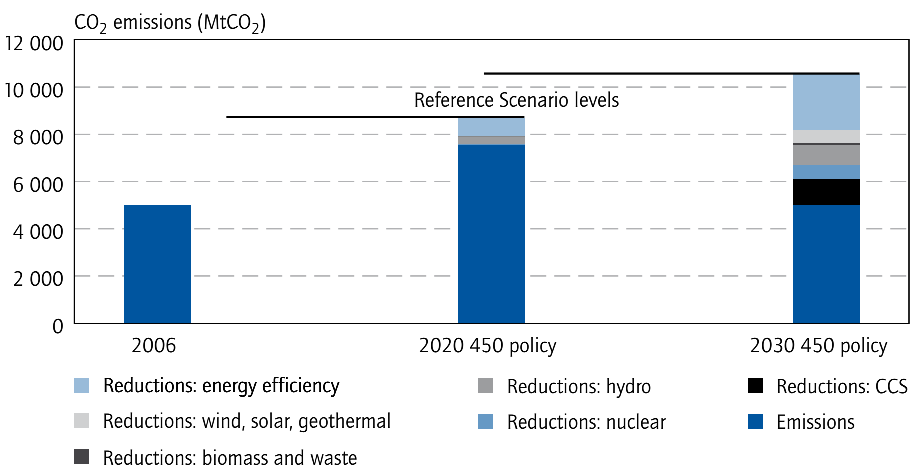
A sobering message on crediting reductions in power generation

Before turning to some of the practical questions laid out in the introduction, a fundamental question: can sectoral crediting be the sole instrument for GHG mitigation in the power sector? By crediting, we mean a transfer mechanism that rewards reductions below business-as-usual through payments via the carbon market, the way the CDM currently operates.

The answer is unequivocally no, or, rather: not as a sustainable policy option. This is best illustrated with figures from the *WEO 2008*. The following figure gives a breakdown of the sources of CO_2 emission reductions in various scenarios, measured in the power generation sector of so-called Other Major Economies (IEA, 2008g).[13]

FIGURE 13

Breakdown of emission reductions in the electricity sector of Other Major Economies



Source: IEA, 2008g.

KEY MESSAGE

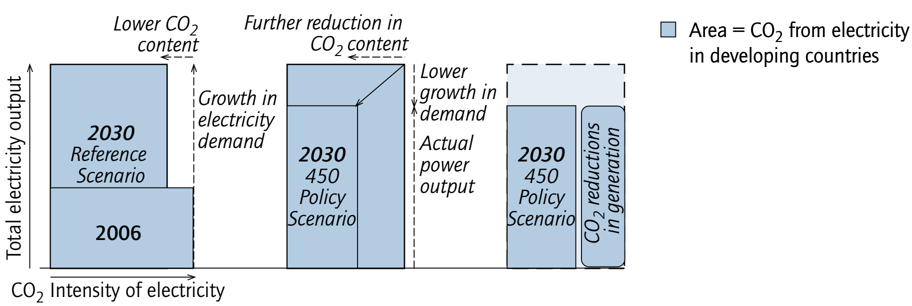
Under the 450 Policy Scenario of WEO 2008, emissions from the power sector of Other Major Economies would be cut by more than 50% from Reference Scenario levels, through end-use efficiency and the penetration of low-CO_2 technologies.

13. This group includes: Brazil, China, India, Indonesia, Iran, Russia, Saudi Arabia and South Africa (South Africa is, however, excluded from the modelling results in these scenarios).

Under crediting as it is currently known (*i.e.* project-based CDM), project performance is assessed against a baseline. In the case of power generation, the baseline could be expressed as the carbon intensity of power generation, in tonnes of CO_2 per unit of electricity output measured by megawatt-hours (tCO_2/MWh). Credits would be issued in quantities corresponding to the difference between actual performance and the baseline (in tCO_2/MWh), multiplied by the total output (MWh). The performance would be measured at the country level; how a country would then implement changes domestically is another question. The main difference between an absolute emissions cap and an intensity target is that the latter would not result in credits from savings achieved through lower electricity demand.[14] This is illustrated in Figure 14. In the policy scenario that we envision for sectoral crediting, we therefore deduct mitigation through end-use energy efficiency.

Figure 14

From power generation to generating CO_2 credits



Note: The above illustrates crediting for all power sector abatement in developing countries, on the basis of the business-as-usual (Reference Scenario) CO_2 intensity in 2030. CO_2 mitigation achieved through electricity savings would be subtracted from the equation: credits only applied to actual generation.
Source: Numbers taken from IEA, 2008g.

KEY MESSAGE

Under a crediting mechanism based on performance (CO_2 per MWh), credits are based on actual, not projected output. The quantity equivalent to the box labelled "CO_2 reductions in generation" would be eligible for crediting.

14. This is an important difference with an absolute cap on emissions, whereby all reductions below the agreed cap would be eligible for sale, whether they result from end-use savings and lower electricity output, improvements on the generation side, or any other external factor.

The *WEO 2008* did not explicitly simulate the implementation of sectoral crediting, but its scenarios provide an excellent reference to gauge the role of crediting, if it were the instrument chosen to drive a carbon price in emerging economies. Based on the emissions reductions in the 450 Policy Scenario, the annual reductions that would be eligible for crediting – following the above definition – would amount to 409 $MtCO_2$ in 2020 and 3 064 $MtCO_2$ in 2030 in the power generation sector alone. Adjusting for geographical coverage,[15] a sectoral crediting mechanism could generate as many as 2 700 $MtCO_2$ by 2030 in the 450 Policy Scenario, in the power generation sector alone. These preliminary numbers are striking on three grounds:

- Under the – arguably implausible – assumption that all such reductions would be credited, the 450 Policy Scenario would imply a carbon market value of some USD 490 billion in the year 2030 alone, based on the carbon price of USD 180/tCO_2 used in the 450 Policy Scenario.

- This quantity of credits would only have market value if developed countries took emission commitments stringent enough to require the purchase of this many credits to achieve compliance (2 700 $MtCO_2$ in 2030 alone).[16]

- In addition to power generation, other sectors may participate in the carbon market via sectoral market mechanisms; the Clean Development Mechanism would still be generating credits as well (see Box 11 for an overview of supply and demand in the context of sectoral market mechanisms).

There is an effort-sharing element in the elaboration of any sectoral trading mechanism; this extends beyond a technical analysis to the domain of international negotiations. Clearly this scenario would call for growing support for mitigation in major economies and other developing countries in the coming decades, while

15. We assume in particular that Russia would not be eligible for crediting as envisioned here, because as an Annex I country, it is expected to adopt a country-wide, ambitious mitigation objective. We therefore subtract Russia's power generation emissions from the total electricity-related emissions of the Other Major Economies group.

16. Under the 450 Policy Scenario, the emissions of OECD+ countries reach 8.2 $GtCO_2$, already 37% below current levels. For these countries to absorb the mere quantity of credits from power generation would require a commitment as low as 5.5 $GtCO_2$, a further 21% reduction.

some of these countries develop rapidly and increase their economic and technical capacity to address their emissions. This would suggest more active participation by developing countries. In terms of a crediting mechanism, this implies that not all GHG reductions should generate credits; the remaining reductions would represent the developing countries' contribution to the effort to reduce emissions globally.

While this may be needed in the case of least-developed countries, crediting all reductions from business-as-usual – as is done under the CDM – is an unlikely model for a sectoral market mechanism. The crediting baseline would have to be negotiated to ensure that host (developing) countries achieve some domestic reductions in emissions before they can be credited for additional ones.

Box 11

Sectoral crediting: an overview of supply and demand

Estimates of supply and demand for sector-based credits are plagued with uncertainty related to: the participation of various countries and sectors; how effective crediting would be in driving change at sectoral level; the possible compliance gap that would trigger credit demand; and possible restrictions of access to international credits.

- *The supply side for credits. Focusing on 2013-2020, a relevant time horizon for what may come into play after the Kyoto Protocol's first commitment period, mitigation potentials and crediting potentials in several key sectors and key countries under different policy assumptions give an idea of the potential credit supply in sectoral crediting mechanisms:*
  - *In the power sector, the potential crediting supply ranges between roughly 110 and 770 $MtCO_2$ per year mainly from China and other major emerging economies.*
  - *In the cement sector, the mitigation potential ranges between 450 and 720 $MtCO_2$ per year for China, Mexico and Brazil only.*
  - *In forestry, the mitigation potential in developing countries is estimated to be around 1.4 $GtCO_2$ per year, with much uncertainty.*

Following the logic of moving from projects (pure offsets) to sectors (with contribution to mitigation), the mitigation potentials ought to be higher than the amount that would could be credited.

- *The demand side for credits. Focusing on the European Union and the United States, whose policy positions seem to be at a more mature stage – albeit far from final – the average annual demand for international credits could amount to roughly 1 $GtCO_2$. Other industrialised countries are likely to augment this demand, although by how much is unknown. The general post-2012 policy trend seems to be towards a restricted, not unlimited, demand for credits.*

In summary, preliminary estimates suggest that as much as two-thirds of possible demand for credits could be met by the power sector alone – assuming that all major emerging economies participate. The total mitigation potential of the cement sector in Brazil, China and Mexico could meet the remainder, although no attempts at baselines were discussed here. This picture would have to be completed with the expected contribution of the CDM, and sectoral crediting estimates for other sectors. In some cases, supply could surpass the estimated demand by a wide margin, especially if forestry were eligible: its mitigation potential is larger than estimates for United States and European Union demands together.

The global supply-demand balance and factors that influence this balance need to be kept in close consideration when contemplating a sectoral crediting mechanism.

Source: Baron, Buchner and Ellis, 2009.

It is clear from the above that moving from a project-based to a sector-based crediting mechanism will require adjustments, reflecting the following issues:

- The importance of moving progressively away from the current CDM approach whereby all reductions are credited to host countries (the offset issue). Policy proposals on the table of the UNFCCC negotiations for a post-2012 framework (*e.g.* sectoral no-lose targets) assume that host countries would adopt ambitious baselines, thereby reducing the quantity of credits generated.
- The need to encourage early action, and pave the way for a more meaningful participation by developing countries in the global mitigation regime.

These issues can be addressed jointly in the discussion of methodologies to define the crediting baselines, *i.e.* the quantitative threshold level below which a country could receive credits for sale on the international carbon market.

Baselines for sector-wide crediting in power generation

The preceding section illustrated the importance of emission baselines in defining the role of sectoral crediting, both as a carbon market instrument, and as a tool to deliver global emission reductions.

Sectoral crediting supposes some deviation of the baseline from business-as-usual. This deviation reflects the host country's contribution to global mitigation. Below the baseline, the issued credits are "offsets" for emissions that occur elsewhere. Defining the baseline is therefore equivalent to setting the effort that a developing country participating in sectoral crediting would undertake to reduce global GHG emissions. In effect, this baseline cannot be the result of technical analysis only, it would eventually result from a political negotiation.[17]

Countries that wish to participate in a sectoral crediting mechanism would nevertheless need to evaluate their current performance (how many tonnes of CO_2 do they emit per MWh of electric output?), their options for improving on existing performance, and the cost of doing so.[18] These are country-specific questions, although answering them may require international support. How the baseline itself is designed is a question that must be addressed first. Several options are described below.

A sectoral crediting baseline inspired by the CDM

Attempts have been made to estimate crediting baselines for sectoral targets, and to draw scenarios in actual country situations. A method has been proposed, drawing from the CDM experience with projects in power generation, *i.e.* an actual, approved methodology for projects in this sector. In this method, the baseline emission factor (combined margin) is calculated from a weighted average of the emission factor of all existing power units and the emission factor of a cohort of the most recently built power units. This method was then applied

17. Alternatively, the process to define the "business-as-usual" could follow the CDM logic, *i.e.* be based on technical analyses and a set of principles. To go from this scenario to the baseline, a discount rate could be applied to the quantity of observed reductions. The effort-sharing aspect would be encompassed in the negotiation of the discount rate (see Schneider, 2008, and Chung, 2007).

18. Estimating the cost of avoiding CO_2 by switching to less CO_2-intensive technologies is not terribly complicated, as options are well known, and sometimes also limited by physical or technology constraints. However, this should be done on a country by country basis as economic conditions differ – energy prices, access to finance, procedures and lead-time for plants to come on line. See NEA/IEA, 2005 for a review of the cost of generating electricity.

to elaborate national crediting targets from 2005 to 2020 for seven[19] of the ten developing countries with the largest CO_2 emissions from electricity generation (Amatayakul *et al.,* 2008).

The above-mentioned study assumes an emission trend under business-as-usual, based on an expected improvement in intensity unfolding between 2005 and 2020.[20] The crediting target for 2020 is set as the weighted averages of the performance of all existing plants and that of new built plants (the weights would be negotiated). For a country where the emission factor in 2005 of existing power units is higher than for newly built units, the weighted averages for calculating the crediting targets are set to 0 for existing and to 1 for newly built power units. Conversely, for countries where the emission factor in 2005 is higher for newly built than for existing power units,[21] the weighted average is set to 0.5 for both categories.[22]

Credits are computed as the difference between the sector's overall performance and the baseline – individual plants are not evaluated against the baseline: it may well be that new coal plants are built in a country whose baseline intensity is lower than the performance of these plants. However, because they could be more efficient than existing coal plants, they would contribute to improve the country's overall performance. Put differently, the performance defined by a sectoral baseline is not a criterion stating that plants with lower performance should not be authorised and those with higher performance accepted. In the end, it is the average performance of the sector that defines whether or not the baseline is met.

Based on these assumptions, and different scenarios for emission reductions in individual countries, it is estimated that, under the most ambitious CO_2 reduction scenario, the average annual emission reduction credits would be 470 $MtCO_2$ between 2013 and 2020.[23] Credits, in this case, would amount to 74% of total annual emission reductions – the remaining 26% would be the countries' own contribution to global GHG reductions (Amatayakul *et al.,* 2008).

19. Countries included are: China, India, Indonesia, South Korea, Mexico, Thailand, and South Africa.
20. The 2020 performance (in tCO_2 /MWh) is set as a weighted average of performance of all existing power units and the performance of a recent cohort of plants, with weights of 0.25 and 0.75 respectively.
21. Cases where, for instance, the share of coal based electricity generation is higher in newly built power units than in the average of existing units.
22. The paper also points out that negotiating these weights internationally could be the mode of setting sectoral targets for the power sector in the context of the international climate negotiations.
23. The paper also calculates a fixed crediting target which gives slightly different results, but would represent a more uneven annual distribution of credits over the crediting period of 2005-2020 with a higher proportion of the credits being generated in the later years.

One drawback of these estimates is the absence of the CO_2 price as a factor driving electricity choices in the various scenarios – one would assume that a high international CO_2 price would drive more reductions, by creating an additional incentive to pursue mitigation. Further, we argue that a comprehensive approach to the power sector should also address demand growth. As a result, the mitigation scenarios should show a lower level of electricity output, and a correspondingly lower quantity of credits, if the "no-lose" sectoral targets were expressed in terms of CO_2/MWh. This study nevertheless provided a methodology that countries could use to implement a sectoral crediting mechanism, and one that relies on now well-known methodologies under the CDM (Amatayakul *et al.,* 2008).

Ideas for dynamic baselines

The above-mentioned study assumes a baseline that is fixed once and for all, over the agreed crediting period. Baselines could also be designed to be more dynamic, to reflect the evolution of best practice in the country over time. Further, they could be designed so as to allow an explicit negotiation on the stringency of the baseline. Such a methodology is explored here, and tested on a coherent climate policy scenario to 2020 (the *WEO 2008* 450 Policy Scenario), in which developing countries take measures to cut their CO_2 emissions, including through lower electricity demand and therefore lower supply.

We first illustrate a methodology that would seek to minimise the amount of data needed for implementation of the baseline. We then describe a more generic approach.

A crediting baseline without complete performance data

The baseline methodology described here is based on the following principles:

- simple implementation;
- minimal data requirements;
- incentives for early action, to catch the wave of electricity investment in its early phase;
- dynamic downward adjustment of the baseline, whereby with time the country contributes more to global mitigation, and less to "offsets".

The baseline would combine the existing performance of all plants and the performance of all new plants, averaged from year one of implementation. All *new* grid and non-grid connected power plants would be mandated to report their electricity output and CO_2 emissions, data which would be used to define the dynamic baseline over the years. The baseline would be defined as:

$$\textit{Crediting baseline} = A \times CO_2/MWh_{existing} + (1 - A) \times CO_2/MWh_{all\ new\ plants}$$

In this equation that defines the baseline, the performance of existing plants, a major component of the baseline level, could be evaluated on the basis of aggregate statistics (*i.e.* official statistics on total power output and fuel use in power generation in the recent past). Very precise information on the performance of existing plants would, in fact, not be critical: as the baseline would be a negotiated outcome, other parameters would be available to establish the baseline stringency.

The critical assumption is that this crediting baseline would apply only to new plants, with an aim to trigger as much transformation as possible in new investments and reduce the carbon lock-in related to new power demand growth. Figure 3 in Chapter 1 illustrated the significance of new plants in the CO_2 footprint of electricity in developing countries by 2030.

In general, this baseline equation would function as follows:

- The higher "A", the less stringent the baseline. The negotiation over the baseline, once there has been an agreed measure of the CO_2 intensity of existing plants, would focus on the value for parameter A.
- As the performance of new plants improves and more new plants come on line over the years, the baseline moves further away from the initial performance of the sector, providing an incentive to invest early in new, cleaner generation.

The following tables summarise the amount of credits generated in China and India in the year 2020, under different assumptions on the relative weight given to existing capacity (here, 2006, the latest year for which IEA had detailed data). The table offers a range of results, based on different values of A. It shows in particular: annual credits in the year 2020, the share of total reductions that are credited, and cumulative credits over 2010-20. Again, these numbers apply to new plants only.

For this particular scenario, Table 3 indicates a range of credits of 178 $MtCO_2$ to 667 $MtCO_2$ for China alone, based on different values for A in the above equation. With these values, crediting would amount to between 22% and 82% of the power sector CO_2 reduction from the Reference Scenario. In other words, China would contribute 78% of its effort to global mitigation in the first scenario (high), and only 18% in the third (low).[24] The medium and upper ranges of the cumulative volumes of sectoral credits in China alone (2.5 to 3.9 $GtCO_2$) are higher than the total amount of CERs from CDM power projects in the pipeline (about 1.4 $GtCO_2$).

Table 3

CO_2 crediting in power generation with a dynamic baseline methodology - Illustrations for China

China	Stringency		
	High (A = 0.2)	Medium (A=0.4)	Low (A=0.6)
Annual (2020)	179	423	668
Credits/total mitigation (2020)	22%	52%	82%
Cumulative (2010-2020)	1 117	2 540	3 963

In the case of India, based again on the 450 Policy Scenario, different values must be used to ensure that the defined crediting baseline does not exceed business-as-usual (see Table 4); a baseline that is too anchored to current performance – a high value for A – runs the risk of being above business-as-usual over the following decade. The choice of values for A used for China would result in a baseline that is above the business-as-usual; India would then be credited even if its emission trends stayed at business-as-usual, which is contrary to the logic of crediting, where only real reductions can be valued.

Table 4

CO_2 crediting in power generation with a dynamic baseline methodology - Illustrations for India

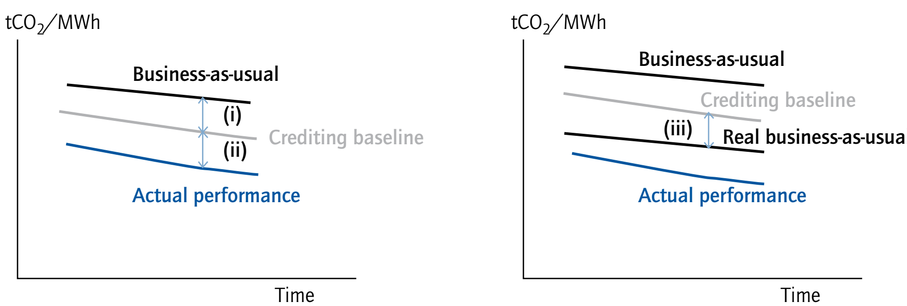
India	Stringency		
	High (A = 0.1)	Medium (A=0.2)	Low (A=0.3)
Annual (2020)	25	70	116
Credits/total mitigation (2020)	16%	44%	73%
Cumulative (2010-2020)	169	437	705

24. A recent study undertaken for the OECD Roundtable on Sustainable Development evaluated the potential credits generated from a sectoral crediting mechanism in the Chinese electricity sector. The study estimates the business-as-usual CO_2 intensity (BAU) and derives three intensity targets against this baseline. If the target is set at 1% below BAU some 500 $MtCO_2$ could be credited in 2020 and a cumulative 3 $GtCO_2$ between 2012 and 2020. By 2030 the potential for credit generation grows to 700 $MtCO_2$ per year and the cumulative flow of credits reaches 7$GtCO_2$. However, a target 5% below BAU halves the quantity of credits issued in 2012-30. At 10% below BAU, no credits would be generated in 2012-30 (Stephenson, 2009).

As is the case with other methodologies, Parties must have information on what a country is projected to do under business-as-usual conditions, so as to ensure that the crediting baseline is below this trend. The mechanism would otherwise generate credits that are not additional, with damaging impact on the global environment as more emissions would be allowed. On the left-hand side of Figure 15, the crediting baseline is set, appropriately, below business-as-usual. (i) represents the sector contribution to global emission reductions: as they are not credited, they will not be used as offsets for emissions elsewhere. Only (ii) are credited for sale. On the right-hand side, the business-as-usual has not been appropriately identified: the real business-as-usual is below the crediting baseline. Credits issued (iii) do not correspond to mitigation. When sold, these credits would offset emissions from other carbon market participants above their targets: the mechanism would therefore add to, not subtract, emissions in the atmosphere.

FIGURE 15

The importance of defining business-as-usual trends in a crediting mechanism



KEY MESSAGE

A reliable business-as-usual emission trend is an essential part of sectoral crediting. Picking the wrong level could lead to higher overall emissions, i.e. *"over-crediting".*

The 450 Policy Scenario, the basis of our illustrations, assumes improvements in the operating efficiency of plants that were in place in 2006, where much potential exists for cheap reductions through improved conversion efficiency. In the above estimates, these improvements are not credited as they occur in existing plants.

