Looking ahead: energy, climate change and pro-poor responses

Teresa Malyshev

Teresa Malyshev is a Senior Energy Analyst based at the International Energy Agency, Paris, France.

Abstract

Purpose – *In the absence of new policies, global trends in energy supply and consumption are unsustainable all around. Today, roughly 2.6 billion people use fuelwood, charcoal, agricultural waste and animal dung to meet most of their daily energy needs for cooking and heating. There are 1.6 billion people in the world without electricity, equal to over a quarter of the world population. The purpose of this paper is to present pro-poor solutions for addressing the crippling impacts of current global energy use on the world's poorest people.*

Design/methodology/approach – *The paper lays out scenarios for global energy demand and greenhouse-gas emissions and highlights the impact of these trends on developing countries. Based largely on publications and research from the International Energy Agency, it shows that better targeted subsidies, capacity building, integrated policy approaches and improvements in data collection can help to alleviate the impacts of current energy use on health and the environment.*

Findings – *Decisive action is needed to expand energy access and to arrest the potential impacts of climate change in poor countries. It is demonstrated here that investments in programs that are tailored to promoting development and addressing climate change simultaneously can be successfully deployed.*

Originality/value – *There is an urgent need for policymakers in rich and poor countries to join together and tackle the global energy and climate challenges, and, as this paper shows, pro-poor foresight is needed to ensure that these challenges are met in an equitable and sustainable way.*

Keywords *Energy, Climatology, Poverty, Energy consumption, Developing countries*

Paper type *Research paper*

1. Introduction

Current global trends in energy supply and consumption are patently unsustainable – environmentally, economically, socially. The future of human prosperity depends on how successfully we tackle the two central energy challenges facing us today: securing the supply of reliable and affordable energy; and effecting a rapid transformation to a low-carbon, efficient and environmentally benign system of energy supply. The recent global economic crisis has made tackling these challenges much more daunting.

There is dire need to secure reliable and affordable energy for the poorest people in developing countries. Today, roughly 2.6 billion people use fuelwood, charcoal, agricultural waste and animal dung to meet most of their daily energy needs for cooking and heating. In many countries, these resources account for over 90 percent of total household energy consumption. The inefficient and unsustainable use of biomass has severe consequences for health, the environment and economic development. Under current trends, the number of people using biomass increases to 2.7 billion by 2030 as population rises. That is, one-third of the world's population will still be relying on these fuels, a share barely smaller than today. Moreover, there are 1.6 billion people in the world without electricity, equal to over a quarter of the world population. Electrification is very unevenly distributed worldwide. Sub-Saharan

Africa and South Asia are the regions with the highest proportion of the population still without access to electricity. Overall, 80 percent of those without access to electricity currently live in rural areas of developing countries. Because of continuing population growth, if no new policies are put in place, there will still be 1.4 billion people lacking access to electricity in 2030.

Preventing catastrophic and irreversible damage to the global climate ultimately requires a major decarbonisation of the world energy sources. On current trends, energy-related emissions of carbon-dioxide (CO_2) and other greenhouse gases will rise inexorably, pushing up average global temperature by as much as 6°C in the long term. Strong, urgent action is needed to curb these trends. The energy sector will have to play the central role in curbing emissions – through major improvements in efficiency and rapid switching to renewables and other low-carbon technologies, such as CO_2 capture and storage (CCS).

Securing energy supplies and speeding up the transition to a low-carbon energy system both call for radical action by governments – at national and local levels, and through participation in co-ordinated international mechanisms. Households, businesses and motorists will have to change the way they use energy, while energy suppliers will need to invest in developing and commercialising low-carbon technologies. To make this happen, governments have to put in place appropriate financial incentives and regulatory frameworks that support both energy-security and climate-policy goals in an integrated way. Importantly, they need to ensure that energy access goals are also met.

