International Energy Agency

UNITED NATIONS DEVELOPMENT PROGRAMME

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

ENERGY POVERTY

How to make modern energy access universal?

Special early excerpt of the World Energy Outlook 2010 for the UN General Assembly on the Millennium Development Goals

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its mandate is two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply and to advise member countries on sound energy policy.

The IEA carries out a comprehensive programme of energy co-operation among 28 advanced economies, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency aims to:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea (Republic of)
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA.

International Energy Agency

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

ENERGY POVERTY
How to make modern energy access universal?

Special early excerpt of the
World Energy Outlook 2010
for the UN General Assembly on
the Millennium Development Goals

International Energy Agency
UNITED NATIONS DEVELOPMENT PROGRAMME
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Foreword

It is an alarming fact that today - in the 21st century - there are still billions of people without access to electricity or clean cooking facilities. The ambitious goals that have been set to eradicate extreme poverty can never be fully realised without acknowledging and confronting this fact. The international community has long been aware of the close relationship between development and access to modern energy services. But there is no Millennium Development Goal specifically related to energy. To help support action and policy making in this area, the International Energy Agency, the United Nations Development Programme and the United Nations Industrial Development Organisation have pooled their resources and expertise to produce this report, an early excerpt from the forthcoming IEA *World Energy Outlook 2010*.

Policy-makers need hard, quantitative information and analysis to make critical decisions regarding the welfare of their citizens. With this in mind, we have quantified the number of people that lack access to modern energy services and the investment costs required to meet this gap. To ensure that every citizen in the world benefits from access to electricity and clean cooking facilities by 2030, this report estimates that investment of $36 billion per year is required. Our analysis indicates that, unless new and dedicated policies are put into place, conditions for the lives of billions of people are not expected to improve. To underpin global goals and help refine policies over time, progress needs to be monitored. The Energy Development Index in this report represents a valuable tool to this end. We encourage governments to continue to improve data collection and reporting to help underpin delivery.

As heads of the International Energy Agency, the United Nations Development Programme and the United Nations Industrial Development Organization, we are dedicated to ongoing collaboration in the area of energy poverty. We hope this report will raise awareness at the highest level of government. But not only there – expanding access to modern energy services will require participation from many other actors, at the regional, national and local levels and from the international community and private sector. As it has done since 2002, the *World Energy Outlook* will continue to highlight the issue of energy poverty in its annual publication. Much work needs to be done. Energy access goals *must* be combined with other poverty eradication goals. The analysis here points to an unsustainable and unacceptable future which needs to be urgently addressed. We must start today.

Nobuo Tanaka
Executive Director
International Energy Agency

Olav Kjorven
Assistant Secretary General
and Assistant Administrator
United Nations Development Programme

Kandeh K. Yumkella
Director General
United Nations Industrial Development Organization

Table of Contents

Highlights

- The 2010 edition of the *World Energy Outlook* (*WEO*) assesses two indicators of energy poverty at the household level: the lack of access to electricity and the reliance on the traditional use of biomass for cooking. In Sub-Saharan Africa the electrification rate is 31% and the number of people relying on the traditional use of biomass 80%: this is where the greatest challenge lies.
- Today, there are 1.4 billion people around the world that lack access to electricity, some 85% of them in rural areas. Without additional dedicated policies, by 2030 the number of people drops, but only to 1.2 billion. Some 15% of the world's population still lack access, the majority of them living in Sub-Saharan Africa.
- The number of people relying on the traditional use of biomass is projected to rise from 2.7 billion today to 2.8 billion in 2030. Using World Health Organization estimates, linked to our projections of biomass use, it is estimated that household air pollution from the use of biomass in inefficient stoves would lead to over 1.5 million premature deaths per year, over 4 000 per day, in 2030, greater than estimates for premature deaths from malaria, tuberculosis or HIV/AIDS.
- Addressing these inequities depends upon international recognition that the projected situation is intolerable, a commitment to effect the necessary change, and setting targets and indicators to monitor progress. A new financial, institutional and technological framework is required, as is capacity building in order to dramatically scale up access to modern energy services at the local and regional levels. We provide a monitoring tool, the Energy Development Index (EDI), that ranks developing countries in their progress towards modern energy access.
- The UN Millennium Development Goal of eradicating extreme poverty by 2015 will not be achieved unless substantial progress is made on improving energy access. To meet the goal by 2015, an additional 395 million people need to be provided with electricity and an additional 1 billion provided with access to clean cooking facilities. This will require annual investment in 2010-2015 of $41 billion, or only 0.06% of global GDP (MER).
- To meet the more ambitious target of achieving universal access to modern energy services by 2030, additional investment of $756 billion, or $36 billion per year, is required. This is less than 3% of the global energy investment projected in the New Policies Scenario to 2030. The resulting increase in primary energy demand and CO_2 emissions would be modest. In 2030, global electricity generation would be 2.9% higher, oil demand would have risen less than 1% and CO_2 emissions would be 0.8% higher, compared to the New Policies Scenario.

Introduction

Making energy supply secure and curbing energy's contribution to climate change are often referred as the two over-riding challenges faced by the energy sector on the road to a sustainable future. This report highlights another key strategic challenge for the energy sector, one that requires immediate and focused attention by governments and the international community. It is the alarming fact that today billions of people lack access to the most basic energy services, electricity and clean cooking facilities, and, worse, this situation is set to change very little over the next 20 years, actually deteriorating in some respects. This is shameful and unacceptable.

Lack of access to modern energy services[1] is a serious hindrance to economic and social development and must be overcome if the UN Millennium Development Goals (MDGs) are to be achieved.[2] This report - which presents the results of joint work of the International Energy Agency (IEA), the United Nations Development Programme (UNDP) and the United Nations Industrial Development Organization (UNIDO) – investigates the energy-access challenge. We estimate the number of people who need to gain access to modern energy services and the scale of the investments required, both in the period to 2015 and over the longer term, in order to achieve the proposed goal of universal access to modern energy services by 2030 (AGECC, 2010).[3] We also discuss the implications of universal access to modern energy services for the global energy market and the environment and health. This report includes an Energy Development Index and a discussion of the path to improving access to modern energy services, as well as financing mechanisms and the implications for government policy in developing countries.

The focus of this report is on expanding access to modern energy services at the household level. This is but one aspect of overcoming energy poverty. Other aspects include providing access to electricity and mechanical power for income-generating activities, the reliability of the supply to households and to the wider economy and the affordability of energy expenditure at the household level. These other aspects of energy poverty are areas for future research in the *World Energy Outlook*.

[1] Access to modern energy services is defined here as household access to electricity and clean cooking facilities (*i.e.* clean cooking fuels and stoves, advanced biomass cookstoves and biogas systems).

[2] In September 2000, at United Nations Headquarters in New York, world leaders adopted the United Nations Millennium Declaration, committing their nations to a global partnership to eradicate extreme poverty and setting out eight goals - with a deadline of 2015 - that have become known as the Millennium Development Goals (see www.un.org/millenniumgoals). The MDGs do not include specific targets in relation to access to electricity or to clean cooking facilities, but universal access to both is necessary for the realisation of the Goals (see Box 2).

[3] The Advisory Group on Energy and Climate Change (AGECC), a committee set up by UN Secretary-General Ban Ki-moon, is charged with assessing the global energy situation and incorporating this into international climate change talks. It has proposed a goal to achieve universal access to modern energy services by 2030.

The numbers related to household access to energy are striking. We estimate that 1.4 billion people – over 20% of the global population – lack access to electricity and that 2.7 billion people – some 40% of the global population – rely on the traditional use of biomass for cooking (Table 1).[4] Worse, our projections suggest that the problem will persist and even deepen in the longer term: in the New Policies Scenario,[5] 1.2 billion people still lack access to electricity in 2030, 87% of them living in rural areas (Figure 1). Most of these people will be living in Sub-Saharan Africa, India and other developing Asian countries (excluding China). In the same scenario, the number of people relying on the traditional use of biomass for cooking *rises* to 2.8 billion in 2030, 82% of them in rural areas.

Table 1: **Number of people without access to electricity and relying on the traditional use of biomass, 2009** (million)

	Number of people lacking access to electricity	Number of people relying on the traditional use of biomass for cooking
Africa	587	657
Sub-Saharan Africa	*585*	*653*
Developing Asia	799	1 937
China	*8*	*423*
India	*404*	*855*
Other Asia	*387*	*659*
Latin America	31	85
Developing countries*	1 438	2 679
World**	**1 441**	**2 679**

*Includes Middle East countries. **Includes OECD and transition economies.

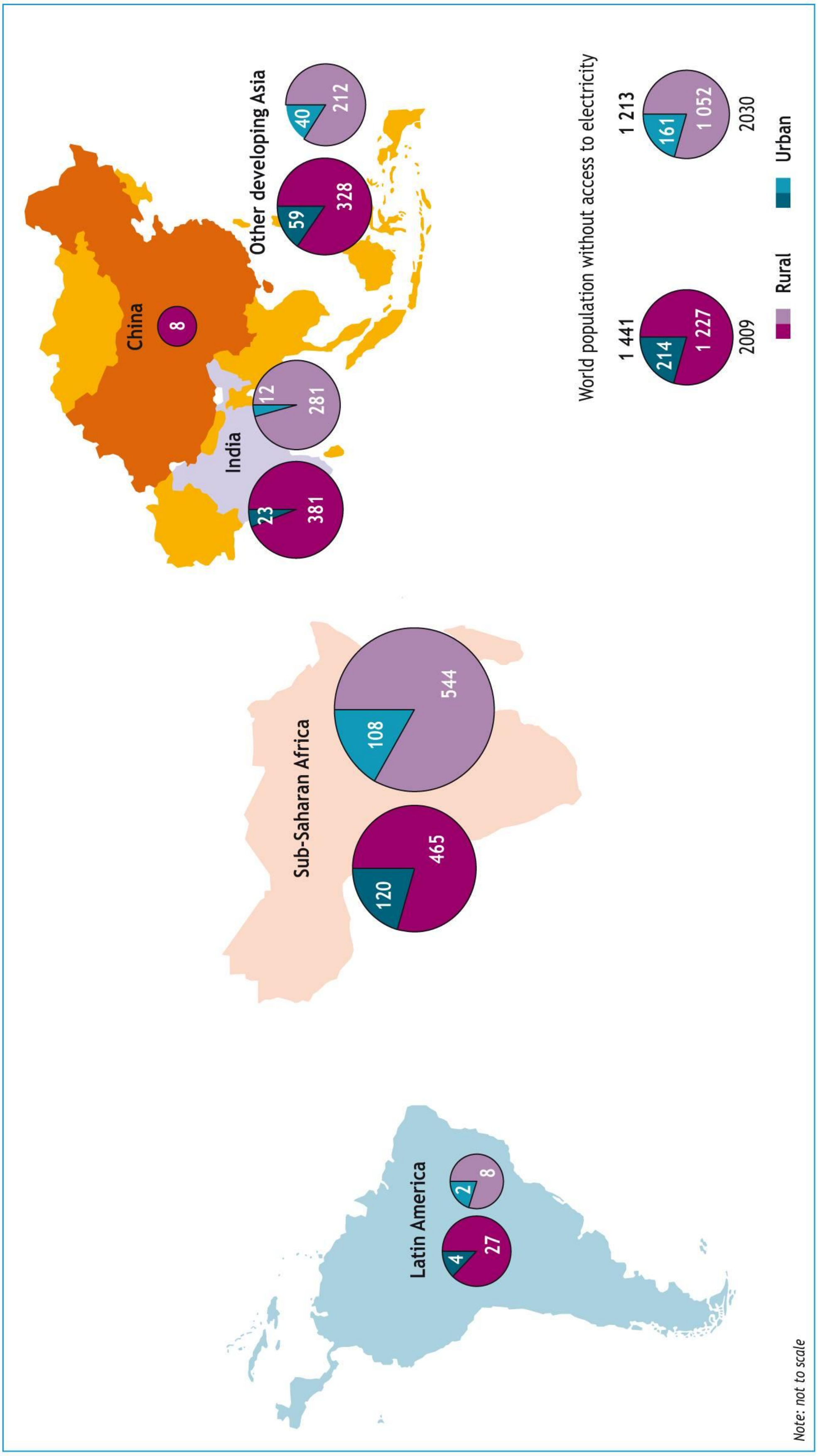
Note: The *World Energy Outlook* maintains a database on electricity access and reliance on the traditional use of biomass, which is updated annually.

Source: IEA databases and analysis.

[4] The traditional use of biomass refers to the basic technology used, such as a three-stone fire or inefficient cookstove, and not the resource itself. The number of people relying on the traditional use of biomass is based on survey and national data sources and refers to those households where biomass is the primary fuel for cooking. While the analysis in this report focuses on biomass, it is important to note that, in addition to the number of people relying on biomass for cooking, some 0.4 billion people, mostly in China, rely on coal for cooking. This is a highly polluting fuel when used in traditional stoves and has serious health implications.

[5] The 2010 edition of the *World Energy Outlook* sets out three scenarios to 2035. The Current Policies Scenario takes into consideration only those policies and measures that had been formally adopted by mid-2010; the New Policies Scenario takes account of broad policy commitments that have already been announced; while the 450 Scenario assumes a pathway to 2035 with the objective of limiting the long-term concentration of greenhouse gases in the atmosphere to 450 parts per million of CO_2-equivalent. The timeframe for the projections in this report is to 2030.