In the design phase of any environmental policy, the identification of covered sources is always important: which types of plants should it include, and which ones should be left out, and on what grounds? In the case of a rapidly expanding sector – the case here – the risk of carbon lock-in rests primarily on new capacity. There are pros and cons to applying the mechanism to new plants only:

- It would simplify measurement, reporting and verification of performance: a regulation could be introduced requiring all new plants to provide such information for the baseline.
- This would restrict the supply side of the sectoral crediting mechanism to new plants. All things equal, this would imply a higher price and therefore a stronger signal to investors in new capacity.
- On the negative side, improvements in pre-existing plants would not be eligible for crediting. The potential for efficiency improvements and for lower CO_2 emissions in existing coal plants would call for specific measures.

A dynamic baseline based on full performance data

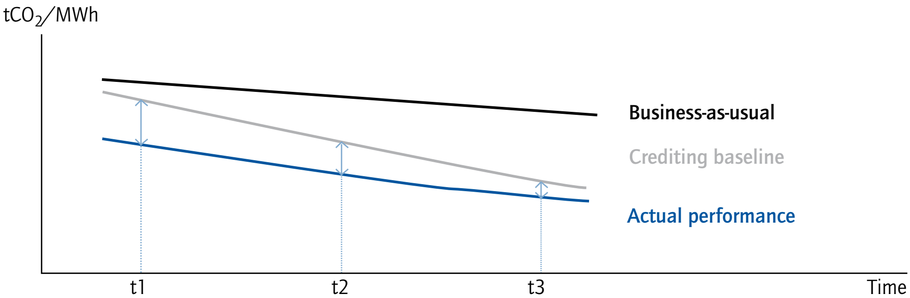
The above methodology illustrated how a baseline for sectoral crediting could be negotiated without requiring great accuracy on the performance of existing plants at the time when the baseline is established. This methodology would also focus on new plants, for which detailed data would be needed both for power generation and CO_2 emissions, to ensure that credits are gauged precisely.

Some countries, however, may have reliable data for existing plants and wish to build their baseline with their full performance data. Let us again assume that crediting would apply only to new plants. One straightforward option for a baseline consists in using the total average CO_2 performance of the sector (tCO_2/MWh), measured annually and to credit the cohort of new plants if their average performance beats the baseline. There would be no crediting if the new cohorts matched, on average, the existing performance, but any significant improvement in performance by these new plants would be rewarded. As new and cleaner generation comes on stream, it would contribute to lower the baseline, and fewer credits would be issued over time. This option would also provide more rewards to early action (see Figure 16).

Initial estimates of crediting with this methodology, based on the 450 Policy Scenario of *WEO 2008,* suggest that a discount factor would need to be applied to measured emission reductions to avoid over-crediting. The choice of the

FIGURE 16

Incentives for early reductions when the crediting baseline converges with performance



Note: Investments in low-carbon generation in t1 earns more credits than in t2 or t3. Existing CDM methodologies for clean-coal generation in China follow a similar logic, with the best, most recent plants being used as baseline. As time goes by and more new efficient plants are built, the baseline approaches the performance of new plants and reduces the amount of credits.

KEY MESSAGE

Crediting baselines can be designed to encourage early action, and to phase out crediting over time.

discount factor would then become the point for negotiation – the baseline, as we explained, would simply be the country's average performance, and new plants only would be credited. Here again, some knowledge of the business-as-usual trend would be required.

Summarising the key requirements of sectoral baselines

There is a range of open questions that would need answering if indeed a country were to propose a sectoral approach to power generation. These questions are both political and technical:

- *Choice of methodology:* should the baseline be fixed or dynamic, *i.e.* evolving with the actual performance of the country?
- *Data requirements:* we propose options that could focus on new plants. This would avoid a lengthy and costly survey of all existing plants and their performance. If that data were readily available, they would of course

facilitate baseline discussions. The set of data that seems critical, however, is a projection of performance under business-as-usual conditions, to ensure that the chosen crediting baseline represents a real reduction from what would have occurred otherwise.

- *Coverage:* there is a case to be made about new plants, for sectors that are rapidly growing, but existing plants should not be neglected as they are sometimes not operated in conditions that minimise their emissions. The crediting mechanism could either include all plants or be supplemented by other policy instruments to avoid further deterioration of existing plants and resulting higher emissions. This issue requires careful analysis, as experience shows that differentiating a refurbishment project from a new plant is not always straightforward.[25]
- *End-use efficiency gains:* as these are critical to curb power generation emissions, a sector-wide approach to the power sector should be assessed against the incentives for demand-side improvements. Intensity targets (in tCO_2/MWh) would in fact introduce a perverse incentive to increase generation if the sector's performance beats the baseline: any additional volume of electricity would mean additional credit revenues. Any crediting baseline set in intensity terms should therefore be accompanied by effective end-use efficiency policy to curb the growth in electricity demand.

In any case, the design of a sectoral market mechanism used in power generation should reflect the need to encourage immediate action, and to evolve towards lower levels of crediting as countries grow more capable of engaging in global mitigation. Various options, some of which were illustrated above, can meet these two objectives. One feature of these dynamic, evolving baselines may appear unsettling from a carbon market perspective: baselines would be constantly evolving with the sectoral performance. Whether or not this uncertainty prevents action at the domestic level is a question that must be addressed. It requires some understanding of how a baseline set for a sector (or a subset thereof) in a country would in fact encourage investors to shift towards cleaner generation choices. This critical issue is addressed next.

25. One possibility would be to define as retrofits projects that aim at restoring the efficiency of the plant back to its design level.

Triggering change with sectoral crediting: practical questions[26]

Experience with the Kyoto Protocol has shown that a number of steps are needed before emissions trading (including the project-based mechanisms) can lead to actual mitigation action. The adoption of national or sectoral emissions targets is a necessary, yet far from sufficient, initial step towards the diffusion of a carbon price to emission sources. This may be even more true for sectoral crediting, which represents a significant departure from the existing project-based approach of the CDM.

To credit or not to credit?

As defined earlier, sectoral crediting could operate from a baseline expressed as an intensity objective, expressed in tCO_2/MWh. A country would collect information on i) emissions in the sector and ii) electricity output. The tCO_2/MWh indicator, if above the baseline, would allow no crediting. If the sector were to outperform the baseline, credits would be issued, for a total quantity equal to the total generated output (in MWh) times the difference between the baseline level and measured performance (in tCO_2/MWh), as shown in Table 5.

TABLE 5

From performance to credits

Baseline	0.5 tCO_2/MWh
Electricity output	50 TWh (millions of MWh)
Performance (measured *ex post*)	0.45 tCO_2/MWh
Credits = (Baseline – Performance) * Output	(0.5 – 0.45) * 50 = 2.5 $MtCO_2$

At first glance, this is a mere extrapolation of how a CDM project operates: CERs are issued for avoided emissions from a baseline, taking output growth into account. In terms of incentives to actual plants and sectoral stakeholders, this approach is quite different from the CDM. A government could not just agree to a baseline and let the carbon market work its wonders to deliver GHG

26. This section relies extensively on Baron, Buchner and Ellis (2009), an IEA/OECD paper drafted for the Annex I Expert Group on the UNFCCC. The authors are grateful to OECD Environment Directorate colleagues and to Annex I delegates for their considerable help on this material.

reductions for crediting. This is because the country/sector performance is the sum of performance of several entities, each in a position to either improve on, or undermine the country's overall performance.

Three broad scenarios can be envisioned, with respect to individual source level performance:

1) Each individual source reduces emissions per unit of output below the sectoral intensity target (*i.e.* baseline) adopted at the national level.

2) Certain sources reduce their intensity below the target, while others do not. In aggregate, the sectoral performance is still better than the baseline.

3) Some plants implement improvements while most do not. Overall performance is worse than the baseline (*i.e.* a higher intensity). No credits are issued to the country.

From domestic policy to carbon revenues

A carbon market investor that considers improving a plant's performance for the purpose of selling credits would be deterred by the risk of having her efforts annihilated by the lack of progress among other entities. She would also need some clarity on how the government intends to reward progress, and to allocate possible crediting revenues to individual entities. This associated risk is illustrated in Figure 17. In this illustration, Group A contributes all of the country's reductions from baseline; Group B deteriorates overall performance. Group A cannot therefore be rewarded for all reductions below the country baseline. As only 2 $MtCO_2$ worth of credits are issued and sold on the international market, Group A could expect this as maximum revenues. Further deterioration of performance in Group B would lower that amount.

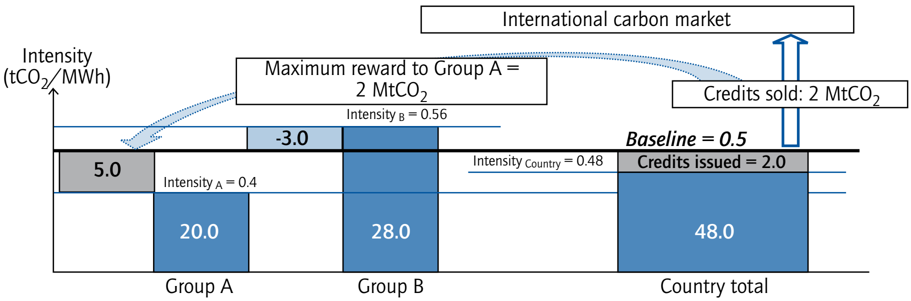
An effective domestic policy framework is therefore needed to encourage improvements and for domestic entities in a sector to outperform the baseline. Only then could governments raise carbon market revenues and decide on their use.

The following scenarios can be envisioned. All would involve a key role for the government:

- The government mandates an increase in the share of low-CO_2 generation technologies, at a level that would ensure that the baseline is outperformed. As utilities are government-owned in a number of developing countries, this

FIGURE 17

Sectoral crediting: how to reward individual performance?



Source: Baron, Buchner and Ellis, 2009.

KEY MESSAGE

Compared with a project-based approach, sectoral crediting blurs the carbon market incentive for individual investors.

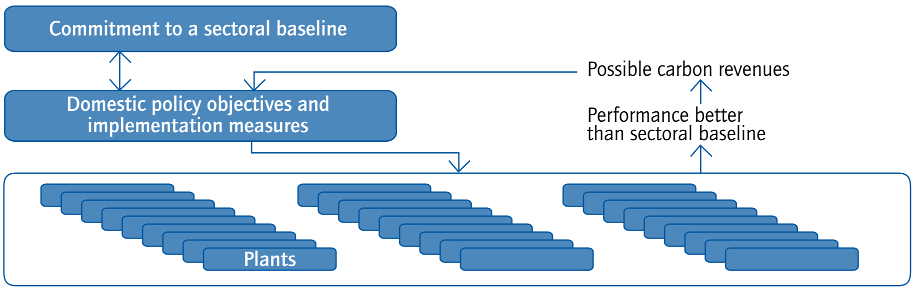
may be a plausible scenario. Credit revenues could either help to finance new low-CO_2 generation, or be directed to the general budget.

- The government mandates a general intensity improvement among its domestic entities (x% over a baseline level set at company level). Performance that exceeds the baseline would be rewarded, including via potential sales on the international carbon market; there would be a penalty for entities failing to meet the baseline.
- The government sets a minimum performance standard, in CO_2/MWh, for all new plants, at a level that would exceed the baseline. Credit revenues could pay back for some of this change.
- The government could decide to guarantee that all good performance below an indicated baseline would be rewarded by credits. It would essentially assume liability for those entities that did not perform well.

To be successful, a country that commits a sector to a sectoral crediting mechanism and an intensity baseline ought to accompany this decision with a coherent set of policies to drive change in power generation choices. There is not a direct path from the carbon market to the individual entities in such a system, so change must be driven by other policies. Carbon revenues appear to be a potentially useful add-on to other policy drivers.

FIGURE 18

Articulating a sectoral baseline commitment with domestic policy



KEY MESSAGE

A national sectoral baseline must be translated into a clear domestic policy framework to trigger change among plant operators and investors.

From a cost-effectiveness perspective, it is important that carbon revenues are used in a way that promotes least-cost solutions to CO_2 reductions in this sector. Some governments have already considered how to use credit revenues from the CDM to offset the cost of domestic policy objectives (Box 12). Revenues from a sectoral crediting mechanism could also be used to finance sector-level efforts, once they have been collected by the country's government. If the carbon price is to be an effective signal for change at a domestic level, one has to ensure that domestic policy frameworks in support of achieving the baseline are as closely linked to the carbon market revenues as possible. Much work remains to be done in this area.

A carbon price: necessary but not sufficient?

The prospect of possible credit revenues through a sectoral crediting mechanism can encourage countries to adhere to such a mechanism. To be successful, a range of policy options is available to trigger change, especially in the power sector. The recognition that a carbon price is eventually needed to encourage cleaner generation should not hide some of the realities of technological progress to date. Many low-CO_2 or CO_2-free technologies are not competitive on a large scale even at CO_2 prices in the European Union Emissions Trading System.

Box 12

Linking CDM revenues to the promotion of renewables

A number of developing countries have introduced support schemes for the deployment of renewable energy sources in electricity generation. In 2006, Pakistan introduced a policy to support small renewable energy projects (wind and small hydro), which accounts for the possibility for independent power producers (IPP) that develop renewable energy projects to be credited with CDM certified emission reductions. Under this policy, power distribution utilities must buy all the electricity offered by renewable energy projects. The tariff is set so as to guarantee a pre-agreed level of return on equity to the IPP. The policy encourages developers to apply for CDM credits and sets the rules on how possible carbon revenues ought to be shared:

- *A nominal fee shall be charged for the administration of the CDM side of the project.*
- *An amount paid to the power purchaser, equivalent to that required to bring the IPP's return on equity to the level allowed by the policy; this would compensate the power purchaser for the extra cost of acquiring renewable energy.*
- *The remaining revenues are to be divided equally between the IPP (enhancing the financial returns for the project investors) and the power purchaser (to lower the per unit price of renewable power and increase its attractiveness).*

The goal is to use CDM revenues to improve the competitiveness of renewable energy projects for both supply and demand sides.

Source: Puhl (2006), Government of Pakistan (2006).

The EU ETS is not yet ready to replace all existing renewable energy support schemes.[27] Few technologies can compete with centralised power plants even at the high CO_2 prices experienced in 2008 – before the crisis led to a slowdown in economic output and lower demand for CO_2 allowances. It is not realistic to assume that carbon revenues from sectoral crediting would be enough to support such technologies in the developing world, although these may present some important competitive advantages, due to low labour costs, or the availability of better wind, hydro and solar resources.

27. Vested interest in feed-in tariffs also play in favour of maintaining the systems in place, however.

As the next chapter will illustrate, some developing countries are actively developing their clean energy supply, with some contribution from the CDM. Countries may wish to increase their contribution to GHG reductions, and to the achievement of a sectoral baseline, through specific support for technology deployment objectives (Duan, 2008). Technology objectives could take a number of forms, *e.g.* a share of power generation to be produced by low-CO_2 sources; an absolute goal for capacity based on renewable, nuclear sources, or on CCS-ready plants.

One advantage of a more targeted approach to cleaner technologies is that it would identify areas where technology transfer is critical. For instance, a relatively low cost of CO_2 may be enough to make wind competitive with coal in a developing country, provided that the technology is manufactured domestically, as it would benefit from lower labour costs. The same technology, imported from developed countries, may require higher financial support to be competitive. The search for a least-cost strategy to reduce CO_2 emissions at a global scale would require that such barriers be identified, and work be undertaken to remove them. This can only be done through international discussions bringing together technology suppliers and local policy makers. Issues related to the access of foreign capital to domestic markets and intellectual property rights would need to be addressed in that context as well. The option of technology support in the context of a sectoral approach in developing countries could be a pragmatic way to engage such discussions.

There could, in this case, be two distinct contributions from the international policy regime to the improvement of the CO_2 content of the country's power generation sector:

- credits for CO_2 emission reductions below the sectoral baseline;
- direct support to achieve technology diffusion objectives.

Such policy pragmatism should nonetheless avoid locking in technologies that may, in the end, not represent the most cost-effective choice for CO_2 reductions – economists generally advise against setting technology-specific goals to reduce pollution on grounds that this approach can freeze innovation and may create too high a cost on covered entities. It is often preferred to express objectives in terms of overall performance *vis-à-vis* the environmental goal, such as emissions per unit of output for a given process. Even so, technological innovation would be best incited if participants were rewarded for going beyond the stated performance goal; GHG crediting would, in principle, create such an incentive.

Sectoral crediting: an intermediary step

This chapter focused on one particular option that relies on the growing carbon market to orient power generation choices towards more climate-friendly technologies. Sectoral crediting would represent a step change from the current project-by-project approach of the CDM. The purpose of a sector-based crediting mechanism is to broaden the reach of the international carbon market, and to provide incentives to move beyond business-as-usual on a sectoral basis. While it would require a comprehensive domestic policy framework to effectively drive change in power generation, it could also be designed to give the host country more freedom on options to achieve its goal – nuclear and CCS are currently not eligible under the CDM, while they are acceptable mitigation options for countries with emission caps.

Sectoral crediting mechanisms are put forward as tools to increase the contribution of developing countries to global mitigation – CDM allows only for cheaper mitigation options to be accessed by developed countries, but does not deliver emission reductions beyond those committed to by these countries. Sectoral crediting requires a negotiation of baselines for crediting that are below business-as-usual. Under one option in particular – the "no-lose" sectoral target – a country/sector could commit to a target, generate credits if it outperformed the target, but not be penalised otherwise.

Baselines for crediting could be designed in a number of ways. It seems essential that baselines encourage early action to minimise carbon lock-in. Ideally, they would also evolve towards a lower amount of credits in time, as host countries develop. The dynamic baselines described earlier, which are adjusted to reflect improvements in a sector's performance, could be used to that effect.

Sectoral crediting departs from an emissions trading instrument, in the sense that individual sources are not directly guided by the carbon price signal. In particular, a sectoral target expressed as an intensity target (tCO_2/MWh) would not immediately translate into company-by-company or plant-by-plant objectives. The carbon market finance could not effectively be put to work at plant level in such circumstances. To be credible, a proposal to achieve an intensity baseline ought to be accompanied by a set of policy instruments for its implementation.

Policies should include clear economic incentives to adopt low-CO_2 technologies, including specific support for those that are not mature enough to be supported by carbon revenues alone.

One way to harness carbon finance more directly is to introduce cap-and-trade at the domestic level, with absolute emission goals for all CO_2-emitting power plants and allocation of emission allowances that these plants can trade to achieve their goals at least cost – this is the approach taken in the EU emissions trading system, for the power sector and heavy industries in 27 European countries.[28] With the emergence of a domestic carbon price, emission allowances become an asset that can be monetised on the carbon market, as soon as allocation has been done – a clear difference from credits that are issued only after performance has been assessed at country level (Baron, Buchner and Ellis, 2009). Mexico is moving in this direction (see next chapter). Domestic cap-and-trade could be also used for a sectoral crediting mechanism based on an intensity goal. The European experience shows, however, that even at relatively high prices of CO_2, other policy measures are needed to foster the deployment of less competitive, clean generation technologies – not to mention dedicated energy efficiency policies to encourage end-use electricity savings.

Domestic cap-and-trade would also open the possibility for the adoption of a sectoral trading mechanism, whereby domestic entities could have immediate access to the international carbon market. Such linking would equalise the domestic and international CO_2 prices. A developing country would then need to commit to an absolute sectoral cap.[29] Whether and when developing countries will adhere to such an option is not a point for discussion here. It is nonetheless useful to consider today's policy choices as part of a continuum going from the current, project-based CDM to sectoral trading and national emission caps.

As the next step to engage developing countries, especially their electricity sector, sectoral crediting would pave the way for more ambitious sectoral trading. Many of the essential pieces needed for sectoral trading would be gathered through the implementation of a sectoral crediting mechanism (Baron *et al.*, 2009). Implementing sectoral crediting would require the collection of plant level data on CO_2 emissions; it could enhance greatly the visibility of climate goals among domestic energy stakeholders; it would create the need to develop

28. See IEA, 2005 for a full discussion of the role of emissions trading in international climate policy.

29. The Waxman-Markey bill agreed by the US House of Representatives only allows the import of emission allowances from sectoral mechanisms if these are based on absolute, not intensity, emission goals.

more ambitious clean technology deployment policies, and could foster more international collaboration on these technologies.

There is obviously not a one-size-fits-all solution to the question of electricity supply and CO_2 reductions in developing countries, from unilateral action to sectoral crediting or sectoral trading. There is of course a political dimension to the choice between one or another approach. Countries' national circumstances will also loom large.

While one should not prejudge the role of the sectoral market mechanisms in future climate policy, some realism is needed. The 450 Policy Scenario of *WEO 2008*, used here as the basis of crediting illustrations, shows that there would be limits on how many reductions may be credited in the end. It appears politically implausible that all power generation reductions from the Reference Scenario achieved in developing countries could be credited and absorbed by the carbon market. This question is primarily one for negotiators as it relates to the sharing of the global mitigation effort.

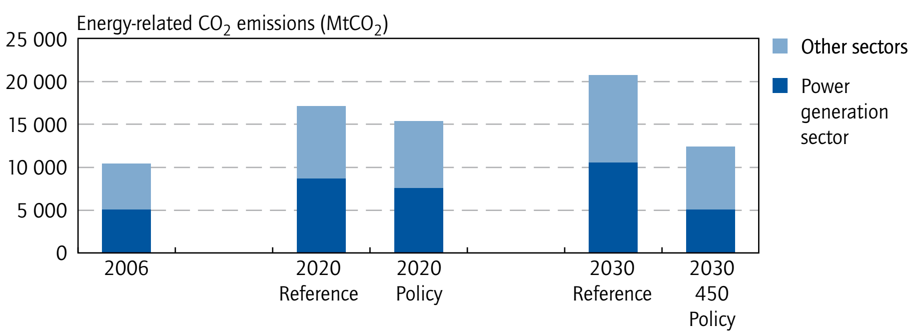
TARGETING CARBON LOCK-IN: CASE STUDIES ON ELECTRICITY

Introduction and scope

Developing countries already have policies in place that lower the CO_2 emissions of the electricity sector. For energy, economic and welfare reasons, these countries have taken a range of measures that sometimes result in lower CO_2 emissions – support for renewable energy deployment and minimum energy efficiency standards are obvious examples. These efforts to date may not be sufficient to stabilise the climate, but they could be useful foundations for more ambitious GHG abatement. They also rest on dedicated regulatory structures that could prove instrumental in this effort, while others may need reforming. Without pretending to comprehensiveness, this chapter documents some key elements that could form the basis of a sector-wide approach to electricity in emerging economies (referred to as Other Major Economies in *WEO 2008*, OME).[30]

Figure 19

Energy-related CO_2 emissions of Other Major Economies in *WEO 2008* scenarios



Source: IEA, 2008g.