This paper lays out scenarios for global energy demand and greenhouse-gas emissions and highlights the impact of these trends on developing countries. Special emphasis is given to the effects on health, economic opportunity, food scarcity, and on energy demand in cities and in the transport sector. The interplay between energy and climate change is profound – energy use is one of the leading causes of climate change and, increasingly, climate change is affecting our future energy choices. There are ways to reduce energy deprivation in developing countries. Some of these are outlined here. The paper concludes with some insights on how we can use the knowledge gained from scenarios and ''success stories'' to meet the challenges ahead.

2. Scenarios: the outlook for energy demand and greenhouse gas emissions

Energy demand projections

In the Reference Scenario of the 2008 edition of the *World Energy Outlook (WEO)*, world primary energy demand grows by 1.6 percent per year on average in 2006-2030, an increase of 45 percent (IEA, 2008b). This scenario embodies the effects of those government policies and measures that were enacted or adopted up to mid-2008, but not new ones. The Reference Scenario does not include possible, potential or even likely future policy initiatives. For that reason, the projections in this scenario cannot be considered forecasts of what is likely to happen. Rather, they should be seen as a baseline vision of how energy markets are likely to develop should government policy making develop no further. Major new energy-policy initiatives will inevitably be implemented, but it is impossible to predict exactly which measures will eventually be adopted in each country and how they will be implemented. The projections are meant to serve as a baseline against which governments and industry can make informed decisions.

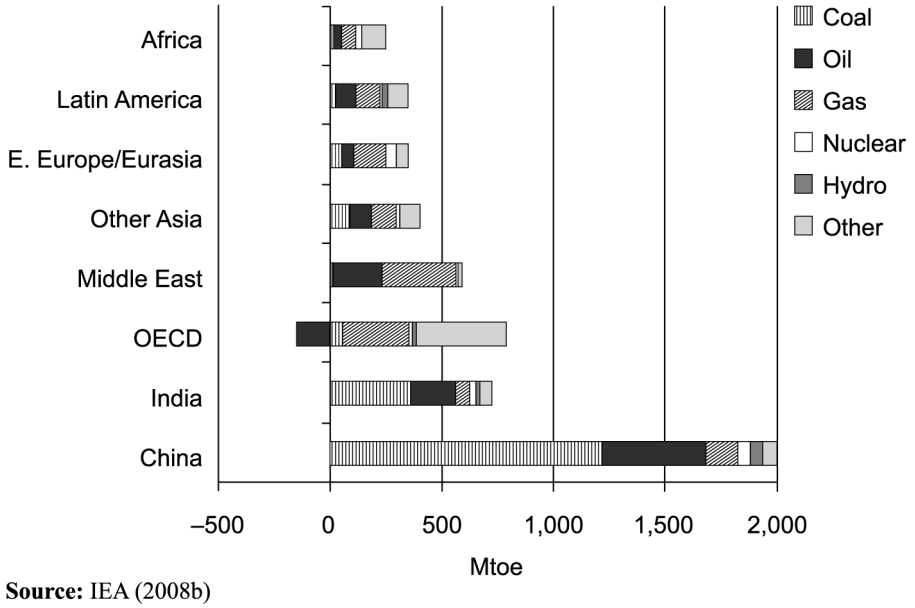
Fossil fuels account for 80 percent of the world's primary energy mix in 2030 – down slightly on today[1]. Oil remains the dominant fuel, though demand for coal rises more than demand for any other fuel in absolute terms. The share of natural gas in total energy demand rises marginally, with most of the growth coming from the power-generation sector. Coal continues to account for about half of fuel needs for power generation. The contribution of non-hydro renewables to meeting primary energy needs inches up from 11 percent now to 12 percent in 2030. The share of the world's energy consumed in cities grows from two-thirds to almost three-quarters in 2030.