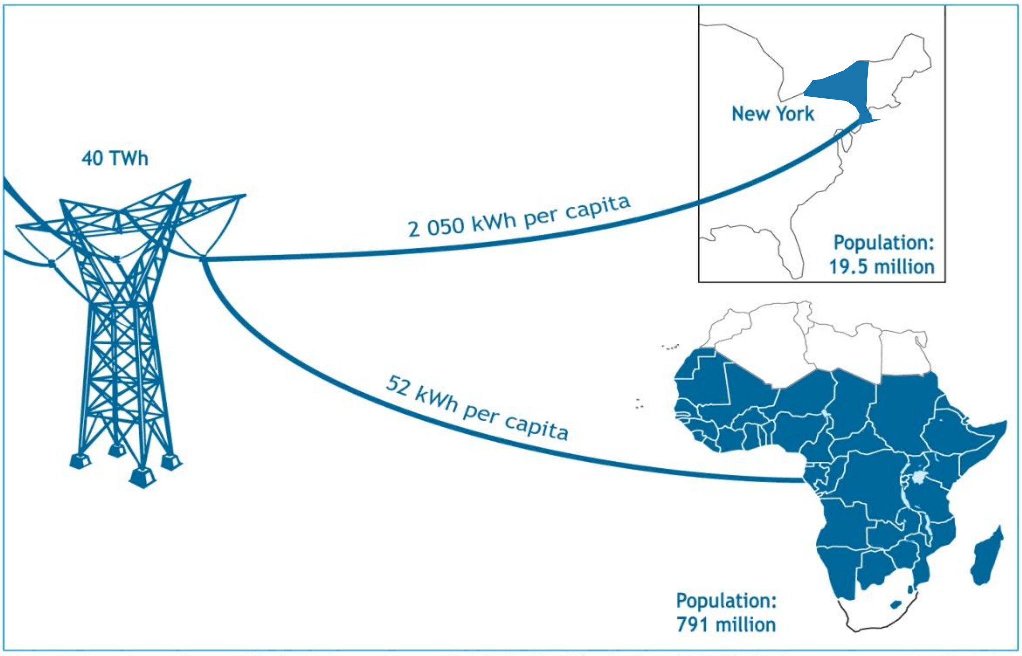
***Figure 1*: Number of people without access to electricity in rural and urban areas in the New Policies Scenario** (million)



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

The greatest challenge is in Sub-Saharan Africa, where today only 31% of the population has access to electricity, the lowest level in the world. If South Africa is excluded, the share declines further, to 28%. Residential electricity consumption in Sub-Saharan Africa, excluding South Africa, is roughly equivalent to consumption in New York. In other words, the 19.5 million inhabitants of New York consume in a year roughly the same quantity of electricity, 40 TWh, as the 791 million people of Sub-Saharan Africa (Figure 2).

***Figure 2*: Electricity consumption in New York and Sub-Saharan Africa**



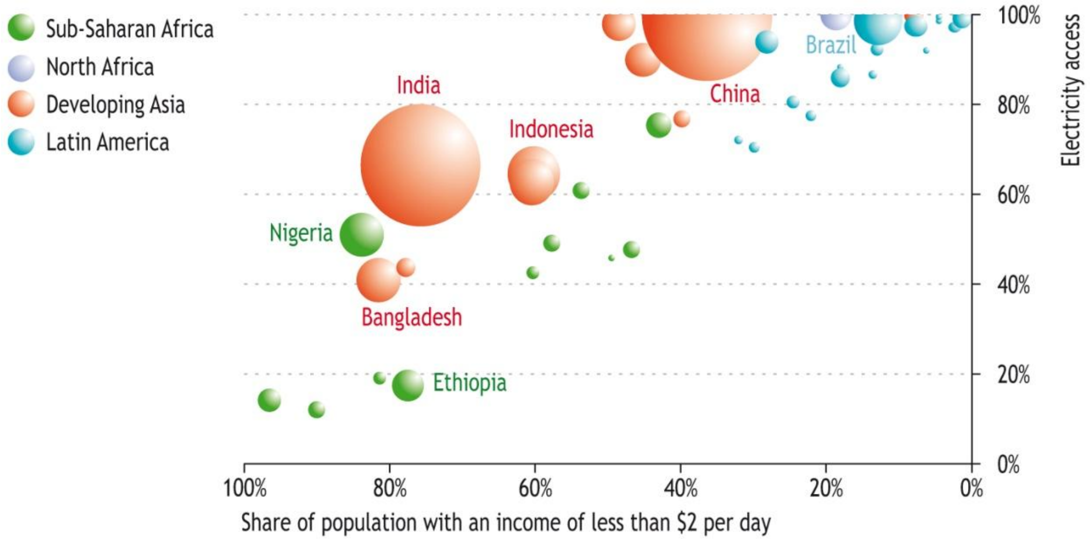
The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Energy and development

Access to modern forms of energy is essential for the provision of clean water, sanitation and healthcare and provides great benefits to development through the provision of reliable and efficient lighting, heating, cooking, mechanical power, transport and telecommunication services.[6] The international community has long been aware of the close correlation between income levels and access to modern energy: not surprisingly, countries with a large proportion of the population living on an income of less than $2 per day tend to have low electrification rates and a high proportion of the population relying on traditional biomass (Figures 3 and 4). As incomes increase, access to electricity rises at a faster rate than access to modern cooking fuels, largely because governments give higher priority to electrification, though access to both electricity and clean cooking facilities is essential to success in eradicating the worst effects of poverty and putting poor communities on the path to development.

[6] Household income is the central factor linking achievement of the MDGs and access to modern energy services. Causality is mainly from income to energy access: although improved access to energy can help raise incomes. Moreover, access to electricity is not only a result of economic growth but electricity access also contributes actively to economic growth (Birol, 2007). In this regard, reliability, and not just access, is very important to sustainable economic growth.

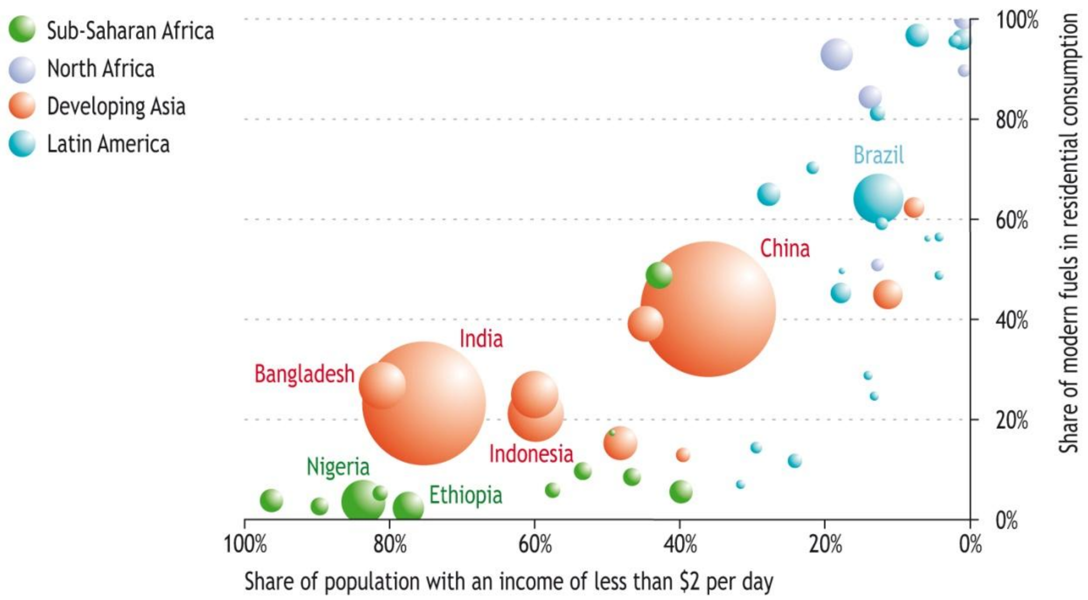
***Figure 3:* Household income and electricity access in developing countries**



Note: The size of the bubble is proportional to population.

Sources: Electrification rate: www.worldenergyoutlook.org; and poverty rate: http://data.worldbank.org/indicator/SI.POV.2DAY.

***Figure 4*: Household income and access to modern fuels* in developing countries**



Note: The size of the bubble is proportional to population.

*Modern fuels exclude traditional biomass.

Sources: Consumption of modern fuels: IEA data and analysis; and poverty rate: http://data.worldbank.org/indicator/SI.POV.2DAY.

The adverse consequences of the use of traditional forms of energy for health, economic development and the environment are well illustrated by the example of the use of traditional biomass for cooking.[7] Currently, devices for cooking with biomass are mostly three-stone fires, traditional mud stoves or metal, cement and pottery or brick stoves, with no operating chimneys or hoods (Box 1). As a consequence of the pollutants emitted by these devices, pollution levels inside households cooking with biomass are often many times higher than typical outdoor levels, even those in highly polluted cities. The World Health Organization estimates that more than 1.45 million people die prematurely each year from household air pollution due to inefficient biomass combustion. A significant proportion of these are young children, who spend many hours each day breathing smoke pollution from the cookstove. Today, the number of premature deaths from household air pollution is greater than the number of premature deaths from malaria or tuberculosis (Figure 5).

Using World Health Organization projections for premature deaths to 2030,[8] the annual number of premature deaths over the projection period from the indoor use of biomass is expected to *increase* in the New Policies Scenario, unless there is targeted action to deal with the problem. By 2030 over 1.5 million people would die every year due to the effects of breathing smoke from poorly-combusted biomass fuels. This is more than 4 000 people per day. By contrast, the World Health Organization expects the number of premature deaths from malaria, tuberculosis or HIV/AIDS to decline over the same period.

Box 1: Cooking and lighting in the poorest households

The poorest households tend to use three-stone fires for cooking. The high moisture content of the biomass resources used and the low efficiency of the combustion process produce dangerous levels of smoke, particularly if food is cooked indoors. The efficiency of biomass can be increased through provision of improved stoves and enhanced ventilation. Adding chimneys to stoves with low combustion efficiency can itself be a useful improvement, as long as the chimney is kept clean and maintained. However, often there is some leakage into the room and the smoke is merely vented outside the house and will, in part, re-enter the dwelling, so this option is not as effective as a change to clean fuels or advanced biomass stoves. Experience suggests that in order for biomass gasifiers for cooking to consistently achieve emissions close to those of liquefied petroleum gas (LPG) stoves, the stove requires assisted air flow by use of a fan. Ventilation of the home (*i.e.*, eaves spaces and larger, opened windows and doors) can contribute to reducing household air pollution but alone is unlikely to make a substantial difference if there is a highly polluting indoor source.

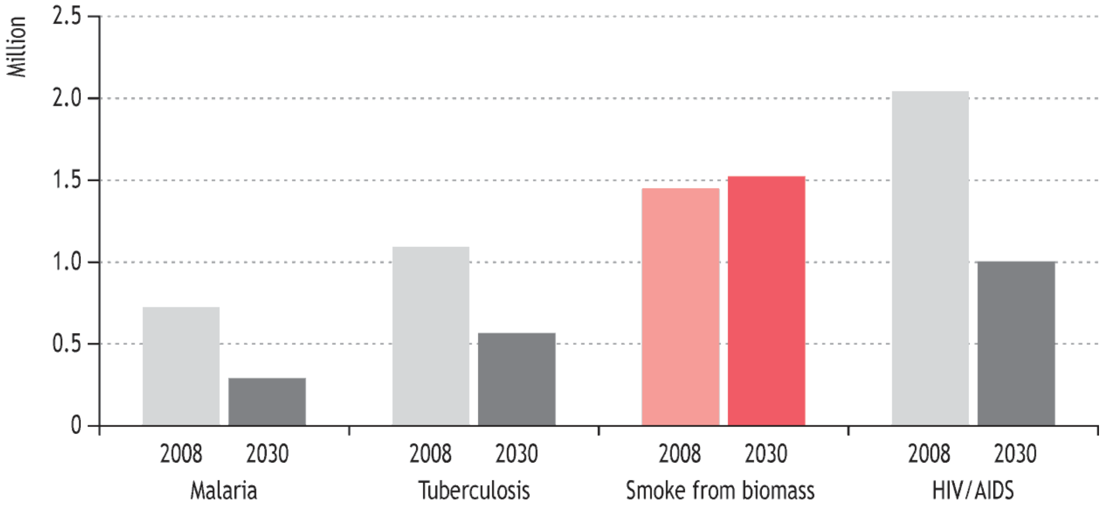
Lighting in low-income households in developing countries is generally provided by candles or kerosene/diesel lanterns. Candles and low-efficiency lanterns emit smoke. Kerosene lamps produce better light, but they are uncomfortably hot in a tropical climate and they can be difficult to light. Use of kerosene also imposes health risks, through fires and children drinking fuel stored in soft drink bottles, and there is emerging evidence of links with tuberculosis and cancer. Switching to electricity eliminates these risks and increases efficiency. A paraffin wax candle has an intensity (in lumens) of 1 and an efficiency (lumen per Watt) of 0.01, while a 15 Watt fluorescent bulb has an intensity of 600 and efficiency of 40 (Yadoo, 2010).[9] There has been much recent success in the dissemination of compact fluorescent light bulbs (CFLs) in many developing countries. High-quality CFLs are four to five times more efficient than incandescent bulbs and last much longer. Large-scale deployment of CFLs can help reduce peak electricity needs and ameliorate infrastructure shortages.

[7] See Hutton, Rehfuess and Tediosi (2007), UNEP (2003) and IEA (2006).

[8] See Mathers and Loncar (2006); WHO (2008); Smith *et al.,* (2004); and WHO (2004).

[9] Light intensity, or illuminating power of a light source, in any one direction is commonly defined as "candela", which can be thought of as "candle-power"; *i.e.*, the output from a standard paraffin wax candle. The rate at which light is emitted is measured in lumens, which are defined as the rate of flow of light from a light source of one candela through a solid angle of one steradian.

***Figure 5:* Premature annual deaths from household air pollution and other diseases**



Sources: Mathers and Loncar (2006); WHO (2008); Smith *et al.,* (2004); WHO (2004) and IEA analysis.

Moreover, in developing regions in which households are heavily reliant on biomass, women and children are generally responsible for fuel collection – a time-consuming and exhausting task. Women can suffer serious long-term physical damage from strenuous work without sufficient recuperation. This risk, as well as the hazards of falls, insect bites or human assault, rises steeply the further from home women have to walk. Inefficient and unsustainable cooking practices also have serious implications for the environment, such as land degradation and local and regional air pollution.[10] In cities where households are primarily reliant on wood or wood-based charcoal for cooking, there is local deforestation in the surrounding areas.

Effective environmental management cannot be excluded from energy and development concerns. Preventing irreversible damage to the global climate will require decarbonisation of the world's energy system. For developing countries, however, difficult choices have to be made in allocating scarce resources among pressing development needs and climate change is often viewed as a longer-term concern that must be traded off against short-term priorities. While the poorest developing countries are not major contributors to climate change, their populations suffer acutely from its effects. For net oil-importing developing countries in particular, rising and volatile prices have amplified the challenge of expanding energy access and put an extra burden on fiscal budgets. In a high-energy price and climate-conscious world, it makes sense for governments tackling the energy poverty challenge to choose a course consistent with long-term sustainable development goals, rather than choose the energy technologies and mix used by OECD countries in the 1950s and 1960s.