KEY MESSAGE

Energy-related CO_2 emissions of Other Major Economies would be slightly higher than present under the 450 Policy Scenario, a substantial reduction from present trends.

30. Throughout this chapter, Other Major Economies includes Brazil, China, India, Indonesia, Russia and Saudi Arabia.

In the *WEO 2008* Reference Scenario, the generation of electricity in OME emits 5.0 $GtCO_2$ in 2006, 8.7 $GtCO_2$ in 2020 and 10.6 $GtCO_2$ in 2030, or about half of all energy-related CO_2 emissions in these countries (Figure 19).[31] The large size and rapid growth of this sector is evident in its share of global energy-related CO_2 emissions, growing from less than 20% in 2006 to more than 25% by 2030.

More striking still is the contribution that the power sector could make to global mitigation, if proper signals and policy instruments were adopted rapidly. In the 450 Policy Scenario, OME power sector emissions reductions reach 1.1 $GtCO_2$ in 2020 and 5.5 $GtCO_2$ in 2030, or some 68% of all energy-related reductions below the Reference Scenario. Emissions would roughly return to their 2006 levels, which requires a significant decarbonisation of power generation and much enhanced end-use efficiency in these economies.

The chapter examines issues confronting the implementation of sectoral approaches (SAs) in the power sectors of four high-growth economies in non-Annex I countries – China, India, Mexico and South Africa. These countries illustrate the diversity of situations, whether in the level of economic development, electricity generation and use per capita, as well as the CO_2 intensity of electricity use.

Box 13

Regional groups in *WEO 2008*

The analysis of this chapter focuses on four countries: China, India, Mexico and South Africa. In addition to publicly available information, the World Energy Outlook projections are used for the first three countries. In the case of South Africa, for which details are not available in the WEO 2008, *we rely on the country's own set of official climate policy scenarios. Following the regional breakdown of the* WEO 2008 *scenarios, we will refer to Other Major Economies (Brazil, China, India, Indonesia, Russia and Saudi Arabia – South Africa could not be included in this region for technical reasons); Mexico is part of the OECD+ region (OECD countries and non-OECD European countries).*

31. The emissions in the *WEO 2008* Climate Policy Scenario refer to physical emissions from a country – including emissions allowed or reduced as a result of emissions trading or crediting regimes. Consequently, the WEO Scenarios should not be seen as indicative of countries emission goals or commitments, whether in terms of emissions reductions or financing, under any global climate change agreement.

Table 6

Key electricity statistics for China, India, Mexico and South Africa

	China	India	Mexico	South Africa
GDP per capita, thousands USD, in purchasing power parity.				
1990	1.6	1.7	8.6	9.1
2000	3.9	2.4	10.0	8.8
2007	7.5	3.6	11.1	10.9
Electricity consumption, kWh per capita				
1990	511	276	1 326	4 431
2000	993	402	1 789	4 417
2007	2 328	543	2 028	5 013
CO_2 intensity of power generation, gCO_2/kWh*				
2000	765	939	566	893
2006	788	944	541	869
2007	758	928	547	845
Share of coal/peat in electricity generation, %				
1990	71	66	6	94
2000	78	71	9	93
2007	81	68	12	95
Share of gas in electricity generation, %				
1990	0	3	12	0
2000	0	8	19	0
2007	1	8	49	0
Share of oil in electricity generation, %				
1990	8	3	57	0
2000	3	5	48	0
2007	1	4	20	0
Share of non-fossil sources in electricity generation, %**				
1990	20	27	25	6
2000	18	17	23	7
2007	17	19	19	5

Notes: * Includes cogeneration and heat output. **Includes non-renewable waste.
Source: IEA statistics.

For each country, the chapter presents:

- power sector generation, consumption, emissions and capacity profiles;
- current power sector and electricity end-use policies – domestic and international activities;
- country-specific issues among the possible elements of sectoral approaches.

To be environmentally effective and cost-efficient, SAs and their supporting international actions must fit well with the developing countries' technical, economic, social and policy circumstances. The situations vary from country to country, so many SA elements must be individualised for each country. Part of the purpose of the case studies is to explore the balance of standardised and individualised features of SAs, with an eye on effectiveness, efficiency and the ease with which international negotiations could address sector-specific matters.

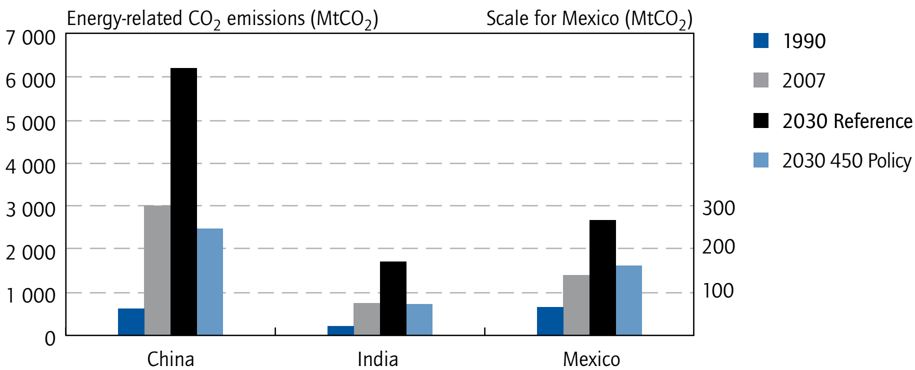
Another issue concerns the expertise needed for developing an effective and efficient mix of SA features. The SA package for individual developing countries cannot be determined by the international community alone. Articulating concrete international measures, as opposed to vague statements of support, requires an ongoing dialogue with the in-country policy makers and stakeholders. The in-depth dialogue is needed to determine the technical, financial, analytical and policy needs for mitigation in each country. Such dialogues, though not always aimed at SAs, have begun in some countries and provide valuable insights into the types of international action that would be useful.

Electricity generation and consumption overview

The power sector emissions in the case study countries vary considerably in size, expected growth and emissions reductions in the 450 Policy Scenario of *WEO 2008*. In 2007, total CO_2 emissions of China were four times those of India, which were three times those of South Africa, themselves nearly 60% greater than those of Mexico. Emissions growth rates in all countries have generally been high – with growth between 2007 and 2030 expected to reach 106% in China, 130% in India and over 90% in Mexico. China and India, the only two case study countries that are both in the OME group and have scenario data available, account for 70% of OME power sector emissions in 2006, 75% in 2030 in the Reference Scenario and 64% in 2030 in the 450 Policy Scenario.[32]

Figure 20

CO_2 emissions of power generation sector in China, India and Mexico in *WEO 2008* scenarios



Source: IEA, 2008g; IEA statistics.

KEY MESSAGE

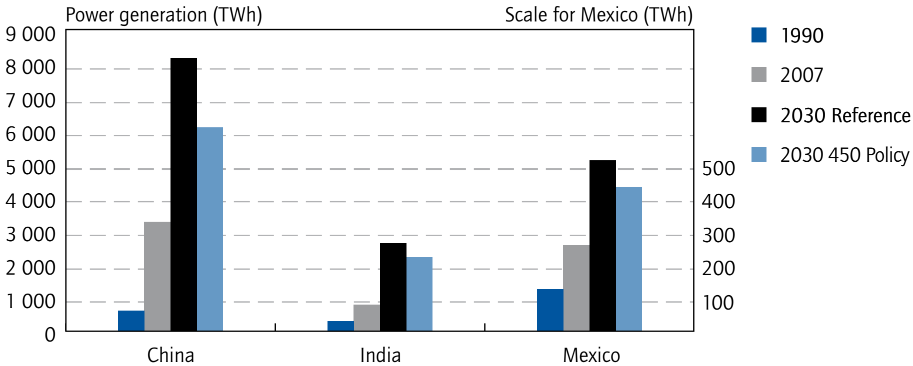
In China, India and Mexico, CO_2 from electricity could be maintained around current levels under the 450 Policy Scenario, with a proper price signal and intensive technology deployment.

Power generation levels among the case study countries show similar patterns as emissions levels, except that Mexico has comparatively greater generation than emissions, as it has considerably more gas-based generation than the other countries (Figures 20 and 21). The trends are similar to the emissions trends, but the magnitude of the changes differ, reflecting shifts towards less carbon-intensive fuels and technologies with time and policy ambition. The decline in generation levels in 2030 from the Reference Scenario to the 450 Policy Scenario – 25% for China, 16% for India and 16% for Mexico – reflect improved end-use efficiency.

32. Mexico is not part of the OME group; no scenario data is available for South Africa.

Figure 21

Electicity output in China, India and Mexico in *WEO 2008* scenarios



Source: IEA 2008g.

KEY MESSAGE

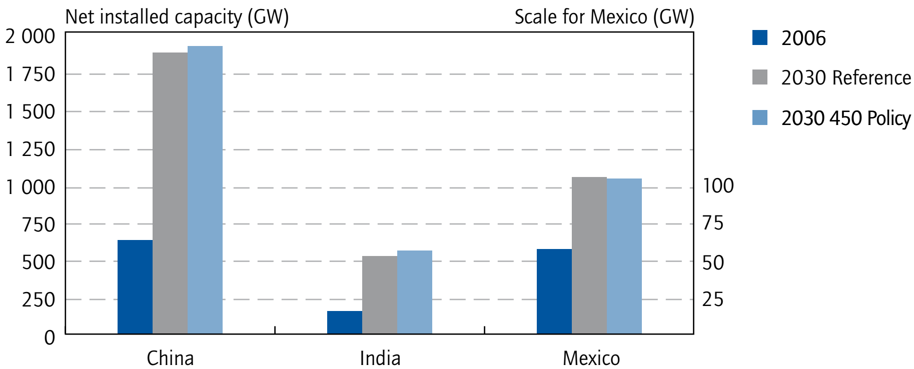
Electricity demand would grow significantly in China, India and Mexico, even in the 450 Policy Scenario, with some reductions achieved through energy efficiency policies and measures.

In all three countries featured in *WEO 2008*, significant additions in power capacity are expected under the Reference Scenario by 2030 – in China 1 250 GW, India 370 GW and Mexico 50 GW. The capacity is also higher in the 450 Policy Scenario, despite reduced demand, partly explained by the intermittency of some renewable sources and the lower efficiency achieved by plants fitted with CCS (Figure 22). Some of the pre-existing capacity is used less, as the result of a shift in the load curve from existing coal to less GHG-intensive generation sources. Considering the magnitude of the generation investment needed in both scenarios, the long lifetime of power plants and the diversity of available fuels and options, the dangers of carbon lock-in are apparent. The huge investment needed is both a threat and an opportunity. Major policy focus is needed for emerging economies to seize the opportunity now.

The fuels shares of power generation vary among the case study countries (Figure 23). Most notably, output in China, India and South Africa is primarily coal-based. In 2007, coal accounted for over 80% of output in China, 68% in India and 95% in South Africa; hydro accounted for 0 to 15%, while gas and oil

Figure 22

Installed power capacity of China, India and Mexico in *WEO 2008* scenarios



Source: IEA 2008g.

KEY MESSAGE

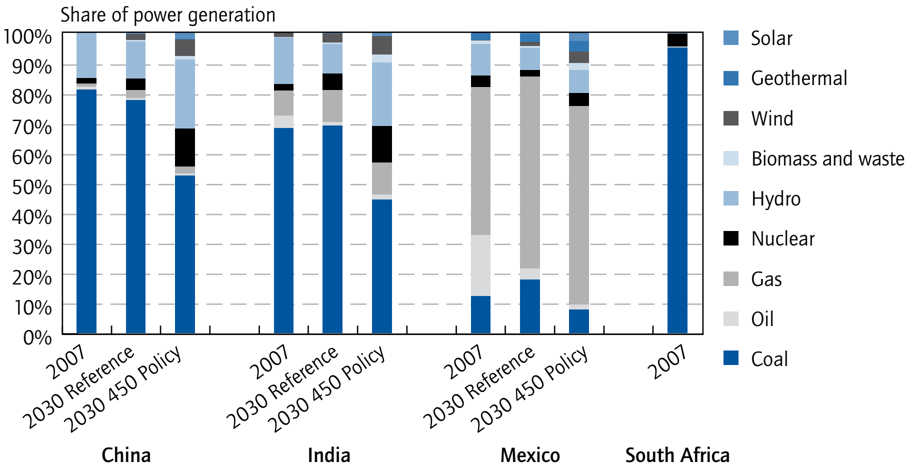
Installed generation capacity would grow significantly by 2030 in China, India and Mexico. The technology mix would differ radically between the Reference and the 450 Policy Scenario.

accounted for 0 to 8% in these countries. These shares shift slightly towards less coal in 2030 in the Reference Scenario, and to approximately 41% of coal in China and 36% in India in the 450 Policy Scenario. In contrast, power generation in Mexico is primarily gas- and oil-based. In 2007 gas accounted for 49% of Mexican output, oil 20% and coal 12%. In the 2030 Reference Scenario, the share of gas stays roughly even, but the shares of coal and renewables increase at the expense of oil.

The power consumption shares are different among the case study countries (Figure 24), but one common feature emerges: the industrial sector is the largest consumer of electricity in all of the case study countries – accounting in 2007 for nearly 70% of consumption in China; 45% in India; 56% in South Africa; and 58% in Mexico (by contrast, the industrial sector consumed 34% of electricity in the OECD+ group). The residential and commercial sectors are the next largest consumers of electricity – together accounting in 2007 for 19% of consumption in China, 30% in India, 34% in South Africa and 37% in Mexico. Agriculture accounted for 19% of electricity consumption in India, and less than 5% in the

Figure 23

Energy sources in power generation sector in China, India, Mexico and South Africa



Source: IEA, 2008g; IEA statistics.

KEY MESSAGE

Technology mixes would change significantly by 2030 to achieve the 450 Policy Scenario emission levels. Fossil fuels would still account for 50% or more of the total generated output.

other countries. The structure of electricity consumption changes very little by 2030 in either the Reference or the 450 Policy Scenarios – the shares change no more than a few percentage points.

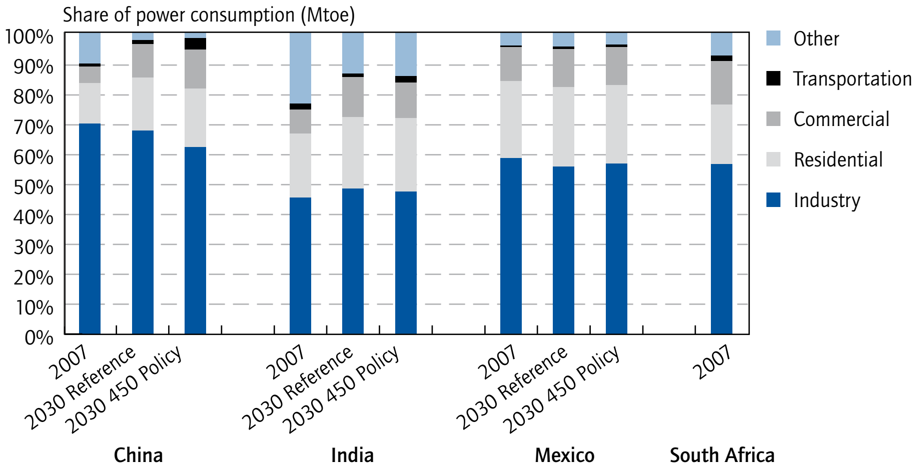
The most notable changes from 2007 to 2030 in the 450 Policy Scenario are:

- China: the five percentage point decline in industry, the 14 percentage point rise in the residential and commercial sectors and the three percentage point rise in transportation.
- India: the two percentage point increase in industry and five percentage point rise in the residential and commercial sectors, at the expense of a five percentage point decline in agriculture.

Figure 25 shows the sources of emission reductions in the 450 Policy Scenario in 2030. Electricity demand reduction (through end-use efficiency improvements) is

Figure 24

Electricity demand by end-use in China, India, Mexico and South Africa



Source: IEA, 2008g.

KEY MESSAGE

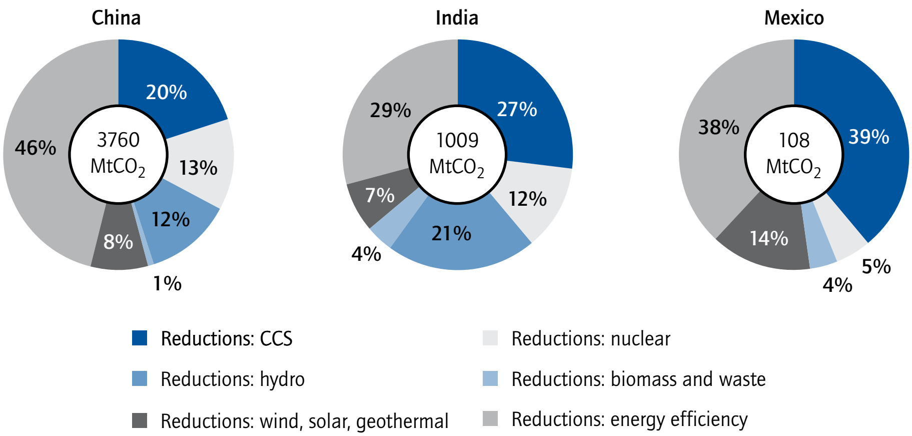
Industry remains a major user of electricity by 2030, in all four case study countries.

the largest contributor to power sector emissions reduction in all three countries, totalling 2.0 $GtCO_2$ in the 450 Policy Scenario. It accounts for 46% of the reductions in China, 29% in India and 38% in Mexico. The next largest sources of reduction in the 450 Policy Scenario are CCS (1 $GtCO_2$) and shifts to hydropower (0.7 $GtCO_2$), nuclear power (0.6 $GtCO_2$) and wind, solar and geothermal power (0.4 $GtCO_2$).

The importance of end-use efficiency actions stems not only from the magnitudes of the reductions in the *WEO 2008* scenarios, but also from their relatively low cost (many energy efficiency measures imply a lower overall cost for the same energy service delivered, than in the Reference Scenario) and their ability to relieve pressure on the supply system. Electricity demand has been growing so rapidly in China, India and other OME countries that planners and electricity supply operators are continually working under emergency circumstances. This forces them to develop public policies, physical capacity and operating procedures that are less than optimal for the long-term environmental, economic and social good.

Figure 25

Breakdown of emission reductions in China, India and Mexico in *WEO 2008* 450 Policy Scenario



Source: IEA, 2008g.

KEY MESSAGE

All options are needed to lower CO_2 from electricity: end-use energy efficiency, fuel switching, renewables (including hydro), nuclear and CCS.

Furthermore, end-use efficiency actions as part of SAs in the power sector would ensure that all important emission reduction opportunities are covered, as there is a risk that they could be overlooked. This holds for two major classes of electricity users:

1. Major emissions-intensive industrial users, which may take measures that cover their direct GHG emissions. Indirect, or offsite emissions (*e.g.* at power plant) resulting from industrial electricity use are not always included in the accounting of industrial emissions.

2. Other users – residential, commercial, less-emissions intensive industrial sectors and SMEs in emissions-intensive sectors – which are less suited to the more rigorous SAs being considered for the larger industrial emitters.

There is also a risk, if intensity-based emission goals were used in power generation, that countries and power generators would have no incentive to improve end-use efficiency, as these do not directly contribute to lowering the CO_2 *intensity* of generation.

The rest of this chapter covers each country in more depth.

China

Power sector generation, consumption, emissions and capacity profile

China's economy has been growing rapidly and this growth is expected to continue. As a result, annual electricity generation increased more than five times from 1990 to 2007, and would increase by another 100% (an additional 3 309 TWh) from 2007 to 2020, unless measures are introduced on the demand side. This growth alone is close to all fossil-fuel based power generation in OECD North America in 2006. By 2030, China's annual electricity generation would grow by a further 20% (1600 TWh) in the Reference Scenario (Figure 26). In the 450 Policy Scenario, the growth nearly ceases (a 2% rise) from 2020 to 2030.

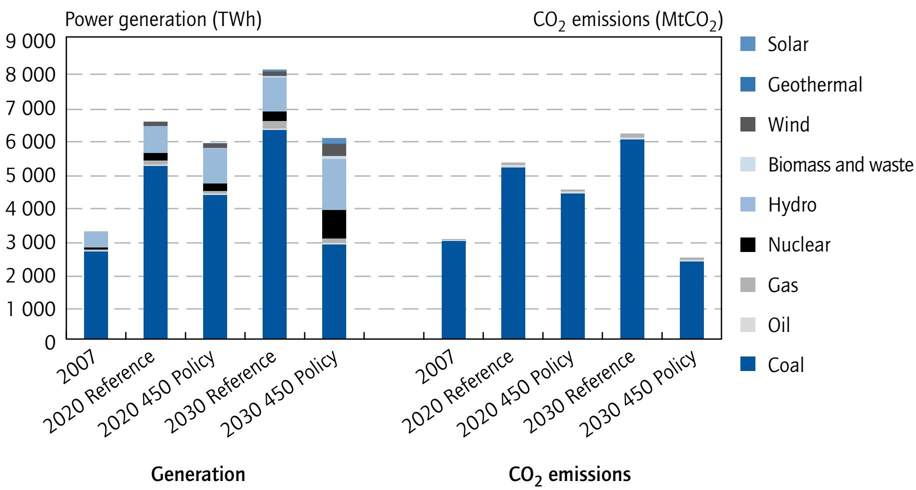
Chinese power generation is based predominately on coal. Coal's share of generation was approximately 80% in 2007, and changes little through 2030 in the *WEO 2008* Reference Scenario. In the 450 Scenario, coal-based generation falls 30%, and is below its 2007 level by 2030; part of this supply is fitted with CCS at that point, most of which is installed from 2020 onward. The shift away from coal is mainly toward nuclear- and hydro-based generation.