Energy demand in non-OECD countries exceeded that in OECD countries in 2005 for the first time ever. The faster pace of demand growth outside the OECD is set to continue. Driven

mainly by brisk growth in China and India, non-OECD countries account for 87 percent of the increase in global demand between 2006 and 2030. The volumetric increase in China's energy demand in 2006-2030 dwarfs that of all other countries and regions, the result of its rapid economic and population growth. The almost 2,000-Mtoe increase in demand in 2006-2030 is nearly four times bigger than the combined increase in all of the countries in Latin America and Africa, and more than three times as large as the increase in the OECD (see Figure 1).

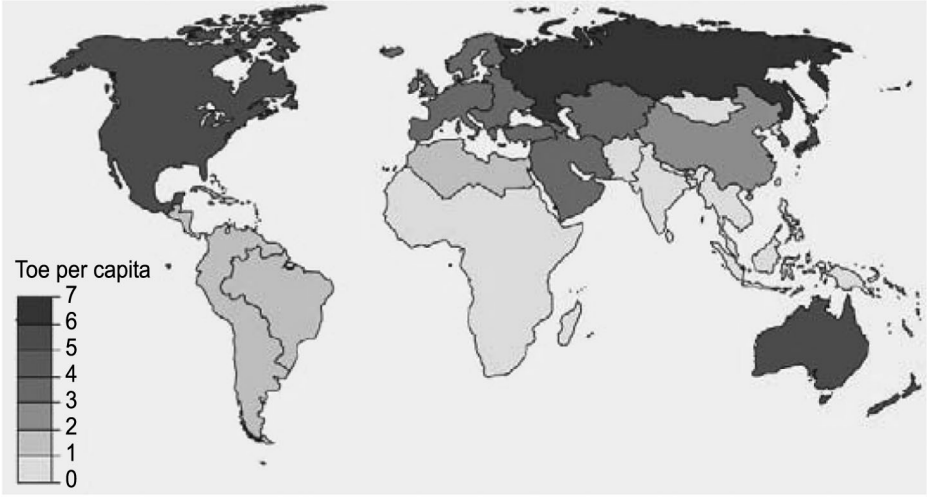
In 2030, disparities in per-capita energy consumption among regions remain stark (Figure 2). Middle East countries see a rapid increase in per-capita consumption, overtaking OECD

Figure 1 Incremental primary energy demand in the reference scenario, 2006-2030



Source: IEA (2008b)

Figure 2 Per-capita primary energy demand, 2030



Source: IEA (2008b)

Europe by 2030. Despite the relatively small increase in energy demand over the projection period, Russia still has the highest per-capita energy consumption, at 7.0 tonnes of oil equivalent (toe), in 2030. Per-capita consumption increases rapidly from 1.4 toe in 2006 to 2.7 toe in 2030 in China, thanks to a booming economy and slower population growth compared with African and other Asian countries. India's per-capita energy use is only 0.9 toe in 2030, but up from 0.5 toe in 2006. On average across countries, per-capita consumption in sub-Saharan Africa is only 0.5 toe in 2030 – about a third of the level in Latin America and one-ninth of that in OECD countries.

Focus: poverty in resource-rich sub-Saharan African countries

Energy poverty in oil- and gas-rich sub-Saharan African countries is as dire as in other African countries without these resource endowments. A number of sub-Saharan African countries hold large oil and gas resources, which are expected to underpin strong growth in their production and exports in the coming two decades or so. In the *World Energy Outlook*, cumulative government revenues from oil and gas output (from royalties and taxes) in the ten largest hydrocarbon-producing sub-Saharan African countries are projected, in aggregate, to total $4 trillion over 2007-2030. Nigeria and Angola remain the largest exporters, with combined cumulative government revenues of about $3.5 trillion. Taxes on oil and gas production account for more than 50 percent of total government revenues in most of the oil- and gas-rich sub-Saharan African countries.