[10] Scientists have recently reported that soot, or black carbon, such as that emitted from the burning of biomass in inefficient stoves, plays a large role in global and regional warming. Black carbon forms during incomplete combustion, and is emitted by a wide range of sources, including diesel engines, coal-fired power plants, and residential cookstoves. Warming driven by black carbon appears to be especially amplified in the high country of Asia's Tibetan Plateau. There, summer melt-water provides water to more than a billion people. Already, glaciers on the plateau have declined by about 20% since the 1960s (Luoma, 2010).

The World Resource Institute has defined Sustainable Development Policies and Measures (SD-PAMs) which offer an opportunity for developing countries to reduce emissions through tailored, development-focused policies, guided by domestic priorities.[11] Policies in the energy sector that countries would be likely to pursue as SD-PAMs include measures to promote energy efficiency, the broader use of renewable energy sources and steps to reduce energy subsidies while safeguarding the welfare of poor households.

Energy and the Millennium Development Goals

Eight Millennium Development Goals (MDGs), adopted in 2000, were designed to eradicate extreme poverty by 2015. Energy can contribute to the achievement of many of these goals (Box 2). But the MDGs contain no goal specifically related to energy and there are no targets or indicators associated with the MDGs that would enable governments and the international community to monitor progress towards universal access.[12] The UN Advisory Group on Energy and Climate Change has called for adoption of the goal of universal access to modern energy services by 2030.

***Box 2:* The importance of modern energy in achieving the MDGs**

Goal 1: Eradicate extreme poverty and hunger. Access to modern energy facilitates economic development by providing more efficient and healthier means to undertake basic household tasks and means to undertake productive activities more generally, often more cheaply than by using the inefficient substitutes, such as candles and batteries. Modern energy can power water pumping, providing drinking water and increasing agricultural yields through the use of machinery and irrigation.

Goal 2: Achieve universal primary education. In impoverished communities children commonly spend significant time gathering fuelwood, fetching water and cooking. Access to improved cooking fuels or technologies facilitates school attendance. Electricity is important for education because it facilitates communication, particularly through information technology, but also by the provision of such basic needs as lighting.

Goal 3: Promote gender equality and empower women. Improved access to electricity and modern fuels reduces the physical burden associated with carrying wood and frees up valuable time, especially for women, widening their employment opportunities. In addition, street-lighting improves the safety of women and girls at night, allowing them to attend night schools and participate in community activities.

Goals 4; 5; and 6: Reduce child mortality; Improve maternal health; and Combat HIV/AIDS, malaria and other diseases. Most staple foods require cooking and reducing household air pollution through improved cooking fuels and stoves decreases the risk of respiratory infections, chronic obstructive lung disease and lung cancer (when coal is used). Improved access to energy allows households to boil water, thus reducing the incidence of waterborne diseases. Improved access advances communication and transport services, which are critical for emergency health care. Electricity and modern energy services support the functioning of health clinics and hospitals.

Goal 7: Ensure environmental sustainability. Modern cooking fuels and more efficient cookstoves can relieve pressures on the environment caused by the unsustainable use of biomass. The promotion of low-carbon renewable energy is congruent with the protection of the environment locally and globally, whereas the unsustainable exploitation of fuelwood causes local deforestation, soil degradation and erosion. Using cleaner energy also reduces greenhouse-gas emissions and global warming.

Goal 8: Develop a global partnership for development. Electricity is necessary to power information and communications technology applications.

Source: Adapted from UN-Energy, 2005.

[11] www.wri.org/project/sd-pams.

[12] The only indicator related to energy is for CO_2 emissions: total, per capita and per $1 GDP (PPP) under Goal 7. At the 12th International Energy Forum (IEF) Ministerial in Cancun in March 2010, the IEF called for the international community to set up a ninth goal, specifically related to energy, consolidating the evident link between modern energy services and achievement of the MDGs.

The Universal Modern Energy Access Case

To illustrate what would be required to achieve universal access to modern energy services, we have developed the Universal Modern Energy Access Case (UMEAC). This case quantifies the number of people who need to gain access to modern energy services and the scale of the investments required by 2030. It includes interim targets to 2015, related to the achievement of the Millennium Development Goals.

The energy targets adopted to 2015 are consistent with the achievement of the first Millennium Development Goal - eradicating extreme poverty. We interpret this, in this context, as meaning that no more than one billion people should be without access to electricity by that date and no more than 1.7 billion should still be using traditional biomass for cooking on open fires or primitive stoves (Table 2). The relationship between poverty and modern energy access has been derived from a cross-country analysis covering 100 countries and the projections are based on regression analyses, which are applied to each region.

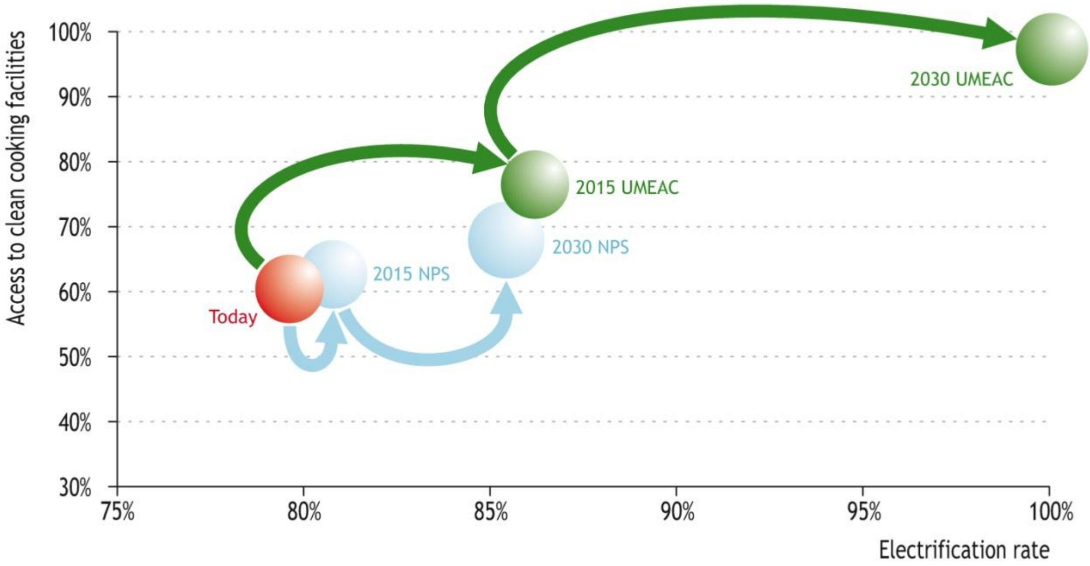
Table 2: **Targets in the Universal Modern Energy Access Case**

	2015		2030	
	Rural	Urban	Rural	Urban
Access to electricity	Provide 257 million people with electricity access	100% access to grid	100% access, of which 30% connected to the grid and 70% either mini-grid (75%) or off-grid (25%)	100% access to grid
Access to clean cooking facilities	Provide 800 million people with access to LPG stoves (30%), biogas systems (15%) or advanced biomass cookstoves (55%)	Provide 200 million people with access to LPG stoves	100% access to LPG stoves (30%), biogas systems (15%) or advanced biomass cookstoves (55%)	100% access to LPG stoves

Note: Liquefied petroleum gas (LPG) stoves are used as a proxy for modern cooking stoves, also including kerosene, biofuels, gas and electric stoves. Advanced biomass cookstoves are biomass gasifier-operated cooking stoves which run on solid biomass, such as wood chips and briquettes. Biogas systems include biogas-fired stoves.

Our analysis shows that, compared to the projections in the New Policies Scenario (footnote 5), in order to achieve the stated interim goals by 2015, an additional 395 million people need to be provided with electricity and an additional 1 billion provided with access to clean cooking facilities. These are demanding targets – in the New Policies Scenario they are not achieved even in 2030 (Figure 6). For 2030, the UMEAC calculates what would be involved in achieving the more ambitious goal of universal access to modern energy services. Beyond the achievement of the interim 2015 target, this translates into the provision of electricity to an additional 800 million people and giving an additional 1.7 billion people access to clean cooking fuels in 2016-2030.

Figure 6: **Access to modern energy services in the New Policies Scenario (NPS) and Universal Modern Energy Access Case (UMEAC)**



The investment implications are examined more closely below. But, in brief, bringing electricity to the 1.2 billion people who would otherwise not have access to it by 2030 would require additional cumulative investment, beyond that in the New Policies Scenario, of $700 billion in 2010-2030, or $33 billion per year. In addition, in order to achieve universal access to clean cooking facilities for some 2.8 billion people, additional cumulative investment of some $56 billion would be required in 2010-2030, or $2.6 billion per year. Thus $756 billion additional investment is required to achieve universal access to electricity and clean cooking facilities by 2030.

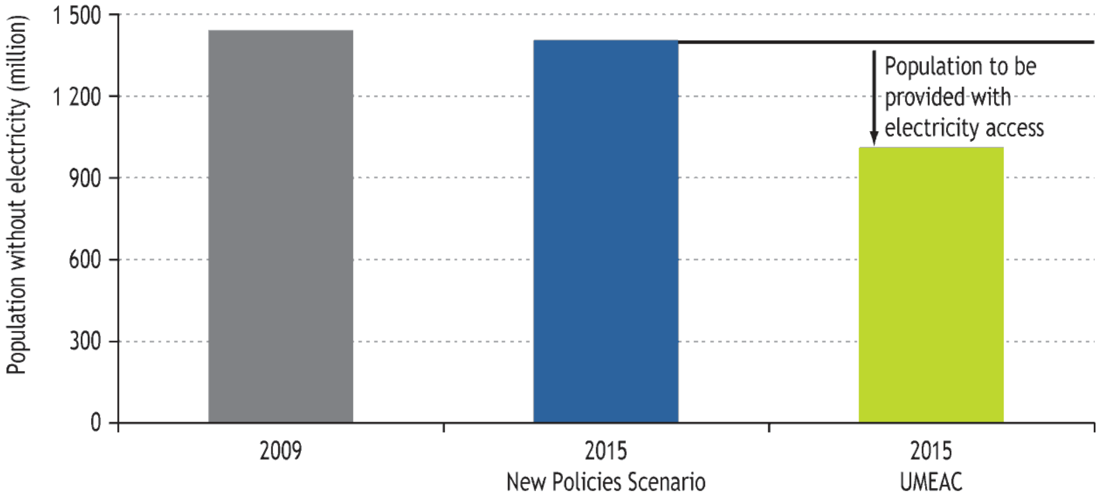
This sum is put in perspective when seen in relation to the projected global energy investment of over $26 trillion in 2010-2030 in the New Policies Scenario: it is less than 3% of global energy investment. Universal access to modern energy services would have little impact on energy demand, production or CO_2 emissions. In 2030, global electricity generation would be 2.9% higher, oil demand would have risen less than 1% and CO_2 emissions would be 0.8% higher, compared to the New Policies Scenario.

Access to electricity

Today, more than 1.4 billion people worldwide lack access to electricity: 585 million people in Sub-Saharan Africa (including over 76 million in Nigeria and some 69 million in Ethiopia) and most of the rest in developing Asia (including 400 million in India and 96 million in Bangladesh). Some 85% of those without access live in rural areas.

In the New Policies Scenario, the number of people lacking access to electricity in 2015 is still around 1.4 billion – practically unchanged from today (Figure 7). To achieve the targets we have defined in the UMEAC to be consistent with the achievement of the first Millennium Development Goal of eradicating extreme poverty by 2015, the number of people without electricity in 2015 would need to be about 395 million less than this, *i.e.* about 1 billion. The global electrification rate would then be 86%, five percentage points higher than the electrification rate achieved in the New Policies Scenario in 2015.

Figure 7: **Implication of eradicating extreme poverty on number of people without access to electricity by 2015**



Although electrification will progress over the period to 2030, the need will grow as the population increases.[13] In the New Policies Scenario, without additional, dedicated policies, there are still nearly 1.2 billion people lacking access in 2030 (Table 3). The electrification rate in developing countries increases from 73% in 2009 to 81% in 2030. China is projected to achieve universal electrification soon after 2015. In developing Asian countries apart from China and India, the electrification rate rises to 82%, but 252 million people still lack access in 2030. Electricity access in Latin America is nearly universal by 2030. In Sub-Saharan Africa, the absolute number of people lacking access is projected to continue to rise, despite an increase in the electrification rate; by 2030, the region accounts for 54% of the world total, compared with 41% in 2009.

Table 3: **Number of people without access to electricity and electrification rates by region in the New Policies Scenario** (million)

	2009			2015	2030	2009	2015	2030
	Rural	Urban	Total	Total	Total	%	%	%
Africa	466	121	587	636	654	42	45	57
Sub-Saharan Africa	*465*	*120*	*585*	*635*	*652*	*31*	*35*	*50*
Developing Asia	716	82	799	725	545	78	81	88
China	*8*	*0*	*8*	*5*	*0*	*99*	*100*	*100*
India	*380*	*23*	*404*	*389*	*293*	*66*	*70*	*80*
Other Asia	*328*	*59*	*387*	*331*	*252*	*65*	*72*	*82*
Latin America	27	4	31	25	10	93	95	98
Developing countries*	1229	210	1438	1404	1213	73	75	81
World**	**1232**	**210**	**1441**	**1406**	**1213**	**79**	**81**	**85**

*Includes Middle East countries; **includes OECD and transition economies.

[13] Electricity access occurs at a much faster rate in urban areas, as companies are often required to provide electricity service and it is more profitable. Most of the increase in the number of people with access over the projection period is in urban areas in the New Policies Scenario.

To assess the extent of the additional generating capacity required to achieve universal access, we have made assumptions about minimum levels of consumption at both the rural and urban level: rural households are assumed to consume at least 250 kWh per year and urban households 500 kWh per year. In rural areas, this level of consumption could provide for the use, for example, of a floor fan, two compact fluorescent light bulbs and a radio for about five hours per day. In urban areas, consumption could also include a television and another appliance, such as an efficient refrigerator or a computer. Consumption is assumed to rise every year until reaching the average national level.

This amounts to total incremental electricity output by 2030 of around 950 TWh. This additional electricity generation represents some 2.9% of the nearly 33 000 TWh generated worldwide in 2030 in the New Policies Scenario. To generate this additional electricity output would require generating capacity of 250 GW.

Various options for supplying this electricity need to be considered, including on-grid, mini-grid[14] and isolated off-grid connections (Table 4). Grid extension will contribute part of the solution, but decentralised options have an important role to play when grid extension is too expensive and will provide the bulk of the additional connections over the projection period (see also, Box 3, Figure 12 and the associated text).