Electricity consumption follows the same patterns as generation in all the scenarios. Industry is the dominant consuming sector, accounting for two-thirds of consumption in 2007 and in 2030 in the Reference Scenario. In the 450 Policy Scenario, electricity consumption falls proportionally more in the industrial sector than in the other sectors, down to 62% in 2030 (Figure 27).

CO_2 emissions closely mirror coal-based electricity generation trends. CO_2 emissions rise from 3 029 $MtCO_2$ in 2007 to 5 340 $MtCO_2$ in 2020, and to 6 230 $MtCO_2$ in 2030 in the Reference Scenario. The 450 Policy Scenario records the most drastic evolution, with emissions falling to 2 470 $MtCO_2$ by 2030, some 18% below the 2007 level.

Figure 26

Electricity production and CO_2 emissions of China in *WEO 2008* scenarios



Note: CO_2 emissions include emissions from heat generation as well as electricity.
Source: IEA 2008g.

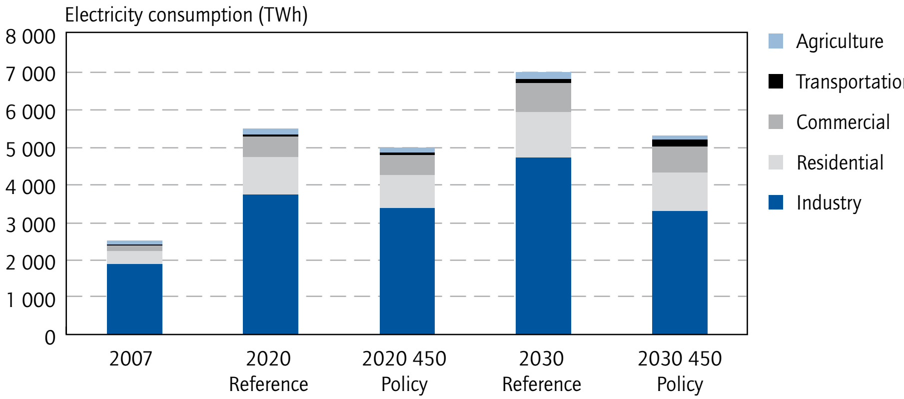
KEY MESSAGE

Under the 450 Policy Scenario, China would rely less on coal (with CCS). Nuclear, hydro and other renewables would account for half of total supply by 2030.

Table 7 summarises the trends in the two primary electricity supply indicators – electricity generation and absolute CO_2 emissions (electricity and heat) – in the two scenarios. Electricity generation (TWh) increase varies according to scenarios, doubling or more in the Reference Scenarios for 2020 and 2030, and increasing by over 80% in both Policy Scenarios. This upward trend is partially offset by the fall in carbon intensity in all scenarios, because of generation efficiency improvements, fuel switching and CCS. Despite declines in carbon intensity, they only result in an absolute decline in energy related CO_2 emissions in the

Figure 27

Electricity consumption of China in *WEO 2008* scenarios



Source: IEA 2008g.

KEY MESSAGE

Electricity end-uses would still grow significantly from today's levels in the 450 Policy Scenario, with industry accounting for some 60% of total consumption in 2030.

450 Policy Scenario in 2030 – for accounting reasons, the reported CO_2 emissions in the *WEO 2008* scenarios include heat generation, which is a significant source of CO_2 in China.

Table 7

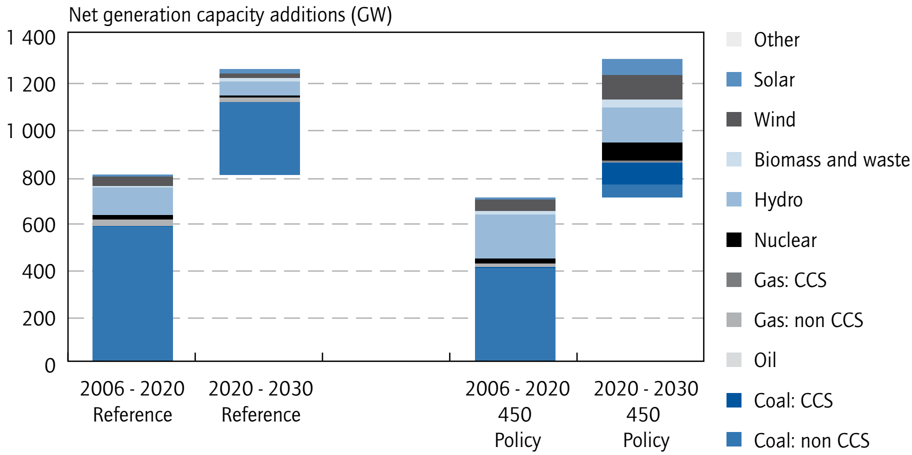
Evolution of power generation and CO_2 emissions in China in *WEO 2008* Scenarios (changes from 2007)

		Power generation (difference in TWh)	CO_2 emissions (difference in $MtCO_2$)
2020	Reference Scenario	100%	76%
	450 Policy Scenario	81%	50%
2030	Reference Scenario	150%	106%
	450 Policy Scenario	86%	-18%

Source: IEA Statistics; IEA, 2008g.

Figure 28

Electricity generation capacity profile of China in *WEO 2008* scenarios



Note: Some 1-2 GW of reductions in oil-based capacity in all three scenarios are not shown.
Source: IEA, 2008g.

KEY MESSAGE

The 450 Policy Scenario would see less new capacity installed by 2020 than under the Reference Scenario, with much additional capacity between 2020 and 2030, with some of the new coal and gas capacity fitted with CCS.

A large amount of investment in power generation, transmission and distribution capacity will be needed to meet power consumption needs in all scenarios. In the Reference Scenario, some 800 GW of net new capacity must be installed by 2020, and an additional 450 GW by 2030.[33] This compares with 620 GW of existing capacity in 2006, and approximately 706 GW in 2007. In the 450 Policy Scenario, some 615 GW of new capacity are needed between 2007 and 2020, with an additional 590 GW installed by 2030 in the 450 Policy

33. These figures refer to net additions to installed capacity. They do not include the capacity that must be built to replace retiring facilities.

Scenario. These trends highlight the importance of early actions (before 2020) to mitigate carbon lock-in. Electricity demand is expected to grow especially rapidly during 2007 to 2020, and the capacity built to meet that demand risks incompatibility – *i.e.* costly obsolescence – with low-carbon pathways unless early measures are taken.

The mix of the types and costs of new capacity vary considerably across the scenarios. In the Reference Scenario, some 71% of net additions are coal-based non-CCS power (increasingly supercritical plants) and 14% are hydro. In the 450 Policy Scenario, 35% of net additions are non-CCS coal, 26% are hydro, 12% are wind, 8% are nuclear, and 7% are coal with CCS (Figure 28). Despite reductions in demand, the costs of which are not factored in, the investment needs for generation are 40% higher in the 450 Policy Scenario than in the Reference Scenario.

Current power sector and end-use policies with effects on CO_2

China released the National Climate Change Programme (NCCP) in July 2007, and a White Paper entitled China's Policies and Actions for Addressing Climate Change in October 2008. The NCCP outlines the impacts that China faces from climate change. It also sets out a strategy to address climate change and sustainable development, including the mitigation actions that China envisages and has already adopted (Table 8). These include economic restructuring, energy efficiency improvement, vehicle emission standards, participation in international R&D programmes, development and utilisation of hydropower and other renewable energy, ecological restoration and protection, as well as family planning, among others. Many of these policies are from the 11th Five-Year Plan, which runs from 2006 to 2010.

The NCCP also indicates challenges in lowering the country's CO_2 intensity, given its existing resources (abundant coal), the resulting lock-in of coal-based energy infrastructure, limited access to more efficient technologies and limited finance.

A key to the country's contribution to lower greenhouse gases is its official energy efficiency objective of reducing energy consumption per unit of GDP by 20% by 2010, and of quadrupling GDP between 2000 and 2020 while only doubling energy use. In addition to this general goal, the government is to take measures to close small, less efficient industrial facilities in sectors including iron and steel, cement, aluminium, copper, glass or ceramics.

Table 8
Main features of China's National Climate Change Programme

Mitigation measure	Mitigation target	Expected GHG reductions
Economy-wide energy efficiency target	Reduce energy intensity 20% between 2005 and 2010.	700 $MtCO_2$ reduction in 2010 compared to baseline; 1 500 $MtCO_2$ reduction in 2010 compared to no intensity change.
Renewable Energy Law	16% of all energy is to come from wind, biomass, solar, and hydroelectric energy by 2020.	Wind, solar, geothermal, and tidal energy expected to have a total reduction of 60 $MtCO_2$ by 2010. Bio-energy is expected to create a 30 Mt CO_2 reduction by 2010. Hydroelectricity development is expected to reduce emissions by 500 $MtCO_2$ by 2010.
Promote nuclear power	Operating power capacity to hit 40 GW by 2020 from 8.6 GW in 2008.	50 $MtCO_2$ reduction by 2010.
Improve power sector efficiency	Close 50 GW of small, inefficient and dated power plant capacity by 2010 and develop 600 MW or above supercritical (SC) or ultra-supercritical (USC). 70-80% of new installations will be SC/USC units. Improve coal-to-electricity efficiency from 366 to 345 Gt coal equivalent per kWh from 2006 to 2020.	110 $MtCO_2$ reduction by 2010.
Develop coalbed methane industry	China targets 10 billion cubic meters (BCM) of gas production by 2010, and 40 BCM by 2020. The 11th Five-Year Plan also calls for the construction of 10 CBM pipelines.	200 $MtCO_2$-eq reduction by 2010.

(...continued)

Top 1 000 Enterprises Efficiency Programme	Cut energy use of the thousand most energy-intensive enterprises.	Cut 100 million tons of coal-equivalent energy consumption and 61 $MtCO_2$ annually by 2010.
Adopt national building codes for residential and commercial buildings	Between 2006-2010, new buildings are subject to the design standard of 50% energy conservation, and major cities (*e.g.*, Beijing and Tianjin) are subject to a 65% energy-saving standard.	Not available.
Establish energy efficiency appliance standards	Reduce residential electricity use by 10% by 2010.	In 2010, 33.5 TWh and GHG emissions are expected to be reduced by 11.3 $MtCO_2$, as a result of standards and labels for refrigerators, air conditioners, clothes washers, and televisions.
Fuel economy standards for vehicles	Passenger vehicles to meet 6.5 liters / 100 km in 2008. Standards for other vehicles under development.	A combined reduction of 488 $MtCO_2$ by 2030.
Closing inefficient industrial facilities	Decommission inefficient cement and steel factories with production capacity of 250 million tons and 55 million tons, respectively, by 2010.	Reduce coal consumption by 60-90 $MtCO_2$ per year by 2010.

Source: US Congressional Research Service (2008).

Recent work points out that most of the policies and programmes in the plan are not targeted primarily at lowering CO_2 emissions, but rather at broader economic development; energy efficiency, industrial policy and renewable energy development are the principal policy areas of this effort. In UNFCCC terminology, such policies would therefore qualify as sustainable development policies and measures, within which CO_2 mitigation is a by-product of other policy objectives. Behind some of these efforts is the country's broad energy efficiency objective of:

"reducing national energy intensity 20 percent below 2005 levels by 2010. Implementation of such centrally administered government targets has proven challenging, particularly at the local level. In an attempt to improve local accountability, the National Development and Reform Commission (NDRC) is allocating the target among provinces and industrial sectors, and energy efficiency improvement is now among the criteria used to evaluate the job performance of local officials" (Lewis, 2008).

After an initial reluctance to approve CDM projects, China is now the largest participant in the CDM. The country has registered 367 (of the 1 016 total) energy sector projects with an expected distribution of 60 million CERs by 2012 (or 58% of the world total).[34] Most of the CERs are to be issued for "Consolidated methodology for grid-connected electricity generation from renewable sources." It has been shown that all new hydro, wind, and natural gas-fired capacity is applying to the CDM (Wara and Victor, 2008). In light of China's domestic goals for renewable power development, which is not meant to be conditional on foreign assistance, this situation has raised concerns about the truly additional nature of these supply-side projects. While supporting renewable energy development is commendable, the issue is that CERs (*i.e.* emission offsets) are generated as a result, hence cancelling the environmental benefit of this policy development.

Coal and renewable power

China's NCCP contains provisions to improve power sector efficiency and a Renewable Energy Law. The measures improving power sector efficiency include: decommissioning small, inefficient power generators and accelerating the deployment of very advanced power plant technology (*e.g.* supercritical and ultra-supercritical combustion technology). A proposed project, supported by the World Bank, is to demonstrate the feasibility of significant efficiency improvements in small-size units in particular (see Box 14). The project is consistent with the goals for coal power generation in the 11th Five-Year Plan. In particular, coal-fired power generation units facing closure in areas with large power grids include: those below 50 MW; those below 100 MW and having operated for more than 20 years; those below 200 MW and having reached their design lives; those with a coal consumption 10% higher than the provincial average or 15% higher than the national average; those that fail to meet environmental standards (IEA, 2009a).

The NCCP measures are expected to reduce GHG emissions by 110 $MtCO_2$ by 2010 (CRS, 2008). A CDM methodology was recently adopted to consider crediting clean-coal technologies, whenever a new plant would show a level of performance that is above the most efficient recent built plant in the region. While such encouragement is welcome, there cannot be a guarantee that other plants, in the region, are not still built with much lower efficiency levels. A sector-

34. UNEP/Risø database, accessed 14 February 2009.

wide approach would avoid the CDM selection bias, whereby good performance is rewarded, while less efficient plants can still operate, or be installed.

Box 14

A Global Environment Facility project on thermal power efficiency in China

The World Bank, through the Global Environment Facility (GEF), is providing a grant of USD 19.7 million to the Government of China for a thermal power efficiency project.

China's coal-fired power plants consume considerably more coal per kWh of electricity supplied than the international average. In 2006 coal-fired generation in China consumed an average 366 grams of coal equivalent (gce) per kWh compared to a 300 gce/kWh benchmark in Japan or Europe. The main factors behind this low power generation efficiency are: a large share (27%) of generation by inefficient small units (less than 100 MW); generation dispatch not optimised for achieving maximum efficiency; small combined-heat-and-power units (CHP) operating for power generation only; relatively old mid-sized coal-fired units operating inefficiently. There is a potential to retrofit more than 100 units built in the 1990s, in the 100-200 MW range, and to convert 81 units of 300 MW to CHP generation.

Against this background the GEF project aims to support the closure of inefficient small coal-fired units representing a total capacity of 7 170 MW by 2010. The project seeks to demonstrate plant efficiency improvement through the conversion of mid-sized plants to CHP units, introduce waste heat recovery at one thermal plant, and improve efficiency at plant level based on recommendations from an energy audit. Furthermore, the grant will support transition to efficient generation dispatch with a view to maximise coal savings.

Source: World Bank, 2009.

The Renewable Energy Law is a framework policy that lays out the general conditions for renewable energy to become a more important energy source in China. It covers all modern forms of renewable energy, *i.e.* wind, solar, water, biomass, geothermal and ocean energy, but not low-efficiency burning of straw, firewood and other waste. Under the law, the State Council is responsible for overall implementation and management for the development and utilisation of renewable energy at the national level. It sets mid- and long-term targets for the total volume of renewable energy development, and prepares national plans for the implementation of these targets, in co-operation with the regional and local governments to reflect regional differences in the final plans.

There is clearly an emphasis on cleaner energy in China, notwithstanding the very rapid growth in coal-based power generation in recent years. The question is whether sector-wide crediting would push such actions much farther towards cleaner energy choices. As there are growing doubts over the true environmental additionality of CDM projects in this area, any sectoral crediting ought to be based on a clear understanding of business-as-usual trends, so as to define an appropriately ambitious baseline.

One positive sign is China's interest in sectoral goals on specific technology diffusion (Duan, 2008), which is in line with its domestic policy approach on the closure of less efficient plants, or target capacities for renewables. In light of past experience with environmental policy in China, it is also important that local governments be pro-active in driving changes. A proper monitoring, reporting and verification framework would be needed to ensure the credibility of actions.

Industrial energy use

A key to China's contribution to lower GHG is its official energy efficiency objective of reducing energy consumption per unit of GDP by 20% by 2010 and of quadrupling GDP between 2000 and 2020 while only doubling energy use.[35]

Two thirds of China's electricity is consumed by the industrial sector, a natural target for the country's end-use efficiency effort. The centrepiece programme is the Top-1000 Energy-Consuming Enterprise Programme (henceforth Top 1000 Programme), announced in April 2006, which covers 998 enterprises in the following sectors: energy production; textiles; iron and steel; chemical industry; construction materials; coal; petroleum and petrochemicals; non-ferrous metals; and paper. In 2004, these enterprises accounted for more than 33% of China's total energy demand and 47% of the total energy consumption of Chinese industry.

The Programme is modelled on the voluntary or negotiated agreement programmes used in some developed countries (most notably the Netherlands) since the 1990s.

35. This latter objective mirrors the four-fold increase in GDP with a two-fold increase of energy use that occurred in China between 1980 and 2000.

In these programmes, plants have had their energy efficiency potential assessed and negotiated targets with government agencies. Compliance with the targets is motivated by regulatory relief, tax exemptions, beneficial permitting provisions and public recognition. In addition, facilities are given assistance and tools – audits, assessments, benchmarking, information, training, technical assistance and financial incentives – to help in meeting goals (Price and Wang, 2007).

The Top 1000 Programme encompasses various goals for energy intensity performance (including some domestic and international best practice levels) and improvement rates for individual enterprise and product lines, as well as for sectors, provinces and the group as a whole over a five-year period. Overall the Programme seeks to save 100 million tons of coal equivalent (or 70 Mtoe) in the 11th Five-Year Plan. The enterprises sign conservation agreements with local governments, which in turn sign with the National Development and Reform Commission (NDRC). The responsible provincial officials are evaluated each year on their performance in achieving their targets. To ensure enterprises stay on track in meeting their targets, each company is expected to set up energy efficiency goals and to carry out a plan that incorporates: a conservation organisation; a reporting system; energy auditing; training and incentives; and investments in energy efficiency improvements. The enterprises report their energy consumption to the National Bureau of Statistics (Price and Wang, 2007).

Country-specific issues of sectoral approaches

In China, as in many other countries, there may be gaps between: climate and energy goals; the policies and measures implemented to achieve them; the potential for international collaborations to support progress towards low-CO_2 choices; and actual choices.

In the case of China, because of its prominent role in the global climate and energy picture, many groups from developed countries, including the IEA, are engaged in policy analysis and capacity building – *e.g.*, data collection and analysis; strategy building and joint technology initiative planning. Below are some recommendations of these groups concerning the issues outlined in the previous sections. These recommendations, on further corroboration with Chinese policy makers and experts, may be useful features of a strategy to tackle China's rising CO_2 emissions from electricity.

Coal and renewable power

The Pew Center on Global Climate Change and the Asia Society (2008) demonstrate how an international dialogue may lead to an international assistance package that could fit with the policy situation in China. The process – a bilateral US-China dialogue – arrived at a concrete strategy that includes the elements related to the coal and renewable energy provisions of the NCCP discussed in the previous section:

- Jointly assess and undertake immediate policy options to create new incentives to increase the efficiency of existing power plants; ensure that new plants utilise high-efficiency coal technologies.
- Jointly refine and develop new renewable energy technologies, such as solar electric and thermal energy storage and biofuel technologies.
- Share expertise in planning for the expanded utilisation of renewable energy through the assessment and mapping of renewable resources in the United States and China; planning of electricity transmission additions and upgrades; testing and certification of new technologies; and the quantification of the economic benefits of renewables.

Another analysis presents three different options for co-operation in the area of electricity efficiency (Chandler, 2008):

- Helping translate China's centralised policy on clean and renewable energy into tangible incentives at the provincial level:

  "The leaders among U.S. states in energy innovation, especially California, could provide assistance to Chinese provincial leaders struggling to deal with energy problems. The Chinese central government has set sound high-level policies for efficiency and clean energy development, but it leaves implementation to unprepared, underresourced provincial leaders. Beijing could support these provincial leaders by providing funds, training, expertise, and tax and regulatory flexibility to enable them to take decisive action to encourage clean energy investment. And the U.S. states could share their experience, providing advice on which policies actually work."

  The lack of relay of central policy at provincial government level was also noted in the IEA analysis of the coal sector in China (see Box 15).
- Joint R&D on clean technologies, for which China is in a position to share costs.
- Making climate co-operation integral to trade policy by agreeing only to export appliances, cars, and equipment with ambitious efficiency levels.

Box 15

Strategies and recommendations for improving the environmental performance of coal in China

The IEA conducted an in-depth analysis of China's coal sector value chain (Cleaner Coal in China, *released in April 2009). Its recommendations are geared towards turning China into the world champion in clean coal technologies, with a view to eventually develop CCS. The following points are relevant for the issue of sectoral approaches in power generation:*

- *To date, legislation on atmospheric pollution prevention and emission standards for power plants have not been successful, largely because of inadequate enforcement by provincial authorities. A more direct incentive through a price on pollution is needed, and market-based mechanism such as pollution taxes, feed-in tariffs or emissions trading should be central to China's pollution abatement strategy.*
- *Removing all forms of subsidies in the coal sector would allow more cost-reflective pricing (which should extend to the power sector) and sustainable coal use.*
- *Access to new technology is in many cases not sufficient. Adaptation of technology to local needs and the associated know-how are also needed. Removing barriers to encourage participation of foreign companies in key energy industries may be helpful in this context, as would further encouragement of joint ventures and foreign direct investments for both the import and export of clean technology.*
- *Focus on implementation and deployment of policies and technology at the lower levels of government. Implementation of strategies and policies need to be backed up with access to adequate resources at the lower level. Tension between state and provincial decision makers could pose a challenge to effective environmental protection.*

The stress on the need for regulatory changes, as well as on local government support, ought to be fully taken into account if new measures are to be effective in guiding investment in cleaner technologies.

Source: IEA, 2009a.

Industrial energy use

Other analysts assessed the status and plans of the Top 1000 Programme and offered 21 recommendations for measures to motivate enterprises to implement energy efficiency actions, as well as for tools to identify and assess the cost-effectiveness of energy efficiency actions. The suggestions for motivations included: national supporting policies; provincial supporting policies; investment incentives; taxes and fiscal mechanisms; and awards (Price and Wang, 2007).