Despite the vast hydrocarbon wealth of these countries, most of their citizens remain poor. As a result, household use of modern energy services is very limited. Two-thirds of households do not have access to electricity and three-quarters do not have access to clean fuels for cooking, relying instead on fuelwood and charcoal. Unless there are major government initiatives to address this problem, the number of electricity-deprived people is projected to increase over the projection period, as the population grows. And more than half of the total population of these countries still relies on fuelwood and charcoal for cooking in 2030 (see Figure 3).

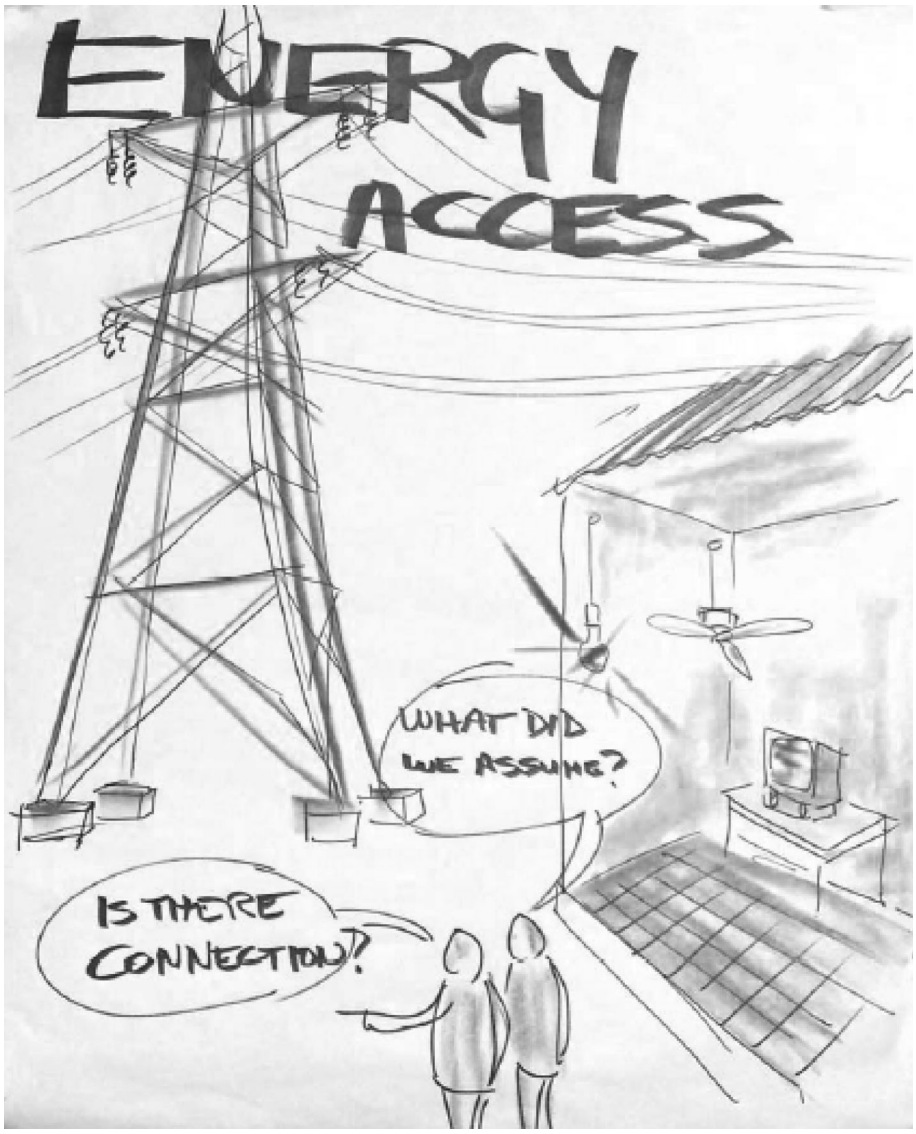
Tackling energy poverty is well within these countries' means, but major institutional reforms are needed. We estimate the capital cost of providing minimal energy services (electricity and liquefied petroleum gas stoves and cylinders) to these households from now to 2030 to be about $18 billion. This is equivalent to only 0.4 percent of cumulative government revenues from oil and gas (IEA, 2008b). Thus, only a small proportion of the available revenues, after debt servicing, need to be dedicated to energy-poverty alleviation, rather than dissipated in subsidies, military spending or corruption. An improvement in the efficiency and transparency of revenue allocation and the accountability of governments in the use of public funds would improve the likelihood that oil and gas revenues are actually used to alleviate poverty.