***Table 4:* Generation requirements for universal electricity access, 2030** (TWh)

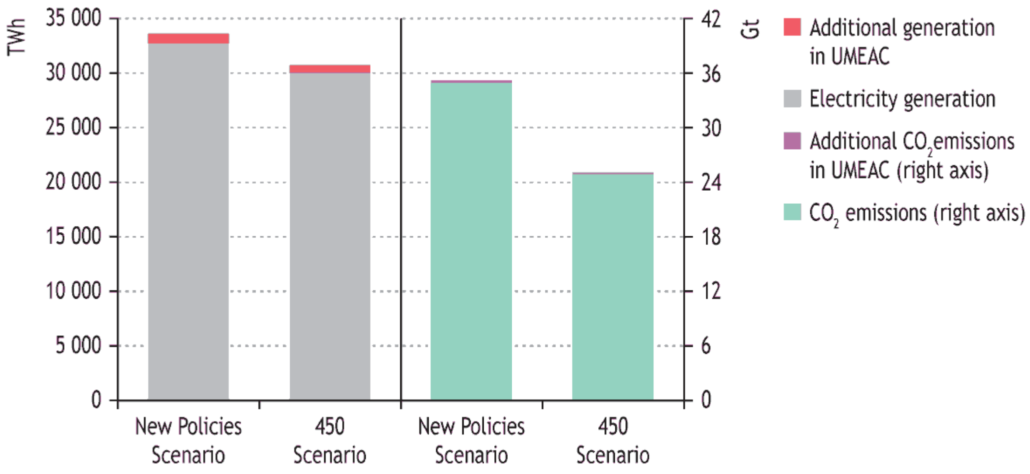
	On-grid	Mini-grid	Isolated off-grid	Total
Africa	196	187	80	463
Sub-Saharan Africa	*195*	*187*	*80*	*462*
Developing Asia	173	206	88	468
China	*1*	*1*	*0*	*2*
India	*85*	*112*	*48*	*245*
Other Asia	*87*	*94*	*40*	*221*
Latin America	6	3	1	10
Developing countries*	379	399	171	949
World**	**380**	**400**	**172**	**952**

*Includes Middle East countries; **includes OECD and transition economies.

Achieving universal electricity access would have a modest impact on energy-related CO_2 emissions. Compared with the New Policies Scenario, global energy-related CO_2 emissions in the UMEAC increase by just 0.8% by 2030, or around 2% of current OECD emissions. If the generation fuel mix to supply the additional demand in the UMEAC was the same as that projected in the 450 Scenario, the increase in energy-related global CO_2 emissions would be a mere 0.6% (Figure 8).

[14] Mini-grids are village- and district-level networks with loads of up to 500 kW.

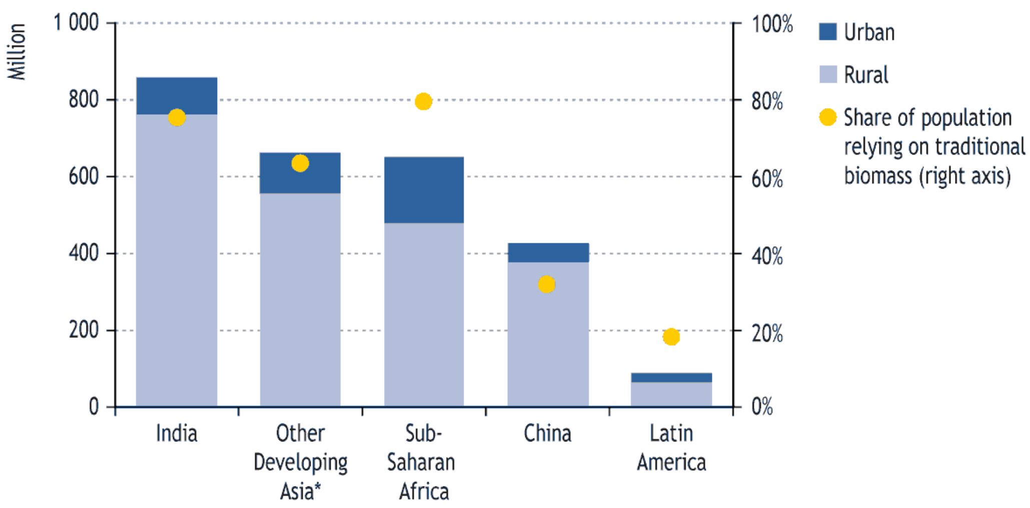
Figure 8: **Global implications for electricity generation and CO_2 emissions in the UMEAC, 2030**



Access to clean cooking facilities

There are currently about 2.7 billion people in developing countries who rely for cooking primarily on biomass, including wood, charcoal, tree leaves, crop residues and animal dung, used in inefficient devices.[15] This number is higher than previously estimated in the WEO, due to population growth, rising liquid fuel costs and the global economic recession (which have driven a number of people back to using traditional biomass).[16] About 82% of those relying on traditional biomass live in rural areas, although in Sub-Saharan Africa, nearly 60% of people living in urban areas also use biomass for cooking. The share of the population relying on the traditional use of biomass is highest in Sub-Saharan Africa and India (Figure 9).

Figure 9: **Number and share of population relying on the traditional use of biomass as their primary cooking fuel by region, 2009**



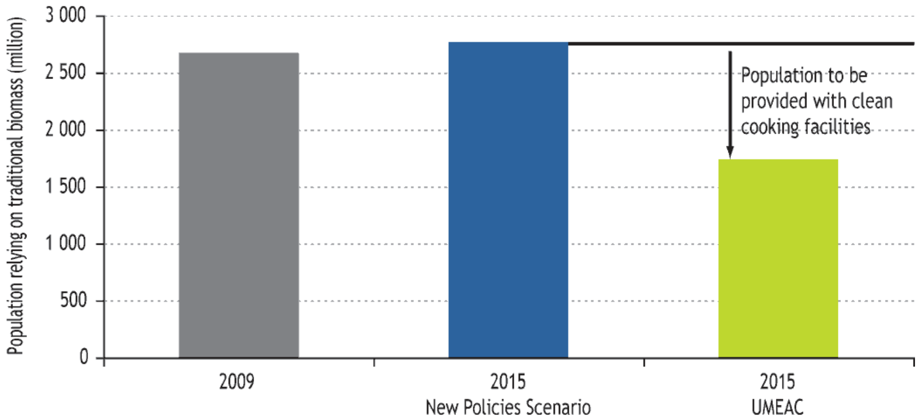
*Includes developing Asian countries except India and China.

[15] In many countries, biomass is also used for space heating. The introduction of cleaner, more efficient devices for cooking does not necessarily reduce the need for traditional stoves or fires for heating.

[16] For example, recent analysis by ECLAC indicates that, while wood consumption for cooking and heating in Latin America and the Caribbean decreased steadily in the 1990s, it has risen this decade in many countries as a result of increasing poverty (ECLAC, *et al.,* 2010).

In the New Policies Scenario, the number of people relying on the traditional use of biomass for cooking increases from just under 2.7 billion in 2009 to about 2.8 billion in 2015. To achieve the Millennium Development Goals would necessitate a substantial reduction. In a similar manner to that used to define targets for universal electricity access, we have defined targets for access to clean cooking facilities, related to the MDG for poverty reduction (see Table 2). In the UMEAC, eradicating extreme poverty by 2015 would mean reducing the number of people still using traditional biomass to around 1.7 billion by 2015 That is, beyond the projections in the New Policies Scenario, 1 billion more people would need to gain access to clean cooking facilities, including LPG stoves, advanced biomass cookstoves and biogas systems (Figure 10).[17] Over 800 million of them would be living in rural areas.

Figure 10: Implication of reducing poverty on number of people relying on the traditional use of biomass for cooking by 2015



Looking further ahead to 2030 in the New Policies Scenario, the number of people relying on the traditional use of biomass remains at about 2.8 billion, one-third of whom live in Sub-Saharan Africa (Table 5). The share of the population relying on biomass falls in all regions/countries, but the pace of decline is slowest in Sub-Saharan Africa. Accordingly, building on the assumed improved results in 2015, the UMEAC means that an additional 1.7 billion people must achieve access to modern cooking facilities in the period 2016-2030.

Table 5: Number of people relying on the traditional use of biomass as their primary cooking fuel by region in the New Policies Scenario (million)

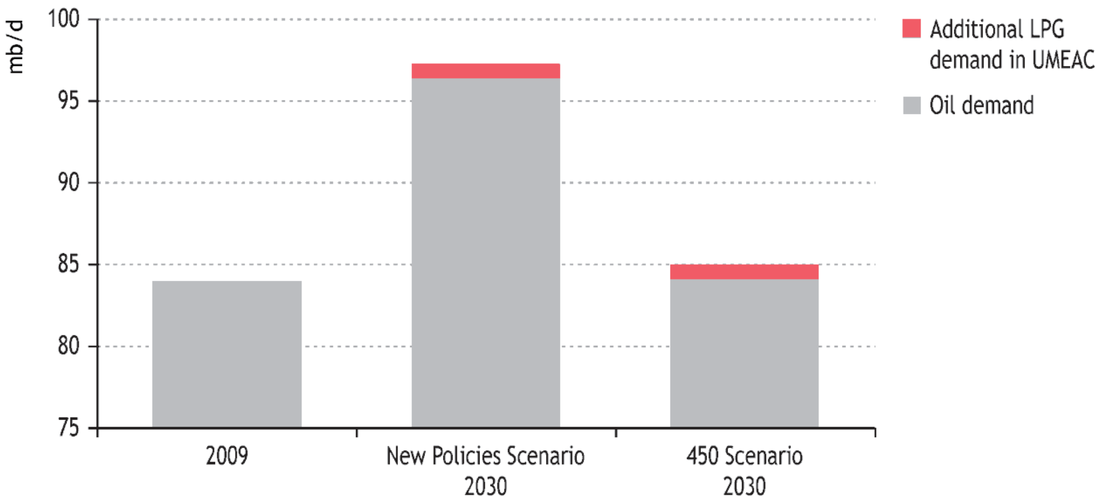
	2009			2015	2030	2009	2015	2030
	Rural	Urban	Total	Total	Total	%	%	%
Africa	481	176	657	745	922	67	65	61
Sub-Saharan Africa	*477*	*176*	*653*	*741*	*918*	*80*	*77*	*70*
Developing Asia	1 694	243	1 937	1 944	1 769	55	51	42
China	*377*	*47*	*423*	*393*	*280*	*32*	*28*	*19*
India	*765*	*90*	*855*	*863*	*780*	*75*	*69*	*54*
Other Asia	*553*	*106*	*659*	*688*	*709*	*63*	*60*	*52*
Latin America	60	24	85	85	79	18	17	14
Developing countries*	2 235	444	2 679	2 774	2 770	54	51	44
World**	**2 235**	**444**	**2 679**	**2 774**	**2 770**	**40**	**38**	**34**

*Includes Middle East countries; **includes OECD and transition economies.

[17] For a discussion of advanced biomass stoves, see C. Venkataraman *et al.*, 2010. For a discussion of biogas digesters, see www.unapcaem.org.

Expanding household access to modern fuels would inevitably increase global demand for these fuels, notably oil, but only by a small amount. In the UMEAC, 445 million people switch to LPG stoves by 2015 and another 730 million by 2030. Assuming average LPG consumption of 22 kg per person per year,[18] total world oil product demand by 2030 would be 0.9 million barrels per day (mb/d) higher than in the New Policies Scenario. This represents 0.9% of the projected 96 mb/d of global oil demand in 2030 (Figure 11). The additional oil demand associated with access to LPG in the UMEAC is roughly equivalent to 5% of oil demand in the United States today. In the 450 Scenario, where in 2030 global oil demand is 12.3 mb/d lower than in the New Policies Scenario, global oil demand still increases by only 1% in 2030.

Figure 11: **Global implications for oil demand in the UMEAC**



The impact on greenhouse-gas emissions of switching to advanced biomass technologies or LPG is very difficult to quantify because of the diversity of factors involved, including the particular fuels, the types of stoves and whether the biomass used is replaced by new planting and that a sustainable forestry management programme is in place. But it is widely accepted that improved stoves and greater conversion efficiency would result in emissions reductions.

Investment needs in the Universal Modern Energy Access Case

In the Universal Modern Energy Access Case cumulative investment of $756 billion, over and above investment in the New Policies Scenario, is needed. This comprises investment to achieve universal access to electricity and to clean cooking facilities by 2030. Some 30% of the investment is needed in 2010-2015 to achieve the interim target. This will require additional annual investment of $41 billion in 2010-2015, or only 0.06% of average annual global GDP at market exchange rates (MER) over the period.

Investment needs for universal electricity access

Achievement of the targets associated with the MDG of eradicating extreme poverty by 2015 requires cumulative investment of some $223 billion in 2010-2015 and another $477 billion in 2016-2030 for access to electricity to be universal by 2030. Rural areas account for the bulk of additional household electrification in this period. The supply arrangements include grid and

[18] A weighted average based on WHO data for developing country households currently using LPG.

off-grid solutions (Figure 12). Consumer density is a key variable in providing electricity access: the cost per MWh delivered through an established grid is cheaper than that through mini-grids or off-grid systems, but the cost of extending the grid to sparsely populated areas can be very high and long distance transmission systems have high technical losses. Thus, decentralised solutions also have an important role to play and will, indeed, account for most of the investment over the projection period (Box 3).

Box 3: Renewable energy for rural applications

Grid extension in rural areas is often not cost effective. Small, stand-alone renewable energy technologies can often meet the electricity needs of rural communities more cheaply and have the potential to displace costly diesel-based power generation options.