The suggestions for tools included: energy management guidance; benchmarking tools; auditing improvements; sharing information sources and opportunities; monitoring and reporting guidelines; and a programme evaluation system.

The IEA energy efficiency concrete recommendations to the G8 leaders contain two items of direct relevance to the Top 1000 Programme: minimum energy performance standards for motors and energy management (see Box 16). Motor standards are a direct motivator – they motivate the purchase and use of high efficiency motors. Energy management is a tool to enable enterprises to more effectively track and more efficiently use the energy they consume. Both policies are applicable and important for all industrial enterprises – energy-intensive ones, such as the Top 1000 entreprises, and non-energy-intensive ones alike. The win-win aspects of these approaches provide the opportunity to enhance China's CO_2 abatement efforts, in line with its domestic policy goals. These measures would also facilitate a later transition towards less CO_2-intensive energy choices through carbon pricing at domestic level, if China wishes to implement such a measure.

Box 16

IEA energy efficiency recommendations and industrial energy use in China

Minimum energy performance standards for motors

- *Governments should consider adopting mandatory minimum energy performance standards for electric motors in line with international best practice.*
- *Governments should examine barriers to the optimisation of energy efficiency in electric motor-driven systems, and design and implement comprehensive policy portfolios aimed at overcoming such barriers.*

(...continued)

Energy management

- *Governments should consider providing effective assistance in the development of energy management (EM) capability through the development and maintenance of EM tools, training, certification and quality assurance.*
- *In addition, governments should encourage or require major industrial energy users to implement comprehensive EM procedures and practices that could include:*
  - o *The development and adoption of a formal energy management policy. Progress with implementation of this policy should be reported to and overseen at company board level, and included in the company report. Within this policy, companies would need to demonstrate that effective organisational structures have been put in place to ensure that decisions regarding the procurement of energy-using equipment are taken with full knowledge of the equipment's expected life-cycle costs and that procurement managers have an effective incentive to minimise the life-cycle costs of their acquisitions.*
  - o *The appointment of full-time qualified energy managers at both the enterprise and plant-specific level, as appropriate.*
  - o *The establishment of a scheme to monitor, evaluate and report industrial energy consumption and efficiency at the individual company, sector and national level.*
- *As a part of this effort, appropriate energy performance benchmarks should be developed, monitored and reported at levels deemed suitable in each sector.*

Source: IEA, 2008c

Reconciling China's priorities with climate change mitigation

China has already established ambitious energy efficiency and clean energy development objectives that contribute to limit the growth in electricity demand – a recent decision to support more efficient air-conditioning units and refrigerators is evidence of this priority.[36] IEA scenarios (among others) have

36. China aims to save 75 TWh of power per year, and about 75 $MtCO_2$, by promoting and subsidising energy-efficient air-conditioners and other home appliances. NDRC claims that this could raise the market shares of such appliances to over 30% by 2012 by subsidising sales. For energy-efficient air conditioners, the subsidy will be in the order of CNY 300 to 850 per unit (USD 44 to USD 125). The subsidies are expected to generate a substantial increase in consumer demand for such appliances (Reuters, 2009a).

illustrated the nature and magnitude of changes that are needed if ambitious climate mitigation objectives are to be achieved globally, and what such changes may involve in the Chinese case.

The next challenge is to determine how our current understanding of China's efforts could be strengthened to identify, in a collaborative fashion, areas of possible policy improvements, and narrow the gap between current trends and a lower CO_2 path. This is especially important whenever a potential for cost-effective energy and CO_2 savings can be exploited, in the interest of energy security, local environmental protection and economic welfare.

Box 17

Recent developments in China's nuclear energy goals

In late March, China's National Energy Agency (NEA) raised the country's 2020 nuclear power target to 75 000 MW of generation capacity, nearly double the initial target set in 2007 of 40 000 MW by 2020. The government aims for nuclear power to account for 5% of China's total generation capacity and 8% of its total power output by 2020, motivated by both economic and environmental reasons. At present, about 2% of China's total power generation is provided by nuclear power.

Source: Interfax, 2009.

As mentioned in the Introduction, in order to be effective international actions must be tailored to indigenous policy environments through a process of dialogue with domestic policy makers and stakeholders. Policy recommendations or support, without local ownership, is unlikely to lead to successful implementation. In the case of China, where new domestic goals are set frequently, and some goals met years in advance of the target date (see Box 17) while others lag behind, it is important to identify where support is really needed (*i.e.* what is the baseline level of domestic action).

India

Electricity generation, consumption, emissions and capacity profile

This section gives a quantitative overview of India's evolution in the power sector (output, carbon intensity, and absolute emissions), based on IEA statistics for 2006 and 2007, as well as on *WEO 2008* Reference and 450 Policy Scenarios.

India's economy is expected to grow rapidly, with annual electricity generation set to increase by 100% from 803 TWh in 2007 to 1 600 TWh by 2020 and to 2 600 TWh by 2030 in the *WEO 2008* Reference Scenario, assuming no new measures are introduced on the demand side (Figure 29). Generated electricity is similar in 2020 under the 450 Policy Scenario, but is 16% lower than in the Reference Scenario by 2030, thanks to end-use efficiency improvements. In the very ambitious 450 Policy Scenario, India's power output is still 170% above its 2007 level in 2030.

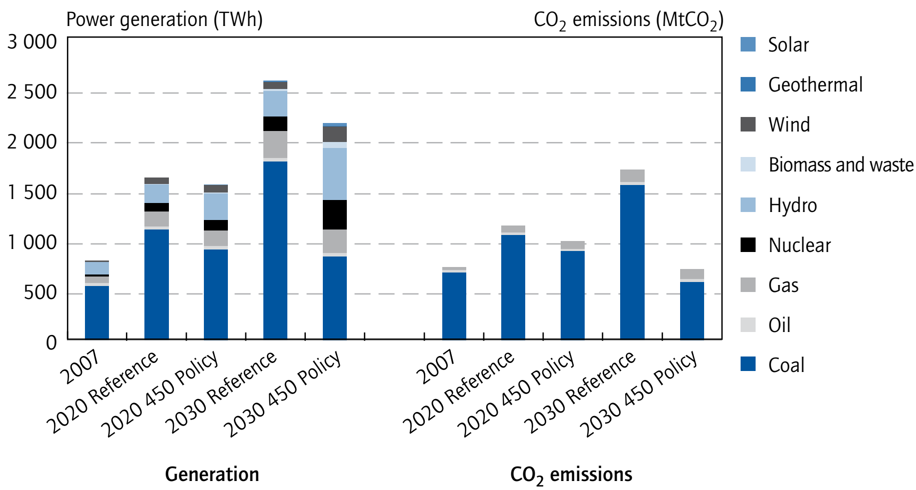
Indian power generation is based predominately on coal. Its share of power generation was 68% in 2007, and changes little by 2030 in the various scenarios. In the 450 Policy Scenario, coal-based generation grows from 549 TWh in 2007 to 900 TWh by 2020 (+67%) and goes down slightly to 850 TWh in 2030. A third of coal-based generation is fitted with CCS at that point (270 TWh). Most of the shift away from coal is toward hydro-, nuclear-, gas- and wind-based generation.

CO_2 emissions closely mirror coal-based electricity generation trends. CO_2 emissions rise from 745 $MtCO_2$ in 2007 to 1 160 $MtCO_2$ in 2020 to 1 700 $MtCO_2$ in 2030 in the Reference Scenario. The 450 Policy Scenario records the most drastic evolution with emissions falling to 720 $MtCO_2$ in 2030, 3% below the 2007 level, after having peaked at 1 $GtCO_2$ in 2020 (Figure 29).

India's overall electricity consumption follows the same trends as generation in all the scenarios. Industry is the dominant consuming sector, accounting for 45% of consumption in 2007, followed by residential (21%), agriculture (19%), commercial (7%) and transportation (2%). These shares change very little (mostly less than 4 percentage points) by 2020 and 2030 in the Reference or 450 Policy Scenarios. Only agriculture's share of electricity use changes by a higher percentage, falling to 14% in the 2030 Reference Scenario.

FIGURE 29

Electricity production and CO_2 emissions of India in *WEO 2008* scenarios



Note: CO_2 emissions include heat generation, which is a relatively small component in India.
Source: IEA, 2008g; IEA statistics.

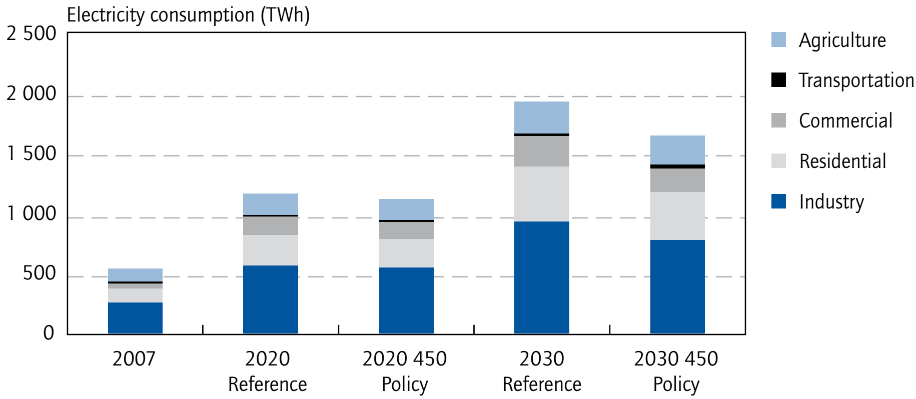
KEY MESSAGE

India's power supply witnesses massive growth between 2006 and 2030, with significant output coming from hydro and nuclear under the 450 Policy Scenario.

Table 9 summarises the trends in the three primary electricity supply indicators – power generation, carbon intensity and absolute CO_2 emissions – in the *WEO 2008* Reference and the 450 Policy Scenarios. The upward trend in power demand is partially offset by the fall in carbon intensity (gCO_2/kWh) in all scenarios, because of generation efficiency improvements, fuel switching and CCS in the 450 Policy Scenario only. The 450 Policy Scenario achieves a carbon intensity 32% below the 2007 level by 2020, the Reference Scenario achieves roughly the same level by 2030. By 2030, the power sector carbon intensity is 65% below the 2007 level in the 450 Policy Scenario. As strong as the decline in carbon intensity is, it only manages to bring emissions slightly below current levels by 2030.

Figure 30

Electricity consumption of India in *WEO 2008 scenarios*



Source: IEA, 2008g.

KEY MESSAGE

Electricity demand is expected to rise significantly by 2030, with or without climate policy. Efficiency gains would deliver some 15% of electricity savings between the Reference and the 450 Policy Scenario.

Table 9

Evolution of power generation, CO_2 intensity and emissions in India in *WEO 2008* scenarios (changes from 2007)

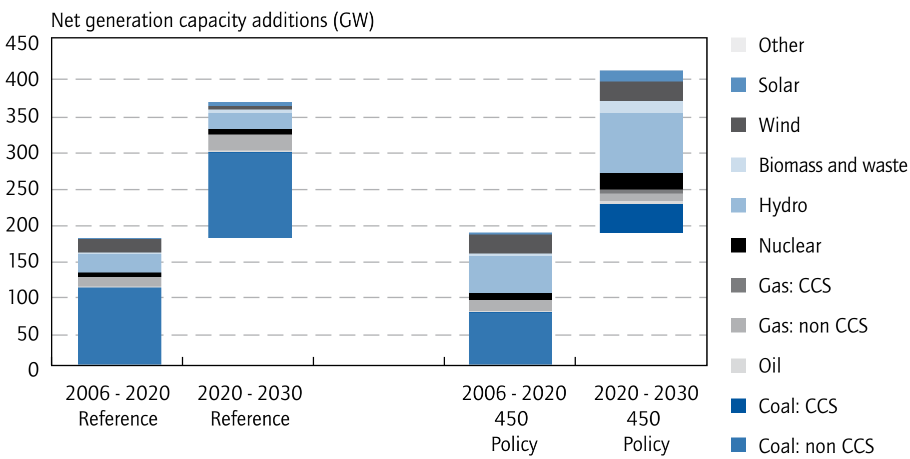
		Power generation (difference in TWh)	Carbon intensity (difference in gCO_2/kWh)	CO_2 Emissions (difference in $MtCO_2$)
2020	Reference Scenario	106%	-24%	56%
	450 Policy Scenario	96%	-32%	35%
2030	Reference Scenario	229%	-29%	132%
	450 Policy Scenario	174%	-65%	-3%

Source: IEA, 2008g; IEA statistics.

India will need to invest heavily in power generation, transmission and distribution capacity to meet its power consumption needs in all scenarios. In the Reference Scenario, some 180 GW of net new capacity must be installed by 2020, and an additional 190 GW by 2030.[37] This compares with 150 GW of existing capacity in 2007. In the Policy Scenarios, some 180 GW of new capacity are needed during 2007 to 2020, with an additional 230 GW needed by 2030 in the 450 Policy Scenario. These trends highlight the importance of early actions (before 2020) to avoid carbon lock-in. Electricity demand is expected to grow especially rapidly during 2006 to 2020, and the capacity built to meet that demand risks incompatibility – *i.e.* costly obsolescence – with low-carbon pathways unless early measures are taken. According to India's projections, 70% of the capacity that will be in place by 2030 has yet to be built (Kumar, 2009).

Figure 31

Electricity generation capacity profile of India in *WEO 2008* scenarios



Source: IEA, 2008g.

KEY MESSAGE

More than 100 GW of new hydro capacity would be built between now and 2030 under the 450 Policy Scenario, out of a total of 400 GW. In comparison with the Reference Scenario, coal capacity fitted with CCS, followed by wind, nuclear, solar and biomass-based plants would fill the gap left by lower investment in standard coal capacity.

37. These figures refer to net additions to installed capacity. They do not include the capacity that must be built to replace retiring facilities.

The mix of the types and costs of new capacity vary considerably across the scenarios. In the Reference Scenario, 62% of net additions are coal-based power (increasingly supercritical plants), 13% are hydro and 10% are gas. In the 450 Policy Scenario, 18% of net additions are non-CCS coal, 33% are hydro, 13% are wind, 8% are nuclear and 6% gas. Approximately 10% of the new capacity uses coal with CCS (Figure 31).

This picture of India's electricity sector would not be complete without a description of access to electricity services in the various scenarios. In 2007, the IEA estimated that some 412 million people had no access to electricity. By 2030, under the Reference Scenario, this number would be reduced to 60 million people, in rural areas. The 450 Policy Scenario is not expected to alter this evolution – it would rather encourage the diffusion of more efficient technologies and, in so doing, provide more electricity services to those that have access to the grid.

Policies in electricity generation and end-use with effects on CO_2

In June 2008, India released its first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programmes directed at climate change mitigation and adaptation. The plan outlined eight "national missions" running up to 2017, and directed ministries to submit detailed implementation plans to the Prime Minister's Council on Climate Change by December 2008 – these implementation plans are behind schedule. The eight missions – focusing on energy efficiency, solar power, urban planning, water, Himalayan adaptation, forestry, agricultural adaptation and strategic knowledge – and their goals and recommended actions are shown in Table 10.

Enhanced energy efficiency

The National Mission for Enhanced Energy Efficiency (NMEEE) is meant to build on the *Energy Conservation Act 2001*, which requires large energy consumers to adhere to energy consumption norms; new buildings to follow the Energy Conservation Building Code; and appliances to meet energy performance standards and to display energy consumption labels. As of April 2009, the final implementation plans for the missions of the NAPCC had not yet been announced. However, a short overview of the planned energy efficiency initiatives had been released for public comment.[38] The broad elements are shown in Table 11.

Table 10

Main features of India's National Action Plan on Climate Change

National missions	Goals and recommended actions
National Mission for Enhanced Energy Efficiency (see discussion below)	To yield savings of 10 000 MW by 2012. • Market based mechanism, with trading of "white" energy savings certificates, for energy-intensive industries – Perform Achieve and Trade (PAT). • Energy efficient appliances – Market Transformation for Energy Efficiency (MTEE). • Financing demand side management – Energy Efficiency Financing Platform (EEFP). • Fiscal instruments – Framework for Energy Efficient Economic Development (FEEED). • Power Sector Technology Strategy.
National Solar Mission	To promote the development and use of solar energy for power generation and other applications. • Specific goals for solar thermal technology use in urban areas, industry, and commercial establishments. • A goal of increasing production of photovoltaics to 1 000 MW/year. • A goal of deploying at least 1 000 MW of solar thermal power generation. • Other objectives, including the establishment of a solar research centre, increased international collaboration on technology development, strengthening of domestic manufacturing capacity, and increased government funding and international support.
National Mission on Sustainable Habitat	To promote energy efficiency as a core component of urban planning. • Extending the existing Energy Conservation Building Code. • A greater emphasis on urban waste management and recycling, including power production from waste. • Strengthening the enforcement of automotive fuel economy standards and using pricing measures to encourage the purchase of efficient vehicles. • Incentives for the use of public transportation.
National Water Mission	To improve water use efficiency by 20% to combat water scarcity projected to worsen as a result of climate change. • Pricing and other measures.

38. http://www.energymanagertraining.com/NAPCC/main.htm

National missions	Goals and recommended actions
National Mission for Sustaining the Himalayan Ecosystem	To conserve biodiversity, forest cover, and other ecological values in the Himalayan region, where glacial water supplies are projected to recede as a result of global warming.
National Mission for a "Green India"	To afforest 6 million hectares of degraded forest lands and to expand forest cover from 23% to 33% of India's territory.
National Mission for Sustainable Agriculture	To support climate adaptation in agriculture. • Development of climate-resilient crops. • Expansion of weather insurance mechanisms. • Agricultural practices.
National Mission on Strategic Knowledge for Climate Change	To gain a better understanding of climate science, impacts and challenges. • A new Climate Science Research Fund. • Improved climate modelling. • Increased international collaboration. • Encouragement of private sector initiatives to develop adaptation and mitigation technologies through venture capital funds.

Source: Pew Center on Global Climate Change, 2008.

Table 11

Main features of India's National Mission on Enhanced Energy Efficiency (preliminary)

Main elements	Activities
Perform Achieve and Trade (PAT)	A market-based mechanism, with trading of energy savings – "white" –certificates, to enhance energy efficiency in designated consumers (*i.e.*, large energy-intensive industries and facilities).
Market Transformation for Energy Efficiency (MTEE)	Accelerated shift to energy efficient appliances in designated sectors through: • National CDM Roadmap; • Programmatic CDM for lighting (Bachat Lamp Yojana), municipal demand-side management (DSM), agricultural DSM, small and medium-sized enterprises (SMEs), commercial buildings and distribution transformers; • Standards and labels for appliances and equipment in homes, hotels, offices, industry and transport; • Public procurement;

	• Technology programme, replacing inefficient appliances by efficient products; • Energy Conservation Building Code (ECBC) for new commercial buildings and existing buildings (through retrofit); • Promotion of Energy Service Companies (ESCOs), through accreditation and demonstration projects; • Capacity building and information, including continuing the training of Energy Auditors and Energy Managers; • Policy transparency.
Energy Efficiency Financing Platform (EEFP) and Framework for Energy Efficient Economic Development (FEEED)	Creation of mechanisms that would help finance demand-side management (DSM) programmes in all sectors by capturing future energy savings, including: • Fiscal instruments, such as tax exemptions for the profits and gains made from energy efficiency projects by ESCOs and venture capital funds, and reduction of VAT for energy efficient equipment (*e.g.* CFLs); • Revolving fund to promote carbon finance; • Partial Risk Guarantee Fund to provide commercial banks with partial coverage of risk exposure against loans made for energy efficiency projects.

Power Sector Technology Strategy	Enhancement of the energy efficiency of power plants by:
	• Adopting energy efficient generation technologies in new plants including supercritical boilers;
	• Phasing out of old inefficient coal fired units;
	• Improving energy efficiency in existing plants:
	  • Major renovation and modernisation (R&M) and efficiency improvements in 210, 250 and 500 MW units that make up 80% of capacity;
	  • Reduction in transmission and distribution (T&D) losses;
	  • Mapping of thermal power stations;
	  • Energy efficiency cells at power stations;
	  • Energy audit of power plants.
	• Roadmap for IGCC demonstration plants;
	• Development of know-how for advanced super-critical boilers;
	• Roadmap for fuel shift;
	• CDM projects using the emission factors collected by the Central Electricity Authority (CEA) to establish baselines.

Other initiatives	• Establishment of Energy Efficiency Services Ltd., a public sector company, to address all the issues/barriers which impede investments in energy efficiency projects, and function as a consultancy organisation, resource centre and an ESCO.

	• Strengthening the institutional capacity of State Designated Agencies (SDAs) to perform their regulatory and facilitative functions in their respective states. • Government funding for infrastructure creation that is necessary for the Bureau of Energy Efficiency to implement eight new projects in the XIth plan. • Awareness programmes, including information campaigns in schools, industry, commercial, agriculture and domestic sectors; national painting competition; energy award; publication of manuals and codes for energy efficiency etc.

Source: BEE website, accessed on May 2009.

According to India's Bureau of Energy Efficiency (BEE), these energy efficiency actions could save roughly 10 000 MW by 2012, equivalent to 7% of the current grid-connected capacity. Based on the 2007 CO_2-intensity of India's electricity generation, a 10 000 MW saving could prevent about 46 MtCO_2/year of emissions, equivalent to nearly all of the energy efficiency wedge between the 2020 Reference and 450 Policy Scenarios.

The NMEEE is expected to reduce energy consumption by at least 25% in energy-intensive sectors such as power and cement, a news agency reported (Reuters, 2008b). The publication of the implementation missions ought to clarify the exact goals.

Energy efficiency: white certificates

India's *Perform Achieve and Trade* (PAT) scheme is an energy efficiency, or "white" certificates trading programme.[39] It is an intra-country trading programme that will apply to facilities in 15 energy-intensive "designated consumer" industries, such as cement, iron and steel, aluminium, chemicals, textiles, fertilizers, railways, and pulp and paper. The first three-year cycle would begin by FY2010 (2009). The scheme involves three main steps:

- *Goal setting.* Determining a specific energy consumption (SEC) target for each large industrial plant, based on a percentage improvement on a baseline energy intensity (energy use / production output) of that plant.
- *Reduction phase.* Within a three-year period (2009-12) the designated consumers try to reduce their energy intensity according to their target.