Focus: poverty in India

Poor people in India have minimal access to clean, reliable and efficient energy sources. This is, of course, mostly a result of low incomes – India accounts for about one-third of the world's population living on less than a dollar a day. But there are other barriers to energy access in the poorest households in India including unreliable energy service delivery, ineffective and regressive subsidies, gender discrimination in policy planning, inadequate information about the health impacts of current fuels and technologies, and administrative hurdles in getting connections. Electricity access has improved in India but the number of people relying on fuelwood, dung and agricultural residues for cooking and heating continues to rise.

There are some 400 million people without access to electricity in India. In the *WEO* Reference *S*cenario, the number of people without access declines, but it falls much faster in a High Growth Scenario (IEA, 2007)[2]. In this scenario, all households in India have access to electricity in 2030. In the Reference Scenario, the electrification rate in 2030 in India is 96 percent but nearly 60 million people in rural areas will still lack access. The number of people relying on biomass is nearly 400 million in 2030 in the High Growth Scenario, about 80 million

Figure 3 Energy access



fewer than in the Reference Scenario. But 22 percent of the population will still be relying on fuelwood and dung for cooking and heating in India in 2030, even with higher growth. This highlights the urgency of implementing other strategies, such as improving kitchen ventilation and the efficiency of biomass cookstoves in poor households.

2.4 GHG emissions projections

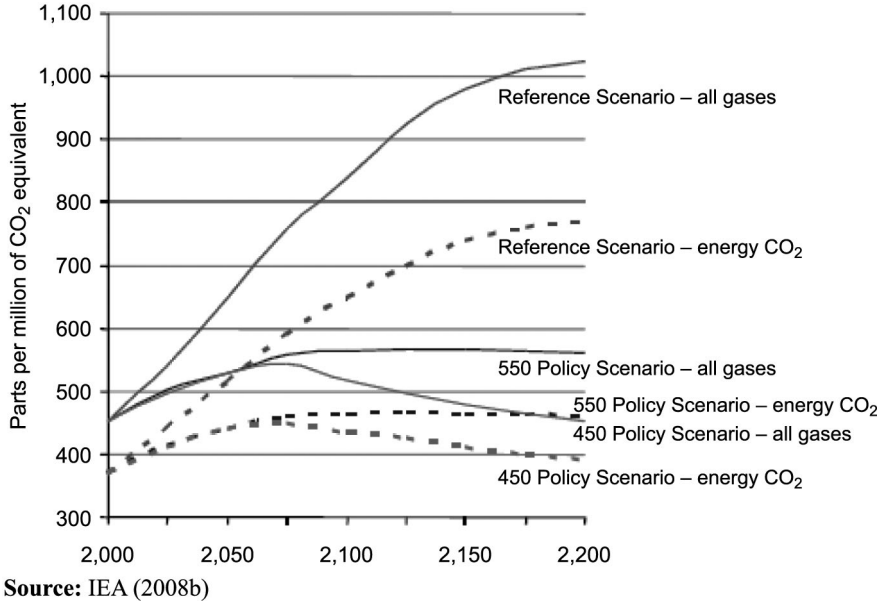
The projected rise in emissions of greenhouse gases in the Reference Scenario of the *World Energy Outlook* puts us on a course of doubling the concentration of those gases in the atmosphere by the end of this century, entailing an eventual global average temperature increase of up to 6°C. The Reference Scenario trends point to continuing growth in emissions of CO_2 and other greenhouse gases. Global energy-related CO_2 emissions rise from 28 gigatonnes (Gt) in 2006 to 41 Gt in 2030 – an increase of 45 percent. World greenhouse-gas emissions, including non- energy CO_2 and all other gases, are projected to grow from 44 Gt CO_2-equivalent in 2005 to 60 Gt CO_2-eq in 2030, an increase of 35 percent over 2005 (IEA, 2008b).