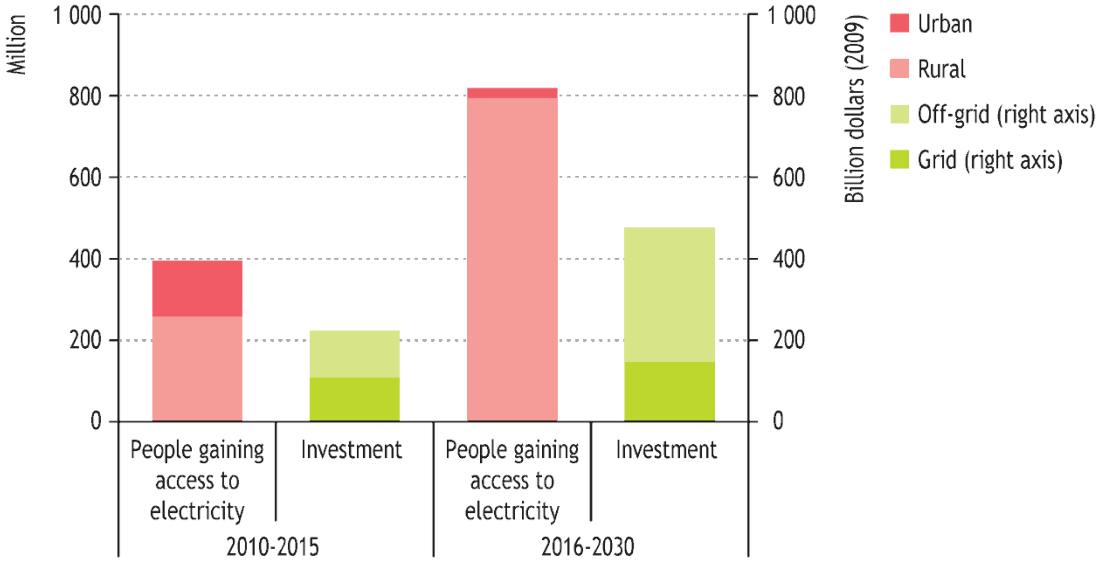
Specific technologies have their advantages and limitations. Solar photovoltaic (PV) is attractive as a source of electric power to provide basic services, such as lighting and clean drinking water. For greater load demand, mini-hydro or biomass technologies may offer a better solution, though PV should not be ruled out of consideration as system prices are decreasing - a trend which can be expected to continue in the years to come. Moreover, PV can also be easily injected in variable quantity into existing power systems. Wind energy represents a good (and available) cost-competitive resource, with mini-wind prices below those of PV. Wind energy systems are capable of providing a significant amount of power, including for motive power. One of the main advantages of renewable energy sources, particularly for household-scale applications, is their comparatively low running costs (fuel costs are zero), but their high upfront cost demands new and innovative financial tools to encourage uptake. To combine these different sources of energy in a power system supplying a mini-grid is probably the most promising approach to rural electrification. It is important that subsidised delivery mechanisms make provision for maintenance and repair.

Improved irrigation is vital to reducing hunger and saving dwindling water resources in many developing countries. Drip irrigation is an extremely efficient mechanism for delivering water directly to the roots of plants. It increases yields and allows for introduction of new crops in regions and in seasons in which they could not be sustained by rainfall alone. Solar-powered pumps save hours of labour daily in rural off-grid areas, where water hauling is traditionally done by hand by women and children. These pumps are durable and immune to fuel shortages. In the medium term, they cost less than diesel-powered generators.[19]

In our calculations, all urban and peri-urban households are assumed to be connected to the grid by 2015 in the UMEAC. About a third of rural areas are assumed to be similarly connected, while other households use off-grid and mini-grid options, including PV, mini-hydro, biomass, wind, diesel and geothermal. In the first year of obtaining access to electricity, the minimum annual consumption per household is assumed to be 250 kWh in rural areas and 500 kWh in urban areas. Household consumption rises every year over the projection period, until reaching the national average in 2030. Average household size is assumed to be five people.

[19] See for example www.self.org/benin.shtml.

Figure 12: Number of people gaining access to electricity and additional cumulative investment needs in the UMEAC*



*Compared with the New Policies Scenario.

The bulk of the investment for electrification by 2015 is incurred in developing Asian countries, primarily because economic growth is expected to be more rapid in these countries than in Sub-Saharan Africa. The path to universal electricity access will require substantial financing in all developing regions, except Latin America, where access is already high. Cumulative investment of some $340 billion would be required to electrify all households in Sub-Saharan Africa by 2030 (Table 6).

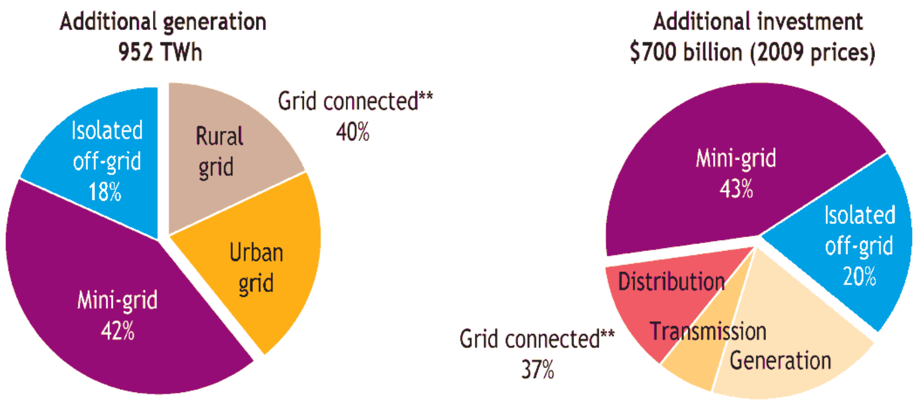
Table 6: Investment requirements for electricity in the UMEAC* ($ billion)

	2010- 2015	2016-2030	2010-2030
Africa	81	262	343
Sub-Saharan Africa	*80*	*262*	*342*
Developing Asia	127	214	342
China	*1*	*0*	*1*
India	*52*	*130*	*182*
Other Asia	*74*	*84*	*158*
Latin America	5	3	7
Developing countries**	219	478	698
World* **	**223**	**477**	**700**

*Compared with the New Policies Scenario; **Includes Middle East countries; ***includes OECD and transition economies.

The additional power-sector investment, $33 billion per year on average in 2010-2030 in the UMEAC (Figure 13), is equivalent to just 5% of the average annual global investment in the power sector in the New Policies Scenario, or around one-fifth of the annual investment required in China's power sector over the projection period. Adding $0.003 per kWh, some 1.8%, to current electricity tariffs in OECD countries would fully fund the additional investment.

Figure 13: Incremental electricity generation and investment in the UMEAC, 2010-2030*



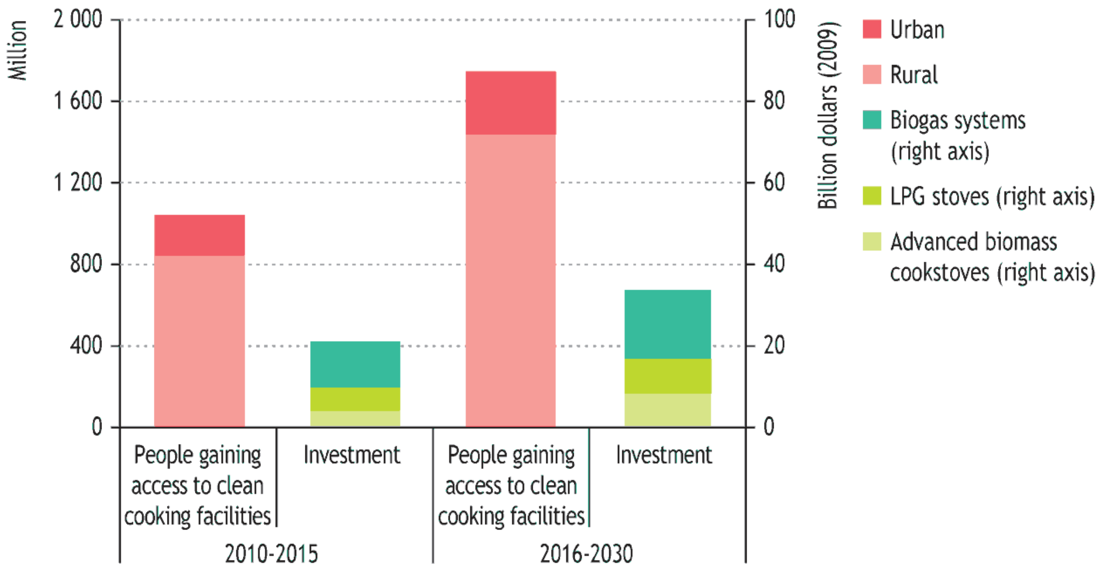
*Compared with the New Policies Scenario.

**Includes generation, transmission and distribution for both urban and rural grids.

Investment needs for universal access to clean cooking facilities

We estimate that universal access to clean cooking facilities could be achieved through additional cumulative investment of $56 billion in 2010-2030, over and above that in the New Policies Scenario. Of this investment, 38% is required in the period to 2015 (Figure 14). Over the entire projection period, 51% of the cumulative investment goes to biogas systems in rural areas, 23% to advanced biomass cookstoves in rural areas and 26% to LPG stoves in both rural and urban areas. The average additional annual investment over the period to 2030 is $2.6 billion. Additional cumulative investment (2010-2030) of some $16 billion is required in China, $14 billion in India and $10 billion in other developing Asian countries (Table 7). The necessary cumulative investment to 2030 is $14 billion in Sub-Saharan Africa.

Figure 14: Number of people gaining clean cooking facilities and additional cumulative investment needs in UMEAC*



*Compared with the New Policies Scenario.

These investment allocations are derived from assumptions regarding the most likely technology solution in each region, given resource availability and government policies and measures. Advanced biomass cookstoves, with emissions and efficiencies similar to those of LPG stoves, are assumed to cost $45. The cost of a biogas digester is assumed to be $400, the middle of the range of estimated costs for household biogas systems. An LPG stove and canister is assumed to cost $60. Infrastructure, distribution and fuel costs are not included in the investment costs. We assume one stove or biogas system per household over the projection period, thus replacement costs are not included.

Developing Asia accounts for 80% of the total $28 billion investment needed for biogas systems, while China alone accounts for 50% of the total. In rural areas of Sub-Saharan Africa, over 60% of the 645 million people that need to gain access to clean cooking facilities in 2010-2030 are provided with advanced biomass cookstoves and the remainder with LPG stoves and biogas systems. In rural areas of China, 55% of the target population are provided with biogas systems, 15% with advanced biomass cookstoves and the remainder with LPG stoves.

Table 7: **Investment requirements for electricity in the UMEAC*** ($ billion)

	2010-2015	2016-2030	2010-2030
Africa	4	9	14
Sub-Saharan Africa	*4*	*9*	*14*
Developing Asia	16	24	40
China	*7*	*9*	*16*
India	*5*	*8*	*14*
Other Asia	*3*	*6*	*10*
Latin America	1	1	2
Developing countries**	21	35	56
World***	**21**	**35**	**56**

*Compared with the New Policies Scenario; **Includes Middle East countries; ***includes OECD and transition economies.

Financing for universal modern energy access

Financing the $756 billion, or $36 billion per year, needed to provide universal access to modern energy services in 2010-2030, compared with the New Policies Scenario, is a major challenge. So far, investments have been far below needs, especially in Sub-Saharan Africa. Investments in electrification have been greater than in clean cooking facilities.

All available sources of finance will need to be tapped: international funds, public/private partnerships, bank finance at multilateral, bilateral and local levels, microfinance, loans and targeted subsidies. The financing mechanism adopted will need to be matched to the particular characteristics of the financing need: for example, the financial mechanisms appropriate to electrification differ according to the scale of the project and also differ from those required for expanding access to clean cooking facilities.

The public sector can be expected to fund the costs of creating the necessary enabling environment, for example, establishing the appropriate policies, regulations and institutions, and will often need to finance the relatively large investments, such as additional generating capacity or transmission links. Indeed, in most developing countries, upfront public investment in developing national and local capacity is the most important ingredient in creating an environment which will encourage the private sector to assume at least part of the risk – essentially, where a commercial return can be reliably earned on the investment. Investment costs which fall to consumers are in a different category. Households will need loans (often on concessionary terms), leasing finance, to convert unaffordable high initial investment costs into affordable operating costs, grants and, even, initial operating subsidies.

Local public banks, as well as bilateral and multilateral agencies, will remain important sources of finance (World Bank Group, 2010). However, those institutions are unlikely to be in a position to provide the level of financing necessary to promote universal access to modern energy services. Existing energy programmes and funds (such as the Renewable Energy and Energy Efficiency Fund (REEF), the Climate Investment Funds administered by the World Bank and implemented jointly with other development banks,[20] the Global Environment Facility and GTZ's Energising Development) can be utilised to administer and distribute finance, but will need to be scaled-up significantly.

Oil and gas-exporting countries have a source of financing that is not available to importing countries. *World Energy Outlook 2008* estimated that the cost of providing electricity and LPG stoves and canisters to those households without access in the ten largest oil and gas-exporting countries in Sub-Saharan Africa would be roughly equivalent to only 0.4% of the governments' cumulative take from hydrocarbon exports through to 2030 (IEA, 2008). Such resource wealth offers a significant opportunity for economic development and poverty alleviation, if managed effectively. Greater efficiency of revenue allocation and greater accountability in the use of public funds are both important.

Long-term financing for rural electrification is important. From the outset, financial provisions should extend long-term (five to ten years) support for the system, under contracts providing also for maintenance and upgrading. Efforts should be made to direct usage, at least partially, towards the development of productive activities, to generate funds to cover the costs, particularly maintenance, once the support arrangements have come to an end (Niez, 2010).

In contrast to investments for electrification, which are mainly funded by governments and institutional investors, cooking services involve products which are paid for by the consumer.[21] The cost of an improved cookstove ranges from a few dollars to $45 (or in some cases considerably more). Where improved combustion leads to substantial, demonstrable reductions in global warming emissions, these costs may be offset by carbon finance through the Clean Development Mechanism or other mechanisms generating carbon credits.[22] To support the uptake of clean cooking facilities, governments and donors need to invest in public awareness campaigns regarding the health and other benefits of clean cooking practices.

Microfinance has proved particularly valuable to poor women. They tend to obtain better credit ratings than men and value highly the improvements that can be made to the quality of family life. In Bangladesh, for example, women have shown to default on loans far less often than men. In many cases, though, the scale of microfinance is insufficient to make large inroads into energy poverty.

[20] For example, the World Bank's Clean Technology Fund, Pilot Program for Climate Resilience and Scaling up Renewable Energy Program.

[21] The provision of cookstoves by themselves is not enough for universal access. The supply chain, including distribution and production, of stoves and fuels, including biomass, also need to be considered.

[22] The Gold Standard Foundation, an international non-profit organisation based in Switzerland, operates a certification scheme for Gold Standard carbon credits.