39. White certificate trading programmes exist in Denmark, France, Italy, the Netherlands and the United Kingdom.

- *Trading phase.* Those consumers who surpass their target SEC improvements will be credited with tradable energy certificates (in the amount of the extra savings), which can be sold to designated consumers who fail to meet their targets.

The energy consumption levels reported by designated consumers are based on audit by BEE accredited agencies.

Few concrete details of the PAT scheme are publically available. It has been reported that:

"the BEE could ... consider mechanisms to protect energy-efficiency credit prices from economic downturns, that often play havoc with commodity and carbon credit prices ... Also, companies that invest in their own renewable energy power sources could be awarded extra credits, both for generating clean power and for not burdening an already overworked power grid – the primary objectives of the efficiency scheme" (Businessworld, 2008). In a related development, India joined the IEA Demand-Side Management (DSM) Implementing Agreement in January 2009. The BEE will lead a project seeking to develop a cogent and comprehensive framework to promote branding of energy efficiency in electricity markets at different levels of maturity. The DSM Implementing Agreement has also done work on market mechanisms for white certificates trading, of use to India's PAT scheme (IEA DSM, 2008).

Energy efficiency: energy services companies

The outline of the NMEEE contains provisions for promoting the use of energy service companies (ESCOs) to identify, finance and execute energy efficiency actions. An ESCO provides energy efficiency-related services on a performance contracting basis, rather than a traditional fee-for-service model. ESCOs develop and implement energy savings projects for their clients, and assume the risk that the projects will save the guaranteed amount of energy. ESCOs measure, monitor and verify the energy savings and are paid on the basis of the realised savings. There are incentives for both the ESCO and the host facility to maximise energy savings (Delio *et al.*, 2009). The NMEEE proposes three actions:

- Promotion of ESCOs, through accreditation and demonstration projects.
- Fiscal instruments, such as tax exemptions for the profits and gains made from energy efficiency projects by ESCOs and venture capital funds, and reduction

of value added tax (VAT) for energy efficient equipment (*e.g.* compact fluorescent light-bulbs).

- Establishment of Energy Efficiency Services Ltd., a public sector company, to address all the issues/barriers which impede investments in energy efficiency projects, and function as a consultancy organisation, resource centre and an ESCO.

ESCOs have been used in developed and developing countries with some degree of success. Compared to similar industries in the United States, Brazil and China, the Indian ESCO industry is relatively small, but has grown quickly over the past five years. One of the factors holding back the Indian industry has been the lack of access to financing, which stems in part from the dearth of market information and analysis as a barrier to investing in the industry (Delio *et al.*, 2009).

Data from the Indian Ministry of Power shows the investment potential for energy savings to be USD 9.8 billion with annual savings of 183.5 TWh. Those energy savings would mean 148.6 million tons of avoided CO_2 emissions per year (more than 10% of the country's energy-related CO_2 emissions in 2007). In recent years, domestic and international energy-efficient technology providers and equipment manufacturers have recognised the market potential of energy efficiency products and services. The growth of this industry has led to investor interest in funding the energy efficiency sector in India (Delio *et al.*, 2009).

Country-specific issues of sectoral approaches

As mentioned above, few concrete details are available on the PAT scheme and the other NMEEE programmes, all pending approval of the implementation missions. As such it is difficult to assess exactly how some international sector-level support may fit with and advance these programmes. They nonetheless appear as possible stepping stones for further action to lower electricity-use and related CO_2 emissions.

The PAT white certificate programme will require many trained auditors and a sophisticated system to measure, report, and verify data (MRV). The BEE already has a well-developed certification system for energy auditors, but the scale of the PAT scheme may benefit from external assistance. The Confederation of Indian Industries supports linking the intra-country energy efficiency market with the international carbon market. One difficulty is how to account for achieved emission savings, especially when power generation may be a candidate of choice for sector-wide crediting. In principle, CO_2 credits issued on the basis of an intensity baseline (expressed in tCO_2/MWh) would be lower if savings were achieved on the end-use side. This suggests no risk of double-counting of credits. We mentioned earlier the risk of perverse incentives that intensity-based credits may trigger – the more electricity output with an intensity below the baseline, the more credits. It could make sense to credit end-use savings separately to counter this effect. Conversely, it may be in developed countries' interest to support end-use savings at cost, and focus market-based support for other, more expensive abatement options (as discussed in the Conclusion of chapter 2).

Solar power development may be an avenue for technical or financial assistance in India. However, as in many industries, there would need to be full consideration of the competitiveness concerns of bolstering India's solar industry with the aid of developed country resources.

The development of India's ESCO activity is another area that may benefit from international assistance, as there appears to be limited access to finance for this activity at the moment. There may also be roles for awareness building (accreditation and demonstration), policy assistance, pro-forma contract development, seed capital, and the possibility to open credit lines with commercial banks to support ESCO-type activities. Training of skilled manpower will also prove critical to foster this new activity.

The NAPCC implementation policies for the Power Sector Technology Strategy are unclear at the moment; hence it is difficult to know how international sectoral support may fit. However, the Central Electricity Authority (CEA) has created a data collection and compilation system that is encouraging for the implementation of a sectoral market mechanism (Box 18). In many other countries, any sectoral crediting or trading mechanism is hindered by lack of comprehensive and credible emissions and performance data. CEA data may make the approach viable in India's power sector.

Box 18

A CO_2 baseline database for the Indian power sector

The Central Electricity Authority (CEA), a statutory organisation constituted under the Electricity (Supply) Act 1948, monitors the performance of India's power sector. By law, the CEA is mandated to collect and compile data concerning generation, transmission, trading, distribution and use of electricity. Some 65 data formats are mandated, 28 of which relate to GHG emissions. The CEA regularly monitors all power plants, captive units and industries consuming electricity at high and extra-high voltages. It is developing an on-line data reporting and monitoring system. A system for reporting power plant efficiency parameters is also being developed under the Indo-German Energy Programme.

In its partnership with BEE to develop a carbon market in India, CEA has established a CO_2 baseline database for the Indian Power Sector, based on plant level information on all operating power stations, including new supercritical units. The database includes main emissions factors for all of five regional grids in India calculated in accordance with relevant CDM methodologies. The database is viewed as a valuable tool for CDM project developers, contributing to some 600 renewable energy projects developed in India. Solid data on the power system also provides a sound basis for shaping India's future climate change policies.

The CO_2 Baseline Database contains plant-level and unit-level information on:

- *date of commissioning;*
- *capacity in MW as of 31 March 2008;*
- *type of the unit;*
- *fuel consumption (main) (annual data);*
- *fuel consumption (secondary) (annual data);*
- *net generation (annual data);*
- *tonnes of CO_2 (annual data);*
- *tonnes of CO_2 per MWh (annual data).*

Source: CEA, 2008.

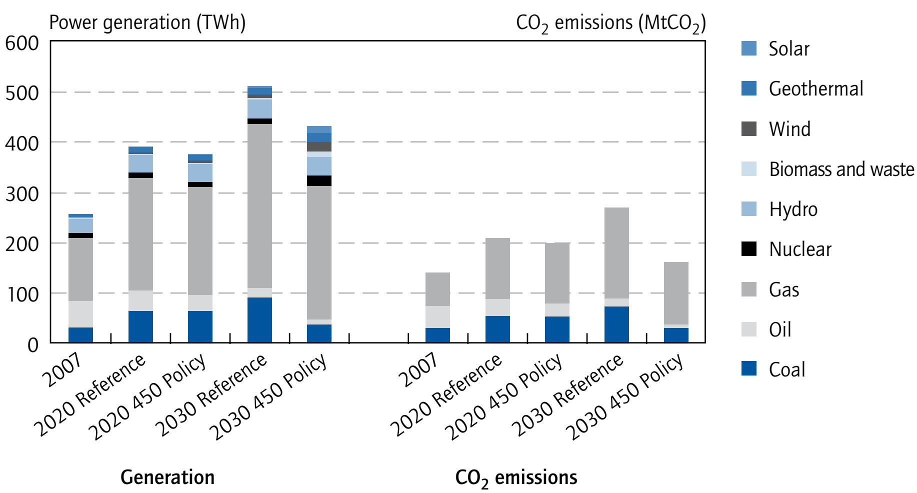
Mexico

Power sector generation, consumption, emissions and capacity profile to 2030

Mexico's annual electricity generation is set to increase by 52% (an additional 134 TWh) from 2007 to 2020, and a further 31% (120 TWh) by 2030 in the *WEO 2008* Reference Scenario, that is unless measures are introduced on the demand side (Figures 32 and 33). In the 450 Policy Scenario, generation growth is roughly 50% until 2020, but is limited to a 15% increase from 2020 to 2030.

Figure 32

Electricity production and CO_2 emissions of Mexico in *WEO 2008* scenario



Source: IEA, 2008g.

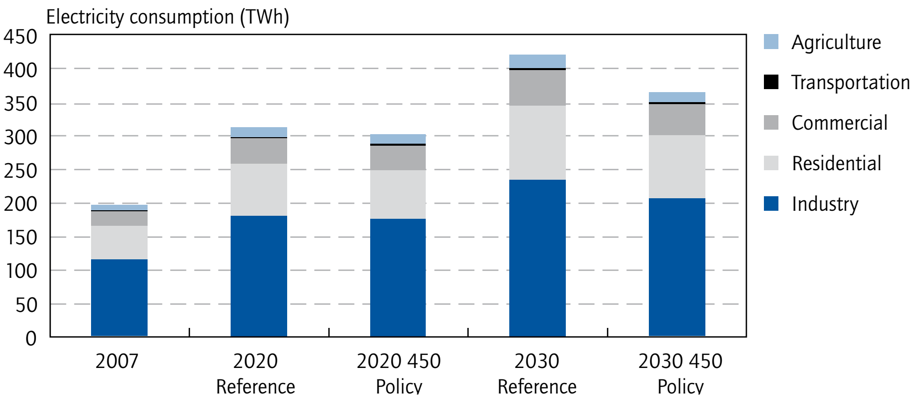
KEY MESSAGE

Power generation will increase substantially in all scenarios. CO_2 emissions increase considerably over the 2006-2030 period, although less so in the 450 Policy Scenario as there is a fairly modest decline in CO_2 intensity in all scenarios.

Source: IEA, 2008g.

Figure 33

Electricity consumption of Mexico in *WEO 2008* scenarios



Source: IEA, 2008g.

KEY MESSAGE

Electricity use would nearly double between 2006 and 2030 in Mexico, with a modest reduction from the Reference Scenario in the 450 Policy Scenario.

Mexican power generation is based predominantly on natural gas, followed by oil and coal. In the past, fuel oil and diesel fuel were the dominant energy supplies for electricity production, but Mexico is pursuing a major shift from oil to natural gas. The share of gas in generation was 12% in 1990, 19% in 2000, 49% in 2007, and grows to more than 60% by 2030 in all *WEO 2008* scenarios. In contrast, oil accounts for 20% of generation in 2007, followed by coal (12%), hydropower (11%), a single nuclear power plant (4%) and renewable sources, mostly geothermal (3%).

Gas-based generation, fitted with CCS, amounts to 53 TWh in the 450 Policy Scenario. Oil-based generation falls from 20% in 2007 to 2% in 2030 in the 450 Policy Scenario. Coal-based generation rises from 12% in 2006 to 17% in 2020 in both scenarios, but its share in 2030 shifts more dramatically, rising to 18% in the Reference Scenario and falling to 9% in the 450 Policy Scenario. In 2007, nearly all of the non-hydro renewable-base generation is geothermal; in 2030, the mix shifts to 54% geothermal, 32% wind and 13% solar in the Reference Scenario, with increasing emphasis on wind and solar in the Policy Scenario. Generation of electricity from non-hydro renewable sources rises from 10 TWh in 2007 to 24 TWh and 50 TWh in 2030 in the Reference and 450 Policy

Scenarios respectively. Overall electricity consumption follows the same trends as generation in all the scenarios. Industry is the dominant consuming sector, accounting for 58% of consumption in 2007, followed by residential (25%), commercial (11%), agriculture (4%) and transportation (1%). These shares change very little by 2020 and 2030 in the Reference or 450 Policy Scenarios.

Mexico is the thirteenth largest GHG emitter in the world. Its power sector CO_2 emissions, 25% of its total GHG emissions, rise from 141 $MtCO_2$ in 2007 to 209 $MtCO_2$ in 2020 to 269 $MtCO_2$ in 2030 in the Reference Scenario. The 450 Policy Scenario records the most drastic evolution, with emissions falling to 161 $MtCO_2$, 19% below the 2020 450 Policy Scenario level. They still remain 14% above the 2007 emission level, however.

Table 12 shows the trends in the three primary electricity supply indicators – power generation, carbon intensity and absolute CO_2 emissions – in the three *WEO 2008* scenarios. Electricity generation (TWh) rises by around 50% by 2020 in both scenarios, and rises by an additional 22 to 47% (according to scenario) in the 2020 to 2030 period. This upward trend is slightly offset by the fall in carbon intensity (gCO_2/kWh), because of generation efficiency improvements, fuel switching and CCS. The effects are not as pronounced as in China and India, because of the higher share of natural gas in the initial supply mix. Very little (2% to 3%) improvements in carbon intensity are achieved by 2020. By 2030, the power sector carbon intensity is 32% below the 2007 level in the 450 Policy Scenario. The modest declines in carbon intensity explain why CO_2 emissions do not decline below 2007 levels in any scenario. In 2030, CO_2 emissions range from 14% above to nearly double 2007 levels.

Table 12

Evolution of power generation, CO_2 intensity and emissions in Mexico in *WEO 2008* scenarios (changes from 2007)

		Power generation (difference in TWh)	Carbon intensity (difference in gCO_2/kWh)	CO_2 emissions (difference in $MtCO_2$)
2020	Reference Scenario	52%	-2%	48%
	450 Policy Scenario	46%	-3%	41%
2030	Reference Scenario	99%	-4%	91%
	450 Policy Scenario	68%	-32%	14%

Source: IEA Statistics; IEA, 2008g.

In the Reference Scenario, some 31 GW of net new capacity must be installed by 2020, and an additional 26 GW of capacity must be built during 2020 to 2030.[40] This compares with 57 GW of existing capacity in 2006 and 59 GW in 2007. The Policy Scenarios show similar trends in capacity additions. The principal difference among the scenarios is the fuel mix of new capacity in the 2020-2030 period – the Reference Scenario is 67% gas and 16% coal; the 450 Policy Scenario is 29% gas with CCS, with most of the remainder being wind (20%), solar (20%) and biomass (15%). This last mix is a radical departure from current trends. For comparison purposes, Box 19 summarises a recent study of a low-carbon development strategy for Mexico, undertaken by the World Bank (Johnson *et al.*, 2009).

Box 19

Summary of the World Bank low-carbon study for Mexico

The World Bank conducted a low-carbon study of Mexico with the objective to evaluate the potential for GHG reductions in Mexico over the next decades. The study highlights the importance of the electricity sector in reducing emission reductions.

The reference scenario used shows a higher growth in CO_2 emissions from power by 2030 compared to the WEO 2008 *Reference Scenario, with CO_2 emissions reaching 312 MtCO_2 in 2030. However, the study also assumes a higher increase in electricity consumption in 2030 (630 TWh against 511 in the* WEO 2008 *Reference Scenario).*

The policy scenario, with emissions of about 200 MtCO_2 by 2030, is higher than the 450 Policy Scenario of around 160 MtCO_2. The overall carbon intensity of electricity production, on the other hand, is more or less in line with the 450 Scenario given the estimate in the study of

40. These figures refer to net additions to installed capacity. They do not include the capacity that must be built to replace retiring facilities.

Box 19

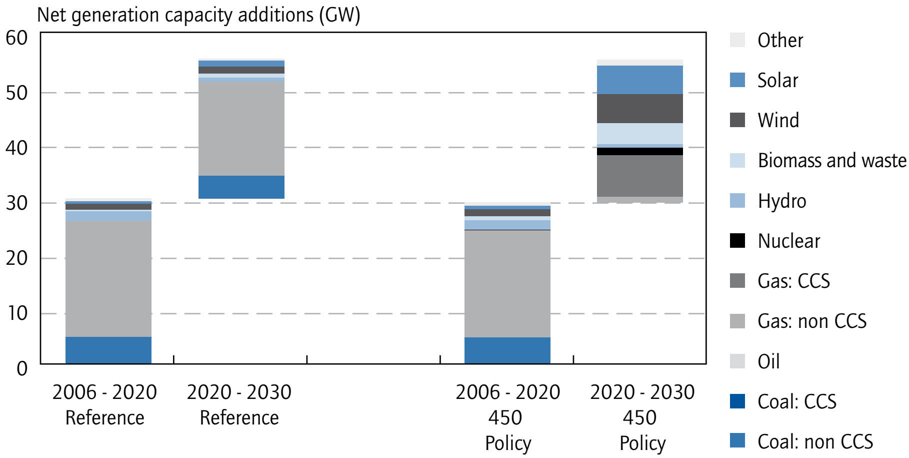
Summary of the World Bank low-carbon study for Mexico

higher electricity consumption by 2030. The technology mix, however, differs somewhat, with a higher share of renewables, geothermal in particular, while WEO 2008 *puts more emphasis on natural gas with CCS. The total incremental costs for the low-carbon scenario in the power sector are estimated at USD 9 billion from 2009 to 2030, much of which would be offset by lower operating and maintenance costs. The study concludes that although much can be achieved at a relatively low carbon price (USD 10/tCO_2), barriers exist in the enabling environment for cogeneration and renewables. Among the reforms needed are the introduction of marginal cost pricing, taking into account local environmental and health benefits of renewable energy, and allowing small-scale renewable energy and cogeneration projects to offer partial capacity in bidding processes.*

Source: Johnson *et al.*, 2009.

FIGURE 34

Electricity generation capacity profile of Mexico in *WEO 2008* scenarios



Source: IEA, 2008g.

KEY MESSAGE

The 450 Policy Scenario witnesses significantly more renewable energy capacity (biomass, wind and solar), while most of new gas capacity is fitted with CCS.

Current power sector and end-use policies with effects on CO_2

The Mexican government announced at COP-14 in Poznan in December 2009 its goal of reducing the country's absolute carbon emissions economy wide by 50% below 2000 levels by the year 2050. This is a non-binding, aspirational, goal. It is conditioned on: 1) availability of financial and technological facilities provided internationally according to the UNFCCC principle of "common but differentiated responsibilities"; and 2) a multilateral agreement to limit the global temperature increase to 2°C to 3°C and stabilise concentrations at 450 ppm CO_2-eq (Muñoz, 2009). Mexico's ambition to cut its GHG emissions was recently reiterated through a commitment by the Mexican President Calderón to voluntarily avoid the emissions of 50 $MtCO_2$ annually by 2012. This represents 8% of Mexico's total emissions. The emission reductions would come from more efficient cars and power plants, and reductions in gas leaks and flaring by the state-owned oil company Pemex. A key element of Mexico's plans to meet this goal is a sectoral approach, in the form of a national multi-sectoral cap-and-trade programme, to be operational by 2012.

This overall goal and specific action are consistent with Mexico's National Strategy on Climate Change issued in 2007 and the Special Programme for Climate Change released in March 2009 (CICC 2007, 2009). The National Strategy identifies opportunities for mitigation measures and estimates their potential for emissions reductions. Mexico received a World Bank loan to help in the implementation of this strategy, an innovative attempt at supporting a broad range of policies to combat climate change (see Box 20).

Box 20

A loan to support Mexico's National Climate Change Strategy

Mexico, the world's 13th biggest emitter of greenhouse gases, has set a voluntary goal to reduce its carbon output by 50% by 2050. In May 2007, President Calderón announced Mexico's National Climate Change Strategy (NCCS), which will be implemented through a Special Programme on Climate Change.

The measures identified in the National Strategy with the largest emission reduction potential include energy efficiency standards and programmes, the conversion of power plants from oil to natural gas and efficiency improvements, and increasing the power generation from renewable energy sources.

As an example, the Government of Mexico intends to build one million new houses for low-income families per year, with the option of accessing a "green mortgages" mechanism whereby a family will be able to finance energy and water efficiency measures through its mortgage, and reimburse the incremental cost of these efficiency measures using their savings over time in electricity and water expenditure.

A World Bank loan of USD 501 million was signed to support the government's efforts under its National Climate Change Strategy to mainstream climate change considerations in public policy. An interesting feature of this loan is that it is financing policies rather than the traditional project financing. This is the first World Bank Development Policy Loan to focus exclusively on climate change policies.

The strategy also proposes a suite of research objectives as a tool for laying out more precise mitigation targets and outlines national requirements for capacity building for adaptation to climate change. Sectoral opportunities and specific mitigation targets (within the timeframe of the present Administration) are identified in two major areas: energy generation and use; and vegetation and land. The strategy also sets forth considerations for introducing a carbon price in the economy (see Box 21).

Box 21

Possible phases for the progressive valuation of CO_2 in the Mexican economy

1. *Consolidate Pemex's virtual emissions trading scheme, setting limits on emissions from participating facilities and link it to the voluntary GHG accounting and reporting system promoted by SEMARNAT, Mexico's Ministry of the Environment; integrate the Federal Electricity Commission (CFE, Mexico's national utility) and Central Light and Power (LFC, the utility for central Mexico) to the voluntary accounting and reporting system; continue to promote CDM projects in all sectors, particularly energy.*

2. *Assign carbon and real exchange values by Pemex, with minimum budgetary affectations for participating facilities; review emissions caps periodically. Integrate CFE and LFC within a national emissions capping system.*

3. *Establish a carbon credit exchange system with capped values, between Pemex, CFE and LFC; introduce regulatory measures that allow the consolidation and extension of this system, including any necessary changes to laws, regulations and standards.*

4. *Promote carbon credit trading with other economic sectors, public or private, managed via projects with simplified criteria, based on the CDM.*

5. *Integrate chosen economic sectors within a national cap-and-trade scheme, with capped carbon prices set by central government, which do not threaten the development of a healthy and competitive economy.*

6. *Integrate a wider range of economic sectors within an increasingly consolidated national scheme, with progressive price liberalisation.*

7. *Coupling of the national cap-and-trade scheme with existing international schemes, whether derived from the Kyoto Protocol or not.*

Source: CICC, 2007.