The *World Energy Outlook* considers two climate-policy scenarios corresponding to long-term stabilisation of greenhouse-gas concentration at 550 and 450 parts per million of CO_2 equivalent. The 550 Policy Scenario equates to an increase in global temperature of approximately 3°C, the 450 Policy Scenario to a rise of around 2°C. The 550 Policy Scenario involves a plateauing of greenhouse-gas emissions by 2020 and reductions soon after (Figure 4). The 450 Policy Scenarios involves much more substantial reductions after 2020. Even then, emissions overshoot the trajectory needed to meet the 450 ppm CO_2-eq target, requiring greater emissions reductions after 2030. In both scenarios, total emissions are significantly lower in 2030 in all major emitting countries. To reach either of these outcomes, hundreds of millions of households and businesses around the world would need to be encouraged to change the way they use energy. This will require innovative policies, an appropriate regulatory framework, the rapid development of a global carbon market and increased investment in energy research, development and demonstration. There is a wide range of international policy mechanisms that could be adopted to meet an agreed climate objective. However, as current political debate shows, and given practical issues in the energy sector, the reality is that nations adopt the approach or approaches that best reflect their varied interests and capabilities.

In the 550 Policy Scenario, world primary energy demand expands by about 32 percent between 2006 and 2030 with the share of fossil fuels falling markedly. Global energy-related CO_2 emissions peak in 2025 and then decline slightly to 33 Gt in 2030, while greenhouse-gas emissions plateau by 2020 and are broadly flat through to 2030. Both total greenhouse-gas and energy-related CO_2 emissions are 19 percent lower in 2030 than in the Reference Scenario.

The 450 Policy Scenario assumes much stronger and broader policy action from 2020 onwards, inducing quicker development and deployment of low-carbon technologies. Global energy-related CO_2 emissions are assumed to follow broadly the same trajectory as in the 550 Policy Scenario until 2020, and then to fall more quickly. They peak in 2020 at 32.5 Gt and then decline to 25.7 Gt in 2030. Hydropower, biomass, wind and other renewables see faster deployment in power generation, accounting for 40 percent of total generation worldwide in 2030. An additional 190 GW of CCS is deployed in the last decade of the projection period compared with the 550 Policy Scenario (Box 1).

Figure 4 Greenhouse-gas concentration trajectories by scenario



Source: IEA (2008b)

Box 1. Climate change impacts

The UNFCCC Intergovernmental Panel on Climate Change predicts an increase in the future in the magnitude of extreme climate events, including droughts, floods and cyclones. Because of the complexity of the climate system, it is difficult to foresee the regional and local impact of climate change. But there is a consensus among scientists that the repercussions of changes in average temperature will be severe and wide-ranging:

- *Agriculture.* Without effective adaptation measures, agricultural yields are likely to decline and cost to rise. Droughts will become more frequent and longer, further aggravating desertification and reducing productivity; and the frequency of the outbreak of animal disease could increase.
- *Forests and ecosystems.* Effects are already being observed, from shrinking glaciers to thinning permafrost. Further warming would affect the geographical distribution of forest cover, increase the frequency of insect infestations and disease outbreaks, accelerate the drying-up of lakes and the shrinking of glaciers, and threaten biodiversity.
- *Water.* Further warming would worsen the already declining runoff in rivers, reduce fresh water drinking supplies and increase the frequency of extreme weather events, such as droughts and floods.
- *Coastal areas.* Sea levels have been rising and the trend is accelerating, making adaptation ever more difficult. In India, one-quarter of the population live along the coast. Climate change can impact coastal areas through an increase in mean sea level and through increased frequency and intensity of coastal surges and storms. Hurricanes and storms are likely to become more frequent, aggravating coastal erosion. Ground water and surface water are likely to become more saline and the homes of millions of people could be flooded.