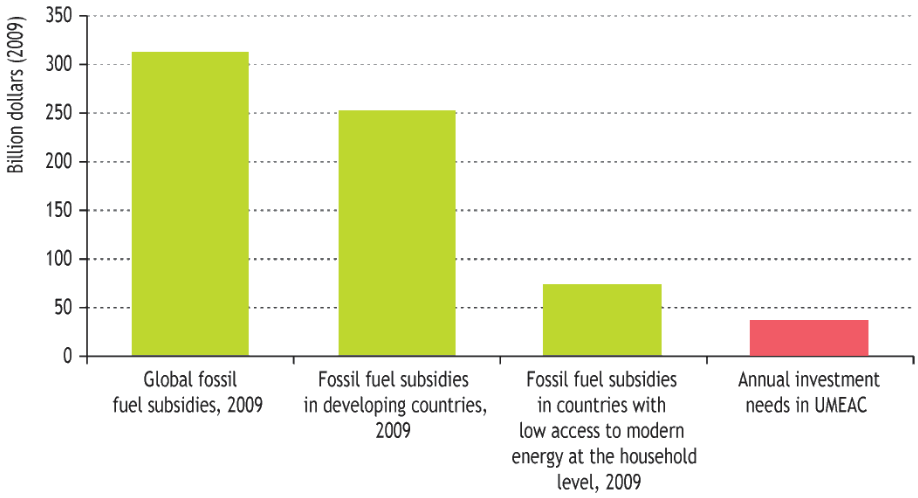
Spotlight: Are fossil fuel subsidies in developing countries crowding out investments that would expand energy access?

According to analysis for the 2010 edition of the *World Energy Outlook*, of the $312 billion of total fossil-fuel subsidies in 2009, $252 billion were incurred in developing countries. Subsidies in countries with low access to modern energy at the household level (*i.e.*, electrification rates less than 90% or access to clean cooking facilities of less than 75%) amounted to $71 billion. Subsidies to kerosene, LPG and electricity in countries with low access to modern energy at the household level were less than $50 billion. Only a small share of oil-product subsidies is typically directed to cooking in the residential sector.

Subsidies impose a significant burden on national budgets, discourage efficiency of fuel use, can create shortages and result in smuggling and illicit use of subsidised petroleum products. Pressure is building in international fora for governments to phase-out blanket subsidies which are not well targeted to the poorest consumers. But phase-out policies must be carefully designed to avoid depriving the poor of basic needs. Direct financial assistance to poor families is probably more efficient than a subsidy to reduce the cost of a particular energy service.

The annual average investment required to achieve universal access to modern energy services by 2030, $36 billion, is around 12% of spending in 2009 on fossil-fuel subsidies in the 37 countries analysed (Figure 15).

***Figure 15:* Annual average additional investment needs in the UMEAC* compared with fossil-fuel subsidies in developing countries in 2009**



*Compared with the New Policies Scenario.

The poor often need to allocate a disproportionately high share of household budgets to energy services (Modi *et al.,* 2005) and the poorest populations accordingly need distinct forms of help, even though their per capita consumption is low. To address this, there is a long history of using subsidies to assist affordability. But ensuring that the benefits are provided only to the people most in need is difficult and consumers ideally should have a direct stake in the investment. A contribution by the consumer is critical to successful uptake. Households that pay for even a small fraction of the cost of modern energy services, whether it is an electricity connection, advanced biomass or LPG cookstove or biogas digester, are more likely to provide for maintenance and operating costs. Upfront costs for connections to the electricity grid or for fuel canisters and clean cooking stoves, can still remain too high for the poor and, in the most extreme cases, there may be no alternative to subsidising initially even a proportion of operating costs. One example, promoted by the EU-PV working group on developing countries is a Regulatory Purchase Tariff for off-grid electrification. Under this, the user pays only part of the tariff and the rest is covered by the government. This type of subsidy is focused on people with low consumption.

Monitoring progress and the Energy Development Index

The IEA has devised an Energy Development Index (EDI) in order to better understand the role that energy plays in human development. It tracks progress in a country's or region's transition to the use of modern fuels. By publishing updates of the EDI on an annual basis the IEA hopes to raise the international community's awareness of energy poverty issues and to assist countries to monitor their progress towards modern energy access (Box 4). The EDI is calculated in such a way as to mirror the UNDP's Human Development Index and is composed of four indicators, each of which captures a specific aspect of potential energy poverty:[23]

- *Per capita commercial energy consumption*: which serves as an indicator of the overall economic development of a country.
- *Per capita electricity consumption in the residential sector*: which serves as an indicator of the reliability of, and consumer's ability to pay for, electricity services.
- *Share of modern fuels in total residential sector energy use*: which serves as an indicator of the level of access to clean cooking facilities.
- *Share of population with access to electricity*.

A separate index is created for each indicator, using the actual maximum and minimum values for the developing countries covered (Table 8). Performance in each indicator is expressed as a value between 0 and 1, calculated using the formula below, and the EDI is then calculated as the arithmetic mean of the four values for each country.

$$\text{Indicator} = \frac{\text{actual value - minimum value}}{\text{maximum value - minimum value}}$$

***Table 8:* The minimum and maximum values used in the calculation of the 2010 Energy Development Index**

Indicator	Minimum value (country)	Maximum value (country)
Per capita commercial energy consumption (toe)	0.03 (Eritrea)	2.88 (Libya)
Per capita electricity consumption in the residential sector (toe)	0.001 (Haiti)	0.08 (Venezuela)
Share of modern fuels in total residential sector energy use (%)	1.4 (Ethiopia)	100 (Yemen, Lebanon, Syria, Iran)
Share of population with access to electricity (%)	11.1 (Dem. Rep. of Congo)	100 (Jordan, Lebanon)

[23] The choice of indicators is constrained by the type of data related to energy poverty that is currently available. For example, the per capita commercial energy consumption figure is one indicator of overall economic development of a country but for reasons of data deficiency it fails to take account of biomass resources, including wood, charcoal and biofuels, which are used for productive activities in developing countries. Biomass data is seldom disaggregated in a sufficient manner to capture this reality. With the introduction of low-emission, high-efficiency stoves, biomass consumption will decline in many countries. Yet the EDI cannot adequately compensate for the fact that this decline will be slower than in those countries where households switch to liquid fuels for cooking, even though the impact on energy poverty could be similar. The countries included in the EDI are those for which IEA collects energy data.

Box 4: Measuring progress with energy poverty indicators

A robust set of indicators for measuring energy poverty is needed to provide a rigorous analytical basis for policy-making. Indicators:

- Improve the availability of information about the range and impacts of options for action and the actions that countries are taking to increase access to energy.
- Help countries monitor actions they take to meet their agreed target.
- Enhance the effectiveness of implementation of such policies at national and local levels.

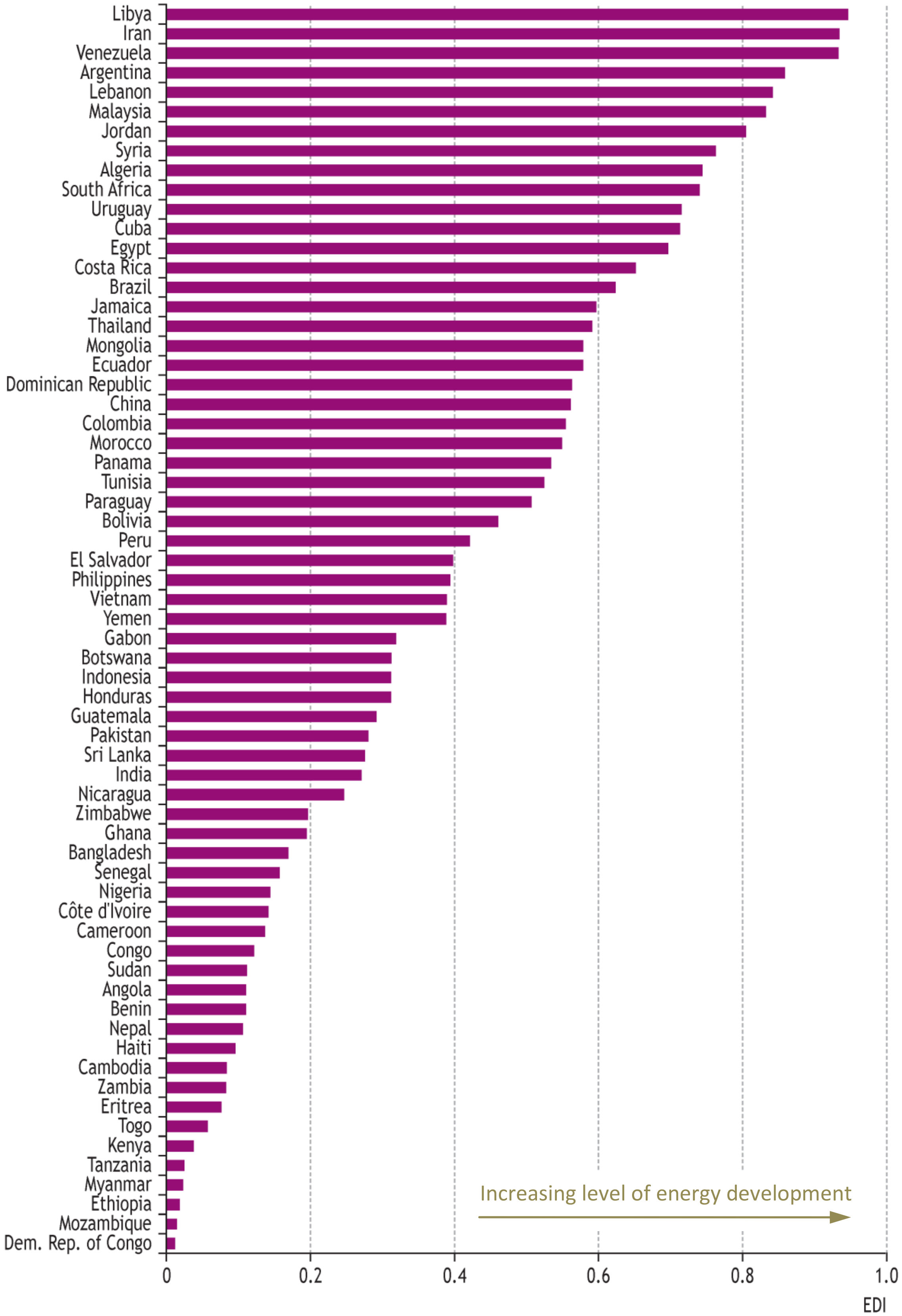
There are numerous examples of single indictors and composite indices to measure concepts related to development and energy (Bazilian *et al.*, 2010). The prime weakness of the various measures is related to data paucity and quality. In theory, energy development indicators should quantify not only the availability of energy - essentially a supply-side approach – but also measure to what extent the available supply is used and how much this contributes to the fulfilment of basic needs. The Earth Institute of Columbia University has pointed out that quantifying the value of some energy services, such as mechanical power or lighting, might benefit from the use of proxy indicators. Mechanical power is one of the largest energy services in terms of volume. It tends to generate a large return on investment and provides significant development leverage. Statistics on energy consumption for mechanical power, however, are not collected. An "ideal" energy development index could be based largely on the energy access recommendations set out by the UN Millennium Project.[24]

Computing a comprehensive energy development index will require the creation of new or augmented data-gathering systems and activities. A robust set of measurement indicators is crucial for informing and ensuring appropriate national policy-making, as well as effective international co-operation. Designing the right indicators and implementing a reporting system can help move energy access to the heart of a development plan. The *World Energy Outlook* has maintained databases on electricity access and reliance on traditional biomass in rural and urban areas since 2002 (IEA, 2002). These databases are updated annually and will be expanded with the emergence of more comprehensive data-gathering systems.

Figure 16 ranks countries using the four energy development indicators discussed above. Except for South Africa, all Sub-Saharan African countries appear in the bottom half of the EDI. Gabon ranks second in Sub-Saharan Africa, behind South Africa but 23 places lower. The ranking of countries in Asia varies greatly; Myanmar and Cambodia are in the bottom ten countries, while Malaysia is in the top ten. Pakistan has the highest EDI ranking of countries in South Asia, while Venezuela has the highest ranking of Latin American countries. Net oil-exporting countries, except for those in Sub-Saharan Africa, are all in the top third of the EDI ranking.

[24] The Millennium Project was commissioned by the UN Secretary-General in 2002 to develop a concrete action plan for the world to achieve the Millennium Development Goals (footnote 2). A common finding of the Millennium Project was the urgent need to improve access to energy services as essential inputs for meeting each MDG. The Millennium Project set out ten recommendations for priority energy interventions which national governments should take to support achieving the MDGs at the national level (Modi *et al.*, 2005).

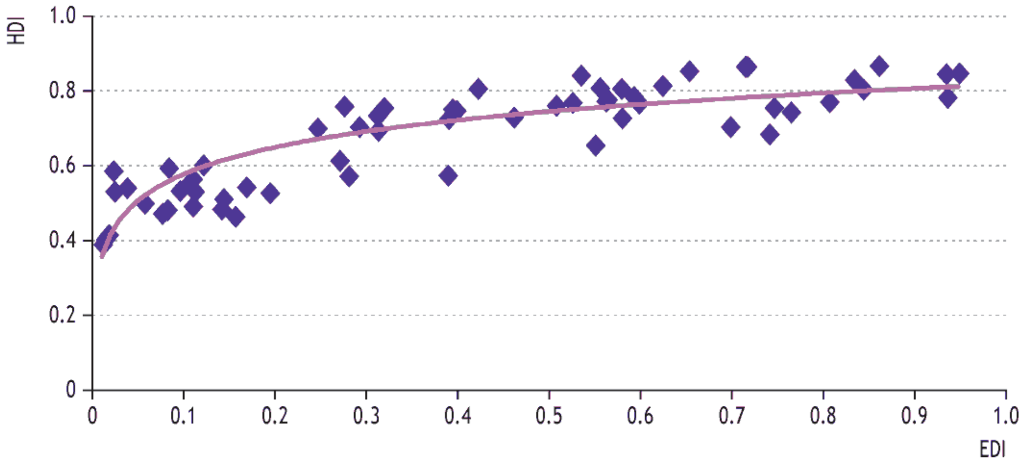
Figure 16: **The 2010 Energy Development Index***



*Based on 2009 data.