Mexico's priorities on energy generation and use are:

Cap-and-trade

- Establish performance standards and GHG emissions baselines for major activities and emissions sources.
- Ensure accounting and reporting of GHG emissions and identification of emissions reductions projects in private and public companies under the CDM and other carbon markets.
- Carry out an economic assessment of the costs of climate change and the benefits of actions to address it, along the lines of the Stern Review (2007).

Improved energy efficiency (see Box 22 for estimates of efforts to date in electricity end-uses)

- Design and implement measures to ensure that Pemex has sufficient resources to improve its energy efficiency.
- Implement compulsory and voluntary standardisation of equipment, vehicles, power generation systems and consumption in homes, offices and industry.
- Repower thermoelectric plants with combined-cycle technology.

Increased deployment of renewable energy

- Promote renewable energy sources and low-carbon technology.
- Facilitate connection of independent suppliers to the national grid.
- Encourage the regulated participation of private enterprise in low-carbon energy generation particularly in combined heat-and-power and renewables (also applicable to fuel switching).
- Amend the proposed *Law on the Use of Renewable Energy Sources* to increase the share of renewables in overall power generation above the present target of 8%.
- Involve new stakeholders and initiatives in government energy efficiency and savings programmes, particularly in thermal efficiency and solar energy use.

Fuel switching

- Reduce the use of fuel oil.
- Encourage the regulated participation of private enterprise in low-carbon energy generation (particularly in combined heat-and-power generation and renewables).

Investment in new technologies

- Establish fiscal and financial incentives for investment in sustainable energy projects.
- Promote research on low-carbon technologies and renewables.

Box 22

Existing efforts in end-use efficiency in Mexico

Mexico's national energy efficiency programmes started in the early 1990s, following the establishment of the National Commission for Energy Savings (CONAE) in 1989 and the Fund for Electricity Savings (FIDE) in 1990. CONAE, a federal agency under the Ministry of Energy has developed and promoted the application of Mexican Official Energy Efficiency Standards for appliances and equipment, as well as other energy efficiency measures. FIDE, a privately-operated organisation created by the national utility CFE, has been a leader in promoting electricity savings through demand-side management measures, such as the introduction of compact fluorescent lamps (CFLs) and the scrapping of old appliances. It is estimated that as of 2006, standards related to electricity end-uses saved a total of 16 TWh, and avoided about 2 926 MW of generation capacity. The FIDE energy efficiency programmes achieved an estimated total electricity saving of 15 TWh, or 1 745 MW of generation capacity, as of 2008.

However, there remains considerable potential for energy efficiency improvements in Mexico. After significant improvements in the 1990s, the downward trend in the energy intensity of GDP in Mexico has stalled. This is primarily due to the rapid increase in electricity consumption, which has grown significantly faster than GDP. Both CONAE and FIDE have set ambitious targets for electricity savings by 2014.

Source: Johnson *et al.*, 2009.

Elimination of subsidies for fossil fuel consumption and production is viewed as an important, cross-cutting element for the success of an effective reduction of CO_2 emissions from power. The strategies, priorities and policies in the National Strategy laid the groundwork for the Special Programme on Climate Change, which itself is an integral part of the National Development Plan, 2007-2012. The Special Programme on Climate Change (PECC), still in draft, gives a long-term outlook for emissions, mitigation and adaptation, and outlines the specific actions to be taken in the 2008-12 period (CICC, 2009). The draft PECC contains 41 objectives and 95 specific targets for mitigation measures. Agriculture, forestry and other land use actions account for the largest share (61%) of the planned emissions reductions during 2008-2012, followed by oil and gas (16%), energy use (12%) and electricity generation (7%). The reductions from the planned cap-and-trade scheme are not included as they mostly occur after 2012. The PECC power sector measures – which include further development of gas, hydro, wind, geothermal and solar facilities; private investment in renewable facilities; and improved refrigerator, lighting, air conditioning and motors efficiency – suggest emissions reductions by 2012 could be greater (perhaps 50% larger) than those in the *WEO 2008* 450 Policy Scenario in 2020.

Without going into an in-depth comparison of the existing climate policy scenarios for Mexico's power sector, wide variations reported here show that any goal-setting will prove controversial, in light of the uncertainty on how much could be achieved and at what cost.

Sectoral approaches and cap-and-trade

The operational details of the sectoral approach announced in Poznan are under development. Fernando Tudela, Vice-Minister, Ministry of the Environment and Natural Resources (2008) has characterised the main features of sectoral approaches and domestic policies as follows:

- A Stern-like review and Center for Clean Air Policy (CCAP) studies will provide baselines and sectoral targets for key energy-intensive sectors.
- Potential targets are being developed through assessment of technology penetration, mitigation costs, emission reduction opportunities and policy barriers.
- The plan is to achieve the targets by linking the oil, electricity, cement and steel sectors in a trans-sectoral cap-and-trade programme.
- Mexico has created a new Energy Transition Fund (MXN 3 billion, or USD 210 million per year). This could be combined with up-front international support for advanced technologies, to facilitate abatement under the cap-and-trade programme.
- Reductions beyond the cap can be sold by companies on the international carbon market.

Current evaluations of sectoral mitigation potentials in Mexico (cement, steel, refining) show in particular some potential for Pemex to build some 3 100 MW of cogeneration facilities. Full implementation of this capacity would reduce emissions by 9.7 $MtCO_2$ annually. Two policy barriers include the pricing of power sold to the electricity grid and financing limitations (Tudela, 2008; CCAP *et al.*, 2008; CCAP, 2008). The regulatory framework governing power generation deserves some attention as the government attempts to trigger change in this sector.

The Mexican cap-and-trade system is still in the design phase, and few details are available. Existing data gathering mechanisms provide a possible sound basis for its development. Begun as a pilot programme in 2004, the voluntary Mexico GHG Programme is an inventory programme that seeks to: promote corporate and project-level GHG management; identify cost-effective GHG reductions; build capacity (training workshops, calculation tools and technical assistance); and enhance participation in carbon markets.

The programme provides technical tools and training to develop inventories of corporate GHG emissions based on the accounting and reporting principles of the WRI/WBCSD GHG Protocol. Companies that participate in the programme can identify opportunities to improve their energy efficiency and develop effective strategies to participate in carbon markets and reduce GHG emissions. Current participants include Cemex México, Cooperativa La Cruz Azul, Cementos Moctezuma, Grupo Cementos de Chihuahua, Holcim Apasco and Lafarge (cement); PEMEX and Gas del Atlántico (oil and gas); Altos Hornos, DeAcero, Grupo IMSA, Mittal Steel, SICARTSA/Villacero, Siderúrgica Tultitlán (iron and steel). It also includes firms in the following activities: beer and brewing; automobile manufacturing; mining; municipal landfills; chemicals; glass; machinery manufacturing; services; swine farms; construction; packing; forestry; and public transport (WBCSD, 2008).

Country-specific issues of sectoral approaches

Mexico has clearly decided to undertake policy measures to explicitly address climate change, including a CO_2 cap-and-trade system that would cover several industries and power generation. The introduction of a carbon price will provide a necessary incentive to guide investments towards the low-carbon generation technologies available in the country: geothermal, wind, solar, all three with significant potential. While Mexico has nuclear generation capacity, it is not clear what role this technology may play in the country's energy future under a CO_2

constraint; the *WEO 2008* projects a tripling of current capacity, from 1 to 3 GW by 2030 in the 450 Policy Scenario.

Studies concur on the importance of the current regulatory framework of the electricity sector and on the barriers that it raises for renewable energy development in particular. To be effective, the cap-and-trade system should be introduced together with some regulatory reform, without which the CO_2 price signal may be less effective than anticipated.

Work done by CCAP (2008) in Mexico reveals the need to gather credible data to move forward on the implementation of sectoral goals; efforts underway in the country to voluntarily gather GHG inventories are encouraging in that respect.

The government has also expressed interest in developing efficiency standards for a range of equipment. This action will prove essential to curb the country's rising electricity demand. Further work would be needed to identify whether and how international support could enhance it.

South Africa

Power sector generation, consumption, emissions and capacity profile to 2030

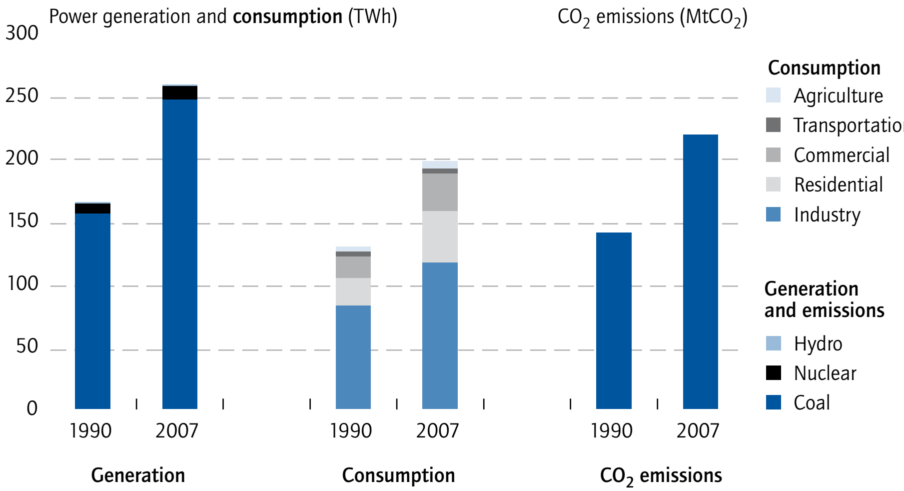
WEO 2008 projection data on South Africa's power sector are not available for 2020-30; this section bases its descriptions of current patterns on IEA statistics, and trends of the Long Term Mitigation Scenarios (LTMS) of the Department of Environmental Affairs and Tourism (DEAT, 2007a). These scenarios emerged from a rather unique multi-stakeholder process to evaluate South Africa's response to climate change. This example could be replicated in other countries as they ask how their economic development can be made compatible with the need to abate GHG emissions.

In 2007, South Africa generated 261 TWh of electricity, slightly more than Mexico. Some 95% of the generation is based on coal of relatively poor quality. The country's single nuclear plant supplied just over 4% of the power; the remaining 1% was mostly hydro-power. Industry, primarily mining, iron and steel, and non-ferrous metals, was the largest electricity user, consuming 56%

of generated output. Power sector CO_2 emissions, exclusively from coal, were 220 $MtCO_2$ (Figure 35).

Figure 35

Power generation, consumption and CO_2 emissions profile of South Africa, 1990-2007



Source: IEA statistics.

KEY MESSAGE

South African power generation is dominated by coal, with a contribution from nuclear and some hydro capacity. More than half of all generated electricity is used in industry.

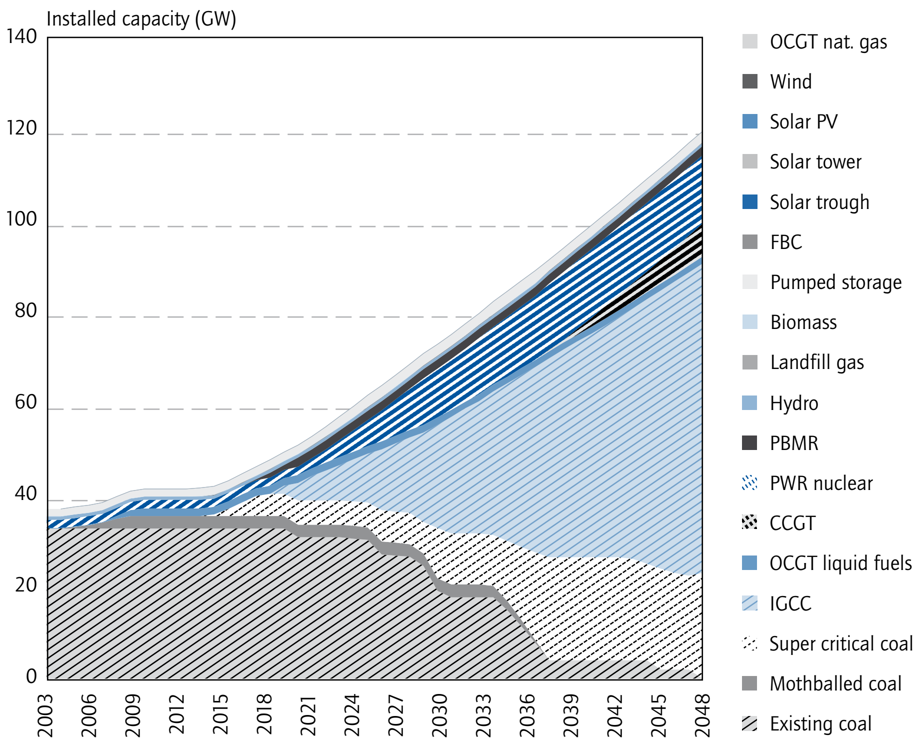
Strong economic growth, rapid industrialisation and a large electrification programme have led to power supply shortages. Nationwide outages lasted about one month in January 2008. In response, South Africa has embarked on a programme to re-commission mothballed power generation capacity; build new capacity; improve transmission and distribution infrastructure; and reduce demand. Eskom, the South African electricity utility that generates 95% of South Africa's electricity, seeks to reduce demand by 3 000 MW by 2012 and an additional 5 000 MW by 2025 (EIA, 2008).

The projected growth and composition of South Africa's power sector, in the LTMS "Growth without constraints case" (GWC), is shown in Figures 36 and 37. Generation capacity is expected to grow 1% annually from 38 GW in 2005 to

42 GW in 2015, and then 3% annually to 120 GW in 2050. By 2030, capacity is expected to be about 70 GW (nearly double that of 2005). It will still be mostly coal-based (78%), of which 48% will be conventional cycle, 15% will be super-critical cycle and 37% will be integrated gasification combined cycle (IGCC).

Figure 36

Power generation capacity expansion plan in South Africa's "Growth without constraints case", 2003-2050



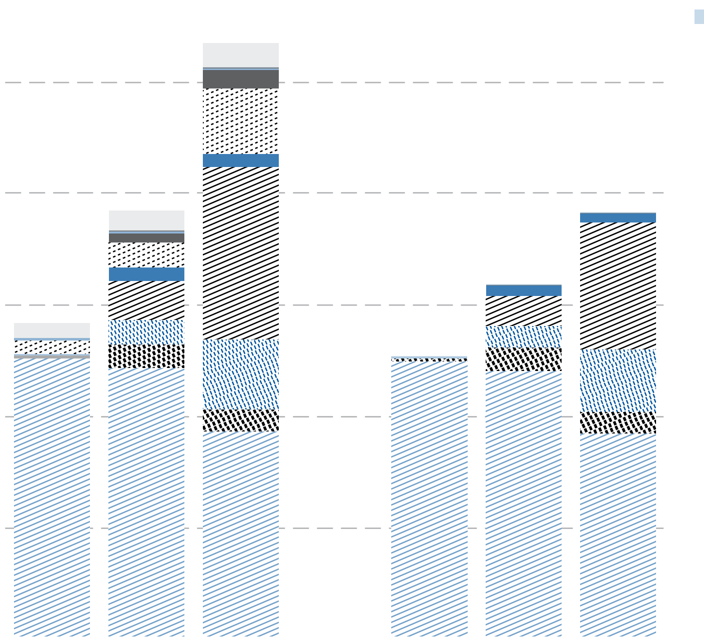
Note: CCGT: combined-cycle gas turbine (gas); FBC: fluidised-bed combustion (coal); IGCC: Integrated gasification combined cycle; OCGT: open-cycle gas turbine; PBMR: pebble-bed modular reactor (nuclear); PWR: pressurised-water reactor (nuclear).
Source: Winkler H. (ed.), 2007.

KEY MESSAGE

Under the "growth without constraints case", the installed capacity of South Africa would still rely largely on coal by 2050, with some increased contribution from nuclear and limited generation from renewables.

Figure 37

Power generation and CO_2 emissions from power in "Growth without constraints case", 2005, 2020 and 2030



Source: Estimates, based on South Africa DEAT, 2007b.

KEY MESSAGE

Under the "Growth without constraints case", the increased reliance on more efficient coal technology and the penetration of new nuclear capacity would trigger a lower growth in CO_2 emissions than in electricity output.

In the GWC case, new coal-fired power plants are projected to use supercritical steam technology (23 GW, or seven new plants, by 2050) or IGCC (68 GW, or 21 new plants, by 2050). IGCC is only slightly more expensive, but significantly more efficient than supercritical coal technology. Since no carbon constraints are imposed, no electricity plants have CCS. A total of nine new conventional nuclear plants are built, mostly between 2023 and 2040, adding 15 GW of new capacity. Twelve modules of pebble-bed modular reactors (PBMR) are built by 2050. Very few renewable sources enter the electricity mix in this scenario. No electricity is generated from solar, thermal, or wind, with the only significant addition being 70 MW of landfill gas (DEAT, 2007a).

This capacity expansion is estimated, by the EIA (2008), to result in an increase in electricity generation of almost 250 TWh, and an increase in emissions of 130 $MtCO_2$, by 2030. The introduction of more nuclear power and IGCC dampens emissions growth to 50% over 2005 levels (in comparison with electricity generation growth of 90%).

The LTMS explored strategies and wedges for mitigating emissions from the GWC case to "Required by science" levels (see Box 23). The latter scenario is, in the LTMS team's view, consistent with the *WEO 2008* 450 Policy Scenario.[41] The estimated emissions reductions associated with each of the strategies explored in the LTMS process are shown in Figure 38.

A key result is the large gap between where emissions are heading and where they need to go. Even with various strategic options, a gap remains. Start Now would achieve around 43% of the goal; Scale Up covers about 64% of the way from GWC to Required by Science; and Use the Market closes the gap by 76%.

41. "In the Required by [Science] Scenario, the burden taken up by South Africa is not exact, but is seen rather as a target band of between -30% to -40% from 2003 levels by 2050. A burden-sharing discount has been assumed *i.e.* that SA bears less than its proportional share of the global burden of reduction because it is a developing country. The lower end of the target (-40%) can be thought of as a global or collective bottom line. The upper end of the target range suggests some differentiation in responsibility, depending on countries' different capabilities and different national circumstances. The target range can be made even wider, although this is not explored in the Required by Science Scenario." (DEAT, 2007a).

Box 23

South Africa's "Long Term Mitigation Scenarios"

The LTMS scenarios and strategies included the following, ranked in decreasing quantities of CO_2 emissions by 2050:

- *Growth Without Constraints (GWC), a scenario that assumes no radical change in energy choices. South Africa's emissions would quadruple between 2003 and 2050.*
- *Current Development Plans portrays the fulfilment of the Government's Energy Efficiency Strategy to achieve a final energy demand reduction of 12% by 2015 and the current target of 10 000 GWh renewable energy contribution to final energy consumption by 2013. The LTMS team acknowledges that Current Development Plans initially reduce emissions below GWC. When extended to 2050, however, the trajectory is not radically different from GWC.*
- *Start Now: this scenario assumes that South Africa implements all measures that result in no net cost.*
- *Scale Up: building on Start Now, this scenario introduces a range of state-led regulatory measures, at positive cost.*
- *Use the Market: this scenario assumes the introduction of a carbon tax and incentives for the penetration of clean technologies.*
- *Required by Science: this scenario assumes that South Africa has all the resources necessary to achieve a mitigation objective coherent with an ambitious global mitigation strategy (a 30 to 40% reduction from 2003 emission levels by 2050).*

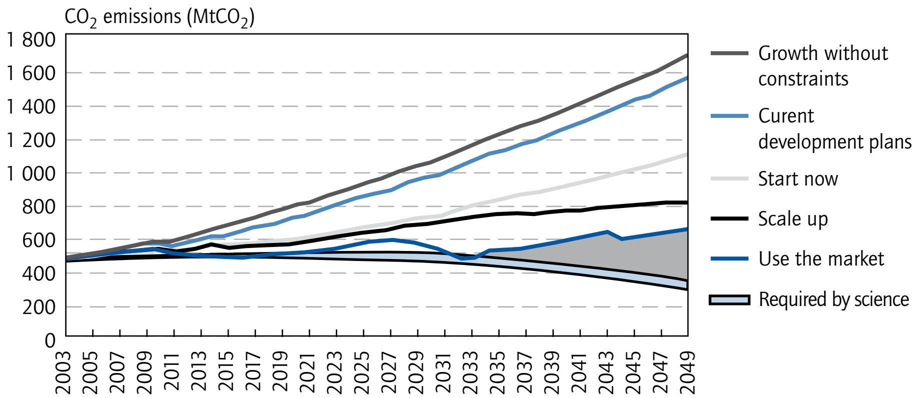
These scenarios represent possible paths, the feasibility of which depend on technology capability over the scenario timeframes.

Source: DEAT, 2007a.

The remaining "triangle" of emissions is uncharted policy and technology territory (Figure 38).

Figure 38

Strategic options from "Growth without constraints" to "Required by science"



Source: ERC, 2007.
Note: See Box 23 for scenario descriptions.

KEY MESSAGE

South Africa has explored a full set of climate policy scenarios, showing some large potential for country-wide GHG gas reductions from a "Growth without constraints case" by 2050.

The LTMS analysed a number of emissions mitigation wedges. Those related to the power sector are shown in Table 13. They include renewables-based power (27% of supply by 2030 in an initial case; 50% by 2050 in an extended case), nuclear power (27% of supply by 2030 in an initial case; 50% by 2050 in an extended case), clean coal and CCS (limited to 2 $MtCO_2$ in an initial case; 20 $MtCO_2$ in an extended case). The importance of renewable and nuclear power is apparent in their high potential for emissions reductions. Renewable power (predominantly solar towers and troughs, *i.e.* concentrated solar power), if cost reductions from learning can be achieved, is the most potent, least costly, stand-alone power measure in both the Start Now and Scale Up strategies. Only the industrial efficiency wedge (not shown) is of comparable reduction magnitude (4 572 $MtCO_2$) and cost (USD -4.10/tCO_2). Nuclear power (mostly Pressurised Water Reactors) is the second least expensive, and could deliver almost as great reductions in the Scale

Up strategies. The options are not additive, because of differing market responses when they are implemented together. However, the combination of nuclear and renewable power was examined explicitly in the modelling effort, and found to be only moderately costly (USD 6.30 to USD 7.80/tCO_2), but capable of delivering 50% to 60% of emissions reductions of the full Start Now and Scale Up wedges.