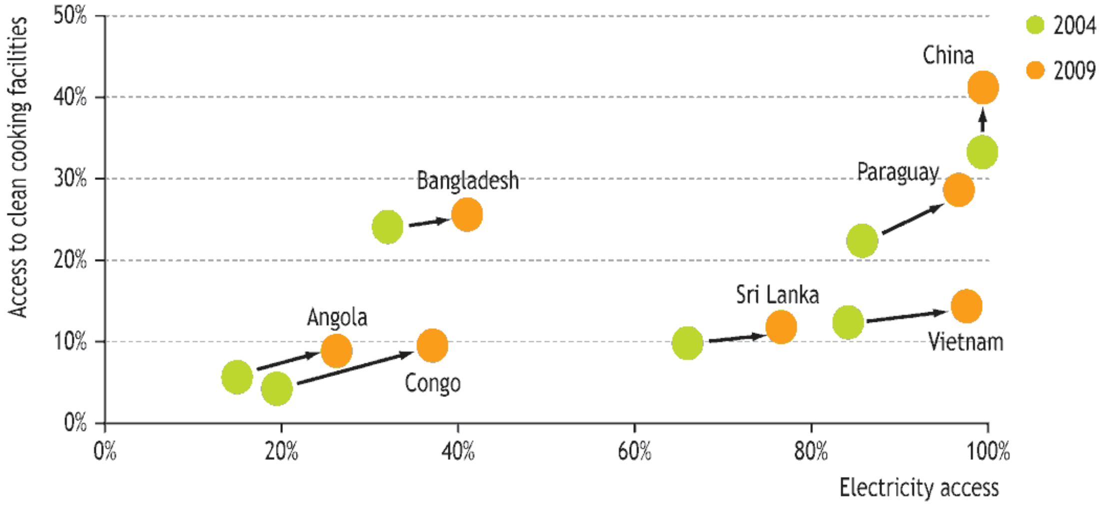
Given the substantial contribution of energy services to advancing human development, it is not surprising that the EDI results are strongly correlated with those of the Human Development Index (HDI) (Figure 17).[25] The HDI is composed of data on life expectancy, education, per capita GDP and other standard-of-living indicators at the national level.

***Figure 17:* Comparison of the EDI to the Human Development Index**



Many countries have made notable progress in improving access to electricity and clean cooking facilities since 2004, when the Energy Development Index was first created (IEA, 2004). In all countries both the absolute number with access and the share of the population with access have increased (Figure 18). In China, substantial progress has been made in the delivery of access to modern cooking fuels. In Angola and Congo, where the share of the population with electricity access and access to modern cooking fuels has expanded, most of the achievement has come from urban areas. While there has been progress on both fronts in Bangladesh, Sri Lanka and Vietnam, more progress has been made in household electrification than in the provision of access to modern cooking fuels.

***Figure 18:* Evolution of household access to modern energy in selected developing countries since 2004**



[25] The correlation is 0.84.

Other potential indicators

The *World Energy Outlook* will update the Energy Development Index on an annual basis. As more and better data become available, the EDI will also be augmented in order to enhance the monitoring of progress towards universal modern energy access. This section explores other possible indicators.

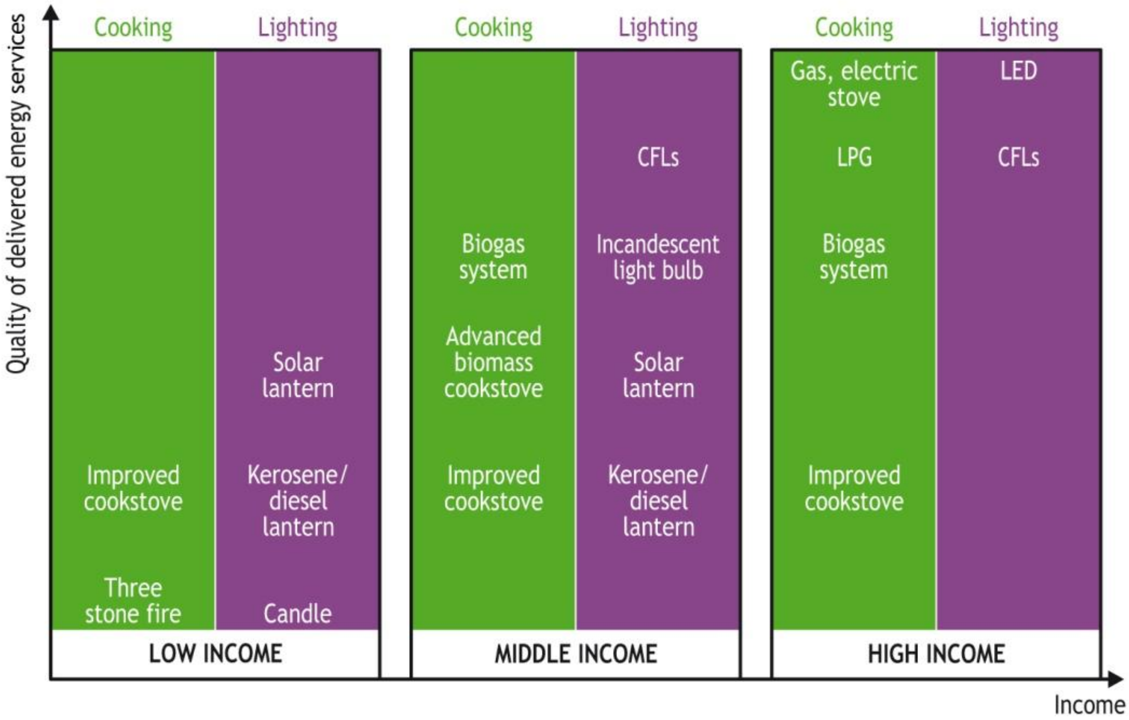
Figure 19 shows the relationship between fuel use and income across a range of developing countries. In low-income countries, final consumption of energy in the residential, services, industry and transport sectors is low and is comprised mainly of biomass. In high-income developing countries, the fuel mix is much more diverse and the overall amount of energy consumed is much higher. Demand for mobility, which is indicated where the share of other petroleum products in final energy consumption is high, is much greater in countries with a very low percentage of the population living on less than $2 per day.

***Figure 19:* The relationship between per-capita final energy consumption and income in developing countries**

Note: Average per capita final energy consumption is 3.1 toe in OECD countries. Other petroleum products are mostly consumed in the transport sector.

The indicators used in the EDI capture the quantity of energy consumed as well as rates of access. Other useful indicators would capture the quality of energy consumed. Figure 20 provides an illustration of the quality of energy services for cooking and lighting as income rises at the household level. The figure is reflective of energy consumption in rural households, but some of the principles also apply to peri-urban and urban households. The concept of a simple "energy ladder", with households moving up from one fuel to another, does not adequately portray the transition to modern energy access, because households use a combination of fuels and technologies at all income levels. This use of multiple fuels is a result of their differing end-use efficiency, of affordability and of social preferences, such as a particular fuel for cooking. Moreover, use of multiple fuels improves energy security, since complete dependence on a single fuel or technology leaves households vulnerable to price variations and unreliable service.

Figure 20: **The quality of energy services and household income**



Note: CFL is compact fluorescent light bulb; LPG is liquefied petroleum gas; and LED is light-emitting diode. Improved cookstoves have higher efficiency than cooking over a three-stone fire, but emissions are not reduced considerably, while advanced biomass cookstoves have equivalent efficiency and emissions reductions as liquid-fuel, gas and electric stoves.

The indicator of the quality of delivered energy services on the vertical axis in Figure 20 is designed to capture a variety of dimensions, including cleanliness, efficiency and affordability. Because the amount of energy delivered from traditional technologies, such as a three-stone fire or kerosene/diesel lanterns, is much lower than that from modern services, such as electricity, poorer households pay a much higher share of their income on energy services. A study of rural energy use in Bangladesh found that, for example, the cost of each kilolumen-hour from incandescent light bulbs or fluorescent tubes is less than 2% of the cost of comparable lighting services from kerosene lamps (Asaduzzaman, Barnes and Khandker, 2009). Access to electricity accordingly can reduce total household energy costs dramatically, if upfront costs related to the connection are made affordable. In addition, successful energy efficiency initiatives reduce electricity demand, which has the secondary benefit that existing generation plants can be used to supply new households, thereby reducing the need for capacity additions.

***Box 5:* Going beyond household access - indicators at the village and national level**

Village level energy services, both for electricity and mechanical power, are extremely important. In poor rural areas, providing household level electricity service is often not economically feasible. The cost of service provision is higher than in urban areas, because support infrastructures for maintenance is lacking and because low population density increases the cost per household. Where household level electrification is not feasible, providing electricity at the village level for productive activities and basic social services can be a useful stepping stone. Moreover, village level energy installations, e.g. mechanical power for food processing and other productive activities, irrigation, and clean water and sanitation, have a significant impact on poverty, health, education and gender equality.

While mechanical power is critical to develop industrial and productive activities necessary to local development, quantified objectives defining rates of access to mechanical power are rarely integrated into national strategies. By the end of 2009, less than 5% of developing countries had defined such targets. Those few countries that had established targets on access to mechanical power—Benin, Cameroon, Central African Republic, Mali and Togo—are all in Sub-Saharan Africa (see Table 10).

In addition to the impact at the household level, unreliable electricity service constrains economic activity and constitutes a severe obstacle to business operation and growth (Table 9). According to the World Bank, countries with underperforming energy systems may lose 1 to 2% of economic growth potential annually as a result of electric power outages, over-investment in backup electricity generators, energy subsidies and inefficient use of energy resources (World Bank, 2009).

***Table 9:* Indicators of the reliability of infrastructure services**

	Sub-Saharan Africa	Developing countries
Delay in obtaining electricity connection (number of days)	79.9	27.5
Electrical outages (days per year)	90.9	28.7
Value of lost output due to electrical outages (% of turnover)	6.1	4.4
Firms maintaining own generation equipment (% of total)	47.5	31.8

Source: World Bank, 2007.

Policy implications

How can countries embark on a dynamic path that will eventually lead to universal access to modern energy services? Experience shows that success can be achieved in a variety of ways. Cambodia, Mali and Madagascar have given support to private developers through rural electrification funds. Bangladesh and Nepal have developed local cooperatives, owned by consumers. Smart subsidy schemes to provide electricity to rural households, such as “output-based aid” subsidies, have been developed in some countries, *e.g.* Senegal and Mozambique, and a similar approach has been used in Colombia to connect poor households to natural gas services. In Mali, multifunctional platform[26] projects have been developed to provide

[26] The multifunctional platform is built around a diesel engine, which can also run off jatropha oil. It can power various tools, such as a cereal mill, husker, alternator, battery charger, pump, welding and carpentry equipment, *etc*. It can also generate electricity and be used to distribute water.

mechanical power and their success has led to similar programmes being adopted in other African countries, such as Burkina Faso, Ghana, Guinea and Senegal. To meet overall universal modern energy access objectives, however, these approaches need to be scaled-up significantly and applied more widely.[27]

Increasing access to modern energy services requires, first, the integration of energy access into national development strategies, preferably with support from the UN system. Strong and sustainable financial, institutional and technology frameworks must be set up and capacity building undertaken at the local and regional levels: developing the capacity of national and local organisations, the private sector and communities themselves to provide appropriate energy technologies and services. In Nepal, for example, well over half of the total programme cost for the implementation of a programme to provide micro-hydropower and improved cooking stoves was dedicated to capacity development (UNDP and AEPC, 2010). Setting national goals and targets is important, but it is not enough, without careful monitoring of progress.

Greater regional cooperation can avoid unnecessary expansion of electricity generation capacity in the future. Coordination within a country and between regional governments can greatly enhance the efficacy of electricity projects and contribute to wider benefits: in Africa, in particular, regional power pools appear to make a valuable contribution to regional integration, which is widely perceived as one of the best engines of Africa's development.

About half of developing countries have set up electricity access targets at the national, rural and/or urban level. Objectives vary among countries. While some countries, such as Bangladesh, Bhutan, Botswana, Ghana, India, Nepal, South Africa or Swaziland aim to reach universal access within the next five to 17 years, others have defined intermediate goals, such as Malawi or Rwanda, that aim to achieve 30% and 35% electrification rates respectively by 2020. Both Laos and Indonesia have a target to electrify 90% of the population by 2020, in the latter case involving expanding access to some two million new subscribers each year. Cambodia has a target to increase its rural electrification rate from 12% today to 70% by 2030.

Worryingly, very few developing countries have set targets for access to modern cooking fuels or improved cookstoves or have set targets for reducing the share of the population relying on traditional biomass (Table 10).

Table 10: **Number of developing countries with energy access targets**

	Developing countries (total)	*Of which*: Sub-Saharan Africa
Electricity	68	35
Modern fuels	17	13
Improved cookstoves	11	7
Mechanical power	5	5

Note: Based on UNDP's classification of developing countries.

Source: UNDP and WHO (2009).

Despite the demonstrable health consequences associated with current cooking practices in many developing countries, access to clean cooking facilities has received very little high level attention, and, not surprisingly, very little progress has been made. Adequate training and support services have been lacking, together with the market research necessary to determine the concerns of the women who would be using the stoves and their different cooking habits.

[27] See UNDP and AEPC, 2010 and UNDP, 2006.

Where initiatives have been taken, governments are becoming aware of the limitations of policies to encourage switching to liquid cooking fuels, such as LPG, and are putting in place strategies to increase the use of advanced biomass cookstoves and biogas systems (Box 6).[28]

Box 6: Initiatives to improve the efficiency of biomass for cooking

The Indian Ministry of New and Renewable Energy (MNRE) launched a "National Biomass Cookstove Initiative" in December 2009. The initiative aims to achieve for all households a quality of energy services from cookstoves comparable to that from clean energy sources, such as LPG. A large proportion of India's population, some 72% of the total population and 90% in rural areas, uses biomass for cooking. Providing a clean cooking energy option would yield enormous gains in terms of health and socio-economic welfare. Advanced biomass cookstoves also greatly reduce the products of incomplete combustion, which are greenhouse gas pollutants, thus helping combat climate change.

The Rwandan government estimates that the value of firewood and charcoal consumed for cooking in 2007 was on the order of $122 million, or 5% of GDP (Ministry of Infrastructure, 2010). About 50% of this was used in rural areas. The government has devised a strategy to increase the efficiency and reduce the environmental impact of using biomass for cooking. Key components are: building capacity among equipment manufacturers and importers, in order to make available modern appliances for the use of biomass; developing a quality label, promoting the use of these modern appliances; and launching a long-term publicity and awareness campaign to encourage households, institutions and businesses to adopt the new equipment.

From 2001 to mid-2010, the programme for the Development and Promotion of Biogas Utilization in Rural China (DPBURC) built some 30 million biogas systems, benefitting around 105 million people in rural areas. Measures that contributed to this achievement included: setting minimum technical and quality control standards; adapting technology to match local resources; focusing government financial support on the poorest; and providing technical support to manufacturers of biogas appliances and owners. The biogas systems are used for cooking, electricity, sanitation and the manufacture of fertiliser. On average, each household using a biogas digester saves 500 renminbi ($74) every year from reduced use of fuelwood, electricity, chemical fertiliser and pesticides (Tian and Song, 2010). By the end of 2010, the total number of biogas systems is likely to reach 40 million, 30% of the estimated potential in China.

To summarise, providing universal access to modern energy services at the household level depends upon recognition by the international community and national governments of the urgency of the need, and long-term policy commitment as part of strategic development plans. These need to make provision for the creation of strong institutional, regulatory and legal frameworks and financing from all available sources, including the private sector. Appropriate technological choices need to be factored in. International aid will be needed to subsidise investments in the production and distribution of both electricity and clean cooking fuels, in capacity building and in creating an institutional system that integrates these different areas over the long term and addresses climate change simultaneously.[29] International development organisations can support research, design and development of appropriate technologies. Promising approaches include reliance on renewable energy in rural applications and the use of locally-produced bioenergy to generate electricity. International development organisations should take the lead in collecting, compiling and sharing knowledge and in developing tools and indicators to measure progress.

[28] The heightened awareness of the need to improve the use of biomass for cooking is driven by different factors among countries. The most important include high oil prices and the global recession, unreliable supplies of liquid fuels and the illegal diversion of LPG and kerosene to the industry and transport sectors.

[29] See, for example, the UNDP-UNEP Poverty-Environment Initiative (UNPEI), www.unpei.org.

Prioritising energy access as a key driver of social and economic development is a first step towards universal modern energy access. The way forward will require:

- Commitment from the international community to the objective of achieving universal access to electricity and to clean cooking facilities by 2030.
- Establishment of national goals for access to modern energy services, supported by specific plans, targets and systematic monitoring, using appropriate indicators.
- Creation of adequate and sustainable financial, institutional and technology frameworks.

Bibliography

AGECC (Advisory Group on Energy and Climate Change) (2010), "Energy for a Sustainable Future, the Secretary-General Advisory Group on Energy and Climate Change", Summary Report and Recommendations, 28 April, United Nations, New York.

Asaduzzaman, M., Douglas F. Barnes and Shahidur R. Khandker (2009), *Restoring Balance: Bangladesh's Rural Energy Realities*, Energy and Poverty Special Report 006/09, March, The World Bank Group, Washington, D.C.

Bazilian, Morgan, Anil Cabraal, Raffaella Centurelli, Reid Detchon, Dolf Gielen, Holger Rogner, Mark Howells, Hilary McMahon, Vijay Modi, Nebojsa Nakicenovic, Patrick Nussbaumer, Brian O'Gallachoir, Mark Radka, Kamal Rijal, Minoru Takada and Florian Ziegler (2010), "Measuring energy access: Supporting a global target", Earth Institute Working Paper, Columbia University, New York.

Birol, Fatih (2007), "Energy Economics: A Place for Energy Poverty in the Agenda?" *The Energy Journal* 28, No. 3, Elsevier B.V., Amsterdam.

ECLAC (Economic Commission for Latin America and the Caribbean), Club de Madrid, Vundesministerium fur wirtschaftliche Zusammenarbeit und Entwicklung, GTZ and UNDP (2010), *Contribution of energy services to the Millennium Development Goals and to poverty alleviation in Latin America and the Caribbean*, United Nations, New York.

Hutton, Guy, Eva Rehfuess and Fabrizio Tediosi (2007), "Evaluation of the costs and benefits of interventions to reduce indoor air pollution", *Energy for Sustainable Development*, Vol. 11, No. 4, December, Elsevier, Amsterdam.

IEA (International Energy Agency) (2002), *World Energy Outlook*, OECD/IEA, Paris.

IEA (2004), *World Energy Outlook*, OECD/IEA, Paris.

IEA (2006) *World Energy Outlook*, OECD/IEA, Paris.

IEA (2008) *World Energy Outlook*, OECD/IEA, Paris.

Luoma, Jon (2010), "World's Pall of Black Carbon Can Be Eased with New Stoves", *Yale environment 360*, 8 March, Yale School of Forestry and Environmental Studies, New Haven.

Mathers C.D. and Loncar, D. (2006), "Projections of Global Mortality and Burden of Disease from 2002 to 2030", *PLoS Medicine*, Vol. 3, No. 11, November 28, doi: 10.1371/journal.pmed.0030442.

Ministry of Infrastructure, Republic of Rwanda (2010), *Biomass Energy Strategy*, Ministry of Infrastructure, Kigali.

Modi, Vijay, Susan McDade, Dominique Lallement and Jamal Saghir (2005), *Energy Services for the Millennium Development Goals*, Energy Sector Management Assistance Programme, United Nations Development Programme, UN Millennium Project, and World Bank, New York.

Niez, Alexandra (2010), "Comparative Study on Rural Electrification Policies in Emerging Economies: Keys to successful policies", Information Paper, March, OECD/IEA, Paris.

Smith K.R., S. Mehta and M. Feuz (2004), "Indoor air pollution from household use of solid fuels" in M. Ezzati, A.D. Lopez, A. Rodgers and C.J.L.Murray (eds.), *Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors,* WHO, Geneva.

Tian, Yishui and Dongfeng Song (2010), "Development and Promotion of Biogas Utilization in Rural China", May, UNDP Regional Centre, Bangkok, forthcoming.

UNDP (United Nations Development Programme) (2006), *Expanding access to modern energy services. Replicating, Scaling Up and Mainstreaming at the local level. Lessons from community-based energy initiatives*, UNDP, New York.

UNDP and AEPC (Alternative Energy Promotion Centre) (2010), *Capacity development in Scaling up Decentralized Energy Access Programmes. Lessons from Nepal on its role, costs and financing*, UNDP, New York.

UNDP and World Health Organization (WHO) (2009), *The Energy Access Situation in Developing Countries - A Review on the Least Developed Countries and Sub-Saharan Africa*, UNDP, New York.

UNEP (United Nations Environment Programme) (2003), *Energy subsidies: lessons learned in assessing their impact and designing policy reforms*, UNEP/Earthprint, Nairobi.

UN-Energy (United Nations-Energy) (2005), *The Energy Challenge for Achieving the Millennium Development Goals*, *http://esa.un.org/un-energy/pdf/UN-ENRG%20paper.pdf*.

Venkataraman, C., A.D. Sagar, G. Habib, N. Lam and K.R. Smith (2010), “The Indian National Initiative for Advanced Biomass Cookstoves: The benefits of clean combustion”, *Energy for Sustainable Development*, Vol. 14, Elsevier, Amsterdam.

World Bank (2007) *Africa Development Indicators*, World Bank, Washington D.C.

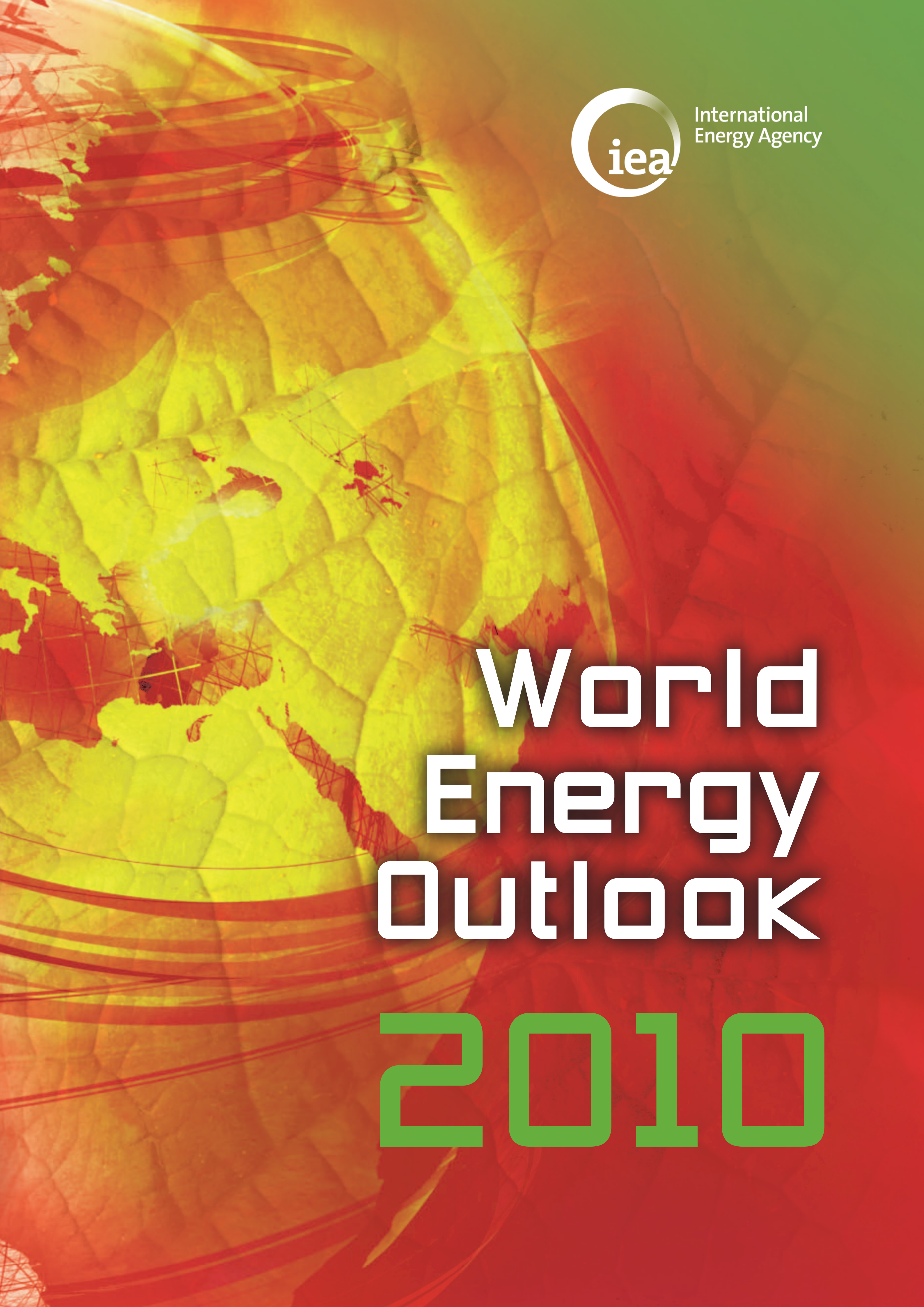
World Bank (2009), "Africa’s Infrastructure: A Time for Transformation", *WorldBank Africa Infrastructure Country Diagnostic*, World Bank, Washington, D.C.

The World Bank Group (2010), *New private infrastructure activity in developing countries recovered selectively in the third quarter of 2009. Assessment of the impact of the crisis on new PPI projects - Update 5*, February, World Bank, Washington D.C.

WHO (World Health Organization) (2004), “Indoor smoke from solid fuel use: assessing the environmental burden of disease”, *Environmental burden of disease series*, No. 4, World Health Organization, Geneva.

WHO (2008), *The Global Burden of Disease: 2004 Update*, World Health Organization, Geneva.

Yadoo, Annabel (2010), “Rural Lighting”, *ITDG Technical Brief*, Practical Action, Bourton on Dunsmore.



International Energy Agency

World Energy Outlook 2010

World Energy Outlook 2010

Many countries have made pledges under the Copenhagen Accord to reduce greenhouse-gas emissions. Commitments have also been made by the G-20 and APEC to phase out inefficient fossil-fuel subsidies. As the world appears to be emerging from the worst economic crisis in decades, will actions such as these guide us to a secure, reliable and environmentally sustainable energy system?

Updated projections of energy demand, production, trade and investment, fuel by fuel and region by region to 2035 are provided in the 2010 edition of the ***World Energy Outlook*** (*WEO*). It includes, for the first time, the results from a new scenario that anticipates future actions by governments to meet the commitments they have made to tackle climate change and growing energy insecurity.

WEO-2010 shows:

- what more must be done and spent **post-Copenhagen** to limit the global temperature increase to 2°C and how these actions would **impact oil markets**;
- what role **renewables** could play in a clean and secure energy future;
- what removing **fossil-fuel subsidies** would mean for energy markets, climate change and state budgets;
- the trends in **Caspian energy markets** and the implications for global energy supply;
- the prospects for **unconventional oil**; and
- how to give the entire global population **access to modern fuels**.

With extensive data, projections and analysis, *WEO-2010* provides invaluable insights into how the energy system could evolve over the next quarter of a century. The book is essential reading for anyone with a stake in the energy sector.

For more information, please visit our website: www.worldenergyoutlook.org

International Energy Agency

9, rue de la Fédération - 75739 Paris Cedex 15 - France

Tel +33 1 40 57 66 90

The Paris-based International Energy Agency is an intergovernmental body committed to advancing security of energy supply, economic growth and environmental sustainability through energy policy and technology co-operation. It was founded after the oil supply disruptions in 1973-1974 and consists of 28 industrialised countries, all members of the Organisation for Economic Co-operation and Development.

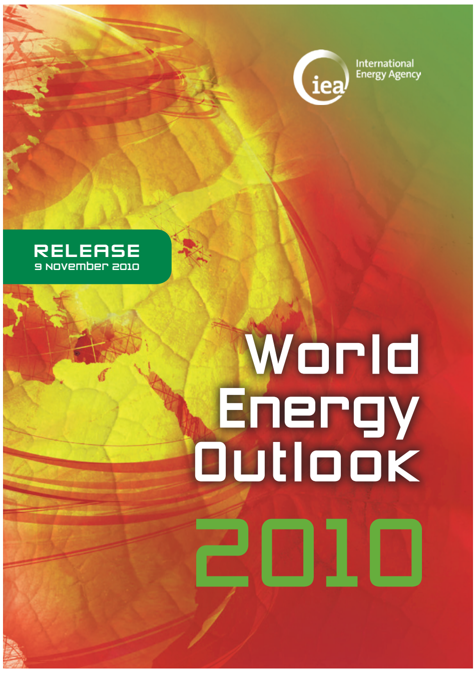


TABLE OF CONTENTS