Table 13

Summary of abatement options and cost in the power sector in various policy scenarios for South Africa

Cumulative GHG emissions reductions 2003-2050 in $MtCO_2$-eq (Average incremental costs of mitigation at 10% discount rate USD/tCO_2)	Current Development Plans	Start Now	Scale Up	Use the Market
Combined wedges $MtCO_2$ (USD/tCO_2)	3 412 $MtCO_2$ (-61.80)	11 079 $MtCO_2$ (-1.60)	13 761 $MtCO_2$ (4.70)	17 434 $MtCO_2$ (1.20)
Individual wedges				
Renewables with learning		2 757 $MtCO_2$ (-17.30)	3 990 $MtCO_2$ (0.40)	
Nuclear		1 660 $MtCO_2$ (2.20)	3 467 $MtCO_2$ (2.40)	
Renewables		2 010 $MtCO_2$ (6.30)	3 285 $MtCO_2$ (11.20)	
Nuclear and renewables		5 559 $MtCO_2$ (7.80 USD/tCO_2)	8 297 $MtCO_2$ (6.30 USD/tCO_2)	
CCS		306 $MtCO_2$ (8.10)	449 $MtCO_2$ (8.70)	
Cleaner coal		167 $MtCO_2$ (-0.60)		

Note: Abatement costs are derived from a MARKAL model analysis based on technico-engineering cost, which would omit non-cost barriers to implementation. Technology mixes are optimised to minimise total cost. Costs converted at USD 1 = ZAR 8.248.
Sources: Adapted from South Africa DEAT, 2007c.

Current power sector and end-use policies with effects on CO_2

As mentioned earlier, the Current Development Plans scenario assumes meeting existing government policies to reduce final energy demand by 15% below projected levels by 2015, and to use 10 000 GWh of renewable energy sources by 2013. The key policy initiatives implementing these power-related goals are:

- Energy Efficiency Strategy of South Africa.
- White Paper on Renewable Energy.
- Renewable Energy Feed-in Tariff (REFIT).

The *Energy Efficiency Strategy of South Africa*, approved by Cabinet in March 2005, links energy sector development with national socio-economic development plans and sets the target for improved energy efficiency in South Africa at 12% by 2015. This target is expressed in relation to the forecasted national energy demand at that time. Among other things, the strategy:

- Provides guidelines for the implementation of efficient practices within the economy, including the setting of governance structures for activity development, promotion and co-ordination.
- Allows for the immediate implementation of low-cost and no-cost interventions, as well as higher-cost measures with short payback periods.
- Acknowledges that there exists significant potential for energy efficiency improvements across all sectors of the national economy.
- Acknowledges that energy efficiency will be largely achieved via enabling instruments and interventions, including economic and legislative means, efficiency labels and performance standards, energy management activities and energy audits, and the promotion of efficient practices.

In May 2005, the Minister for Energy and Minerals, together with the CEOs from 24 major energy users and seven industry associations, signed the *Energy Efficiency Accord*, voluntarily committing themselves to implement the government target for energy savings. Within a framework of eight strategic goals based on the three cornerstones of sustainability, the strategy targets a 15% reduction in final energy demand for the industrial sector by 2015, and a 12% improvement in energy efficiency for the country as a whole by the same date. This target is expressed as a percentage reduction against the projected national energy usage in 2015 (IEA, Energy Efficiency Policies and Measures database).

The *White Paper on Renewable Energy* set up the medium-term target (10-year) of an additional (compared to the level in 2000) 10 000 GWh or 0.8 Mtoe renewable energy contribution to the final energy consumption by 2013. Initially, the renewable energy policy attempts to remove barriers that prevent renewable energy penetration in the South African market. The policy addresses five key strategic areas:

- Promotes appropriate financial and fiscal instruments. This includes redirecting national resources/investment to renewable energy technologies and provision of fiscal incentives.
- Develop effective legislative instruments in order to facilitate renewable energy dissemination. This will be achieved by passing regulations for pricing and the integration of IPP into the electricity system.
- Promotion of R&D on renewable energy technologies through the provision of guidelines, standards and code of practices as well as supporting appropriate R&D and local manufacturing.
- Raising of public awareness about renewable energy through support of training centres, improved information dissemination strategies, improved government communication strategy, etc.
- Establish technology support centres, such as the National Energy Research Institute (IEA, Renewable Energy Policies and Measures database).

On 26 March 2009, South Africa's National Energy Regulator (NERSA) approved the country's first *Renewable Energy Feed-in Tariff* (REFIT) scheme. The REFIT places an obligation on Eskom (South Africa's public utility) to purchase the output from qualifying renewable energy generators at pre-determined prices based on the levelised cost of electricity. Eskom's Single Buyer Office has been appointed as the Renewable Energy Purchasing Agency (REPA), and is obliged to purchase power from licensed renewable energy generators. Licensed independent renewable energy power producers can also sell power directly to buyers outside of the REFIT mechanism. The cost of the tariff will be passed through to Eskom electricity customers.

Four technologies are currently covered by the REFIT, though other technologies will be considered for inclusion within six months (see Table 14).

Table 14

South Africa's renewable energy feed-in tariff

Technology	Feed-in tariff
Wind	ZAR 1.25 (USD 0.15)/kWh
Small hydro (less than 10 MW)	ZAR 0.94 (USD 0.11)/kWh
Landfill gas	ZAR 0.90 (USD 0.11)/kWh
Concentrated solar power	ZAR 2.10 (USD 0.25)/kWh

The REFIT power purchase agreement will last for 20 years, and the tariff can be adjusted yearly for inflation. For the first five years of the REFIT, a full review of the scheme will take place yearly, following this it will take place every three years. Specific license conditions for renewable energy generators include reporting, monitoring and verification requirements, and termination conditions for non-compliance with production of renewable energy. The REFIT scheme does not include off-grid power generation (IEA, Renewable Energy Policies and Measures database).

More recently, the Environment, Energy and Treasury Ministries of South Africa have been drafting a new energy and climate change strategy, slated for released in September 2009. According to Forbes/Oxford Analytica (2009), "the document will form the basis of government climate change policy, leading to an overhaul of existing fiscal, regulatory and legislative regimes by 2012, aimed at capping carbon dioxide emissions by 2025." In order to address the medium-term electricity generating shortfalls and the long-term climate change challenges, the strategy is said to involve the introduction of public subsidies, tax breaks and clearer policy goals designed to boost the contribution of renewables to the national energy mix.

Among the key features of South Africa's developing energy and climate policy said to be under consideration are (Forbes/Oxford Analytica, 2009) (South Africa Climate Change Summit, 2009):

- re-commissioning of three mothballed coal-based power stations;
- building two coal-based power stations;
- a target by Eskom to reducing its dependence on conventional coal to 70% by 2025, with emissions falling in absolute terms by about 2050;
- a target by Eskom to provide at least 1 600 MW in renewable capacity – mostly large-scale solar and wind – by 2025;

- a policy framework and fiscal incentives needed to attract prospective investors in renewable energy;
- a carbon tax regime, possibly in conjunction with an emissions trading scheme that caps CO_2 levels and creates a market for trading in emission reductions as provided for under the provisions of the Kyoto Protocol;
- tougher environmental standards to promote a transition to a low-carbon economy, and foster the development of a domestic CCS capability – on which both Eskom and Sasol will be heavily reliant in meeting emission reduction targets;
- an environmental tax of ZAR 0.02/kWh will be applied to electricity from non-renewable sources.[42]

In addition, as part of a plan to be using CCS technology by 2020, the Council for Geoscience and the Petroleum Agency of South Africa are compiling an atlas of potential underground storage sites for CO_2 emissions. The atlas is scheduled to be completed in April 2010 (Campbell, 2009).

Country-specific issues of sectoral approaches

South Africa's general technology priorities for the electricity supply sector are clear from the LTMS exercise, recent policy initiatives and initial indications of the new energy and climate change strategy. They are energy efficiency, solar, wind, clean coal and nuclear power technologies. These priorities, except for nuclear power, are corroborated by South Africa's Climate Change Technology Needs Assessment (TNA), submitted to the UNFCCC in September 2007 (DST, 2007). The TNA was undertaken to report South Africa's climate change technology priorities to developed country partners in the hopes that the documentation would facilitate the development of specific implementation plans for the prioritised technologies. It was envisaged that the process would open up access to funds, create an enabling environment for the transfer and uptake of technologies, and highlight opportunities for research and development co-operation in this area. The TNA used a consultative process, and identifies the barriers to technology transfer and

42. South Africa's Department of Treasury recently released for public comment proposed amendments to the current taxation act. The draft legislation contains two concrete incentives to reduce GHG emissions. Firstly, the sale of CERs will be exempt from income tax. This is maybe not very relevant in the context of sectoral approaches, but indicates an intention from the government to continue to take advantage of the CDM. Secondly, businesses will obtain notional deductions for income tax purposes for energy efficiency savings from certified baselines based on energy efficiency certificates issued by the National Energy Efficiency Agency, signalling a commitment from the government in support of the previously approved Energy Efficiency Strategy. The new environmental tax was introduced as part of this package.

measures to address these barriers through sectoral analyses. The technologies were assessed according to their: 1) relevance to climate change - mitigation potential and vulnerability; 2) alignment with national goals - strategies and targets, sustainability, and competitive advantage; 3) market potential - costs/benefits, scale of utilisation scale and technology maturity; and 4) skills and capacity building - support systems, users and indigenous knowledge.

Any sectoral approach applied to South Africa's power industry must necessarily account for the special status of Eskom. It is one of the largest utilities in the world – producing 95% of South Africa's electricity and two-thirds of the electricity for the African continent (EIA, 2008). Eskom's dominant market position allows for streamlined communication and co-ordination of sectoral goals and implementation elements. Its technological capabilities are already high, as shown by the presence of diverse large-scale technologies in its production portfolio (coal, nuclear, hydro), which suggests some flexibility in future generation choices, provided appropriate incentives are in place.

Stepping stones to curb CO_2 from electricity

This section reviewed the existing electricity and CO_2 picture of four major emerging economies: China, India, Mexico and South Africa. These countries cover a wide range of situations in terms of energy supply mix – although coal dominates supply in China, India and South Africa. Mexico is the exception with its important natural gas resource – as well as electricity use per capita, not to mention their different stages of economic development. All have witnessed a rapid growth in electricity use and generation, and showed no sign of slowing down until the economic recession hit. Under business-as-usual conditions, demand will keep rising and, with it, CO_2 emissions.

These countries have, to a different extent, all started taking measures to address the rise in their CO_2 emissions and electricity use. All have developed energy efficiency policy instruments (see Table 15), yet studies and projections concur on a large remaining potential for end-use improvements – although this is not specific to these countries. They all recently took measures to address the rising energy demand of industrial sectors, which account for the majority of electricity use in all four countries. Approaches to curb industry's demand vary from country to country, with voluntary agreements (in China and South Africa), support for energy management, ESCOs and white certificates (India); there is less clarity on Mexico's policies on industrial end-use efficiency, although voluntary and mandatory standardisation of end-use equipment is part of the country's strategy and significant savings have already been achieved – not to mention efforts to introduce a cap-and-trade system that includes industry. In light of the rapid industrialisation and infrastructure needs of these countries, industry energy efficiency ought to be a priority, both for electricity and other energy sources.

On the supply side, some policy instruments are in place to support the development of technologies to lower the reliance on fossil fuels for new power generation capacity. These efforts may appear insufficient to date, although many are at rather early stages of policy implementation or still under discussion. In discussions of possible international support, it will be essential to assess the contribution of existing instruments to ensure that such support adds to, and does not duplicate ongoing domestic efforts.

Table 15

Energy efficiency measures in the four case study countries – a survey from the IEA database

	China	India	Mexico	South Africa
Energy efficiency and DSM				
Industrial (incl. power sector)				
Voluntary agreements				✔
Obligations/targets	✔			
Energy management & audits	✔	✔	✔	✔
Regulations/standards	✔			
Financial incentives	✔	✔	✔	✔
Tradable certificate schemes		✔ planned		
Residential and commercial				
Building codes or regulations	✔	✔	✔	
MEPS	✔		✔	
Voluntary standards	✔	✔	✔	✔
Labels/certificates	✔	✔ voluntary	✔	✔ voluntary
Financial incentives			✔	✔
Education/training		✔	✔	

Source: IEA energy efficiency policy database.

All four countries have put forward climate change action plans, although Mexico and South Africa are proposing more targeted CO_2 abatement policy instruments or strategies. CO_2 mitigation appears more as a co-benefit, in the case of India and China's energy policy goals, even if it is clearly on the policy makers' radar screen. The carbon footprint of these two countries' electricity generation makes it the focus of much international analysis – this one included. Their presence in the CDM market via a large number of power generation activities indicate some command of carbon market mechanisms, and there is interest in further linking domestic efforts with the international carbon market. Two elements could prove crucial in facilitating such a transition:

- The regulatory structure of the generation sector and, in particular, the mechanics of plant-level choices for specific technologies, the ownership structure of the sector, as well as pricing. While these dimensions could not be covered in the chapter, they are an important element of India's recurring electricity supply and demand problems. IEA analysis of coal issues in China also shows the difficulty in getting central policy decisions implemented at provincial level. Any strategy that seeks to influence power generation choices cannot be abstracted from the underlying regulatory reality of these countries. Arguably, it may be easier for South Africa's Eskom to engage in a rapid shift in power generation choice, than it will be for the power generation sectors of China and India, with numerous stakeholders, including local governments that have not always responded effectively to central government's policy directions. Economic incentives may be more effective – in its analysis of the coal sector in China, IEA recommends market instruments to tackle the power sector's emissions (IEA, 2009a).
- The existence of a reliable database of electricity production, fossil fuel consumption and CO_2 emissions. India has developed an impressive record of plant performance for its generation capacity, already of use for its participation in the CDM. Any scaling-up of crediting mechanisms will only be acceptable if it is accompanied with proper mechanisms to monitor, report and verify emissions and other indicators used to evaluate performance.

In all, however, efforts to date provide some of the indispensible stepping stones for any further action in the electricity sector in non-Annex I countries that may be supported internationally.

NEXT STEPS

Electricity: a priority for global abatement

Electricity sector is an essential component of the energy sector's contribution to climate change and to its mitigation. Efforts are underway in many countries to improve generation efficiency, enhance the penetration of renewable energy as well as nuclear, and to curb the striking electricity demand growth that drives the rise of CO_2 emissions in power generation. While much remains to be done, and results have yet to come, most developed countries have taken major policy actions to specifically address CO_2 from power generation (from cap-and-trade to support for low-carbon technologies, including targeted support for CCS). There is now a fairly narrow window of opportunity available to the international community to avoid the lock-in of significant carbon-intensive generation in non-OECD countries. IEA projections make it clear that the next wave of electricity investment in this region could irreversibly add to the world's carbon footprint for decades to come. Time is short, and effort should focus on instruments that can be put in place to assist developing countries in their current ambitions, and enhance these further to avoid locking in fossil-fuel based power generation. This diagnosis alone justifies calling on the UNFCCC Parties to make this sector a priority for mitigation in the near term.

We presented the main policy options under discussion that could apply to the electricity/CO_2 challenge. The power generation sector in developing countries could adopt a range of GHG mitigation goals, from an intensity target (tCO_2/MWh) to an absolute emission level on the basis of which international emissions trading could occur. Many support mechanisms could be brought forward to facilitate such action, from technology finance, information sharing on best available technologies and best policy practice (following, *inter alia*, the work of the APP task force on generation), to GHG crediting or trading (expanding from the rather successful experience with the CDM in this area).

How can domestic policy frameworks be supported by international carbon markets?

Moving from the current support via CDM and a range of bilateral activities, to sectoral objectives and crediting represents a significant change. This remains true whether or not the goal would be of non-binding nature ("no-lose"). Without adequate domestic policy frameworks in place, the newly proposed crediting mechanisms will provide little, if any, direct incentives to individual investors.

Because performance will be set and rewarded at a national level, it will not alone suffice to guide investors towards low-carbon investment. This is because an investor's effort to improve performance could be annihilated by others' inaction. Building a bridge between the carbon market and sector-level shifts in investment will require domestic policy tools, suited to each country's situation. Work should be undertaken immediately to elaborate these tools, if sectoral crediting is to succeed in guiding international carbon finance towards cleaner investment choices.

A more advanced form, sectoral trading based on absolute emission goals would offer an easier access to the carbon market by granting allowances to countries at the beginning of a commitment period – when crediting must first go through a performance evaluation. So-called hard caps on emissions, however, raise political problems to many emerging economies, although Mexico intends to pursue this approach domestically.

Emerging economies are acting already – international support should enhance not constrain these actions

Fortunately, developing and emerging countries have started taking policy measures that lower the power sector's carbon footprint. Existing efforts offer the advantage of having met the constraints of national circumstances, while an international top-down approach may require much adjustment. A political agreement on global mitigation at Copenhagen could launch an implementation phase using existing policy initiatives as stepping stones.

Some countries, like Mexico or South Africa, have put together national GHG mitigation strategies that could benefit from international collaboration to move to the implementation stage. It is noteworthy that, in the example of South Africa, the strategy involves the use of nuclear and CCS, both technology options so far excluded from the CDM. It seems legitimate that, as countries become full partners in global mitigation, they are free to contribute with options that are suitable to their domestic circumstances. While this issue has not been addressed in discussions so far, it is difficult to envision a move to sectoral GHG goals that would exclude certain low- and no-carbon technologies from the eligible portfolio – Annex I countries with commitments under the Kyoto Protocol have flexibility to rely on technologies of their choice to reach their emission targets.

Even political goals will require good data to measure efforts

The most sensitive element of market-based approaches is the emissions target that could form the basis for receiving credits. We laid out options that could allow a swift implementation of crediting mechanisms, provided there is some mutual understanding of what constitutes the business-as-usual trend in generation choices, and agreement that the goal, or baseline, represents an additional effort by the host country. For those that favour such a crediting approach, it is indeed essential that the move from projects to sectors be based on two principles:

1. A move away from emission offsets, to a real contribution to global mitigation by so-called host countries.

2. A robust framework to monitor, report and verify emissions to maintain the environmental integrity of the mechanism.

These principles may not be met easily by all countries at present. India has a comprehensive database of its power plants and their performance in fuel, electricity and CO_2 terms. Others may not, and experience with regional cap-and-trade systems such as the EU ETS have shown the importance of gathering accurate data, especially at the stage of allocation of effort among sources. The same demands would be legitimate if countries were to support technology deployment goals, so as to ensure that technology is not just installed but actually used, that it represents an effort beyond business-as-usual, and that standard, fossil-fuel based technologies are adequately reported to ensure that the sector's overall CO_2 performance goes in the right direction. Regardless of the policy path that countries choose to follow to address power sector CO_2 emissions, an adequate inventory of plants and performance ought to be a priority for action in this sector.

Energy efficiency policies: how far from best practice? How to identify needs?

The demand side of the electricity/CO_2 challenge is critical: the potential for cost-effective abatement is clear; the market barriers have long been identified; and they fully justify policy intervention, all the more so when economic welfare, local and global environmental improvements are in the balance.

In this area too, the case study countries have taken major steps in recent years to address the rise in electricity demand, for reasons not primarily related to climate change. These efforts are more or less well documented, though it is still difficult to evaluate how close they are to what could be identified as best practice, to identify possible gaps, or to design an international collaboration strategy to remedy these gaps.

An open and transparent international exchange of views is needed now on policy practices across countries – there are many examples of policy practices that are effective in driving energy efficiency in certain countries, which are completely ignored by others. This is also the case in industrial activities, which represent the lion's share of electricity use in developing countries.[43] The newly launched International Partnership on Energy Efficiency Co-operation, among others, could serve as a forum for such information exchange.[44]

The question for climate policy-makers that seek to enhance mitigation in developing countries is how one can identify and assess actual needs and corresponding capacities? This question cannot be answered without a dialogue with developing countries to identify:

- existing policy efforts and capacities;

43. For a discussion of technology and policy issues on climate change and energy efficiency in heavy industry, see IEA, 2009b.
44. Task forces under the Asia Pacific Partnership consider industrial energy and CO_2 emissions in aluminium, cement, and iron and steel.

- possible areas for improvements and areas where no action has been taken to date, and where it is needed in light of domestic priorities;
- any technology barrier that stands in the way of best practice diffusion globally.

One could envision a policy check-list for energy efficiency measures that are seen as essential in main sectors (*e.g.* industry in developing countries, although other end-uses cannot be left unchecked), to accelerate the identification of gaps and solutions. The methodology that IEA developed to evaluate best policy practice, leading to its 25 concrete recommendations, could be used for that purpose (IEA, 2008c). Once such measures are identified and support for implementation is provided, there will be a need to monitor progress – as has been done by the IEA in its *Progress with Implementing Energy Efficiency Policies in the G8* (IEA, 2009d).

Bringing electricity (and energy) to the climate change table

Some important aspects of the electricity sector and its contribution to lowering CO_2 have not been addressed here, from how to optimise transmission networks, or how to best use global R&D resources to develop the technologies needed to radically change the electricity sector's CO_2 profile. These issues require expertise beyond the scope of the present book, yet they will play a critical role in this debate in the future. Whether best policy practice in energy efficiency or objectives for emission reductions in power are to be the topic of international climate policy, it is critical to bring the relevant expertise to the table. With a few exceptions, very few developed and developing countries have brought energy administrations to the UNFCCC negotiation; and neither has the negotiation put electricity (or energy) on the table at the UNFCCC. If, as we think is necessary, the UNFCCC Parties make electricity one of their priorities for support in mitigation, such expertise will be indispensible. How to make it most useful to the international process is a question that can be best answered after the UNFCCC negotiations in Copenhagen.

Not unlike – and probably more than – land-use change and forestry, which are topical in the UNFCCC, energy is an essential part of the climate change problem. The energy revolution needed to preserve the world climate will not occur if energy policy and climate policy treat each other as marginal parts of their respective business. Many countries have established domestic dialogues and policy frameworks, or changed the structure of their administrations to solve that problem; energy and climate are increasingly treated as two sides of the same coin.

Electricity shows that a sound climate policy approach requires a portfolio of instruments, and that the upcoming international policy framework will only be effective if it rests on sound and clear energy policies at domestic level. This approach must be turned into reality in the electricity sector globally, if the world is to build a bridge from its current unsustainable trends to a safe climate.

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