The main impacts on industry, energy and transport are expected to relate largely to transport and distribution systems, machinery, power plants and water and wastewater systems. Temperature increases can affect the stability and strength of building material, while rainfall increases can cause water-logging and erosion, leading to increased maintenance costs. Changes at sea level can cause land erosion and flooding which would increase infrastructure maintenance costs. The greatest danger to human health may be that of more frequent and intense heat waves, which are debilitating in themselves, because of heat stress, but also spread diseases such as malaria and dengue fever. Climate change could increase the incidence of malaria in areas that are already malaria-prone and introduce malaria in new areas.

The scale of the challenge in the 450 Policy Scenario is immense: the 2030 emissions level for the world as a whole in this scenario is less than the level of projected emissions for non-OECD countries alone in the Reference Scenario. In other words, the OECD countries alone cannot put the world onto the path to 450-ppm trajectory, even if they were to reduce their emissions to zero. Even leaving aside any debate about the political feasibility of the 450 Policy Scenario, it is uncertain whether the scale of the transformation envisaged is even technically achievable, as the scenario assumes broad deployment of technologies that have not yet been proven. The technology shift, if achievable, would certainly be unprecedented in scale and speed of deployment. Increased public and private spending on research and development in the near term would be essential to develop the advanced technologies needed to make the 450 Policy Scenario a reality.

Going out even farther in the future

In the 450 Policy Scenario, the trend in global CO_2 emissions is in line with the BLUE Map Scenario presented in the IEA's *Energy Technology Perspectives 2008*, which leads to global CO_2 emissions of 14 Gt in 2050 (IEA, 2008a). The BLUE Map scenario shows the technology revolution that will be needed in the next four decades if such deep emission cuts are to be achieved. This long-term view is important as guidance for planning because options that are still costly will need government-supported deployment in the years 2020-2030 so as to become competitive after 2030. Important insights are that the power sector needs to be virtually decarbonised, CO_2 capture and storage must be widely deployed, light-duty vehicles will become electric or hybrid, and biofuels will be needed for aviation, marine and heavy-duty vehicles.

The role of governments

The sheer scale of the transformation to the energy sector in these scenarios would place a substantial burden on both the private and public sectors. Countries must shift away from traditional, carbon-intensive technologies and embrace new ones. It is for governments to galvanise the transformation. A necessary first step is ensuring the right business climate, to enable energy-efficient investments to be made when and where they will deliver greatest value. The removal of distortive energy subsidies and development of a global carbon market will be very important. Delivering a low-carbon future requires major breakthroughs in technology development and deployment. Governments have the means to put in place incentives to innovate, to encourage promising research activities and to break down international barriers.

Much of the additional spending in the scenarios is by households: a huge step-change in the attitudes to energy efficiency and consumer purchases by hundreds of millions of people worldwide is needed. Governments, through information provision, sound regulation and targeted fiscal incentives, have a key role to play in ensuring that, worldwide, the right decisions are taken to safeguard the future of the energy sector – and of the planet.

3. Implications of scenarios for poverty and for energy demand in cities and the transport sector

Health impacts of energy poverty

Some 2.6 billion people in developing countries rely on inefficient, polluting fuels, such as fuelwood, charcoal, agriculture residues and animal dung, for cooking and heating. The World Health Organization estimates that 1.5 million premature deaths per year are directly attributable to indoor air pollution from the use of these fuels. That is more than 4 000 deaths per day, more than half of them children under five years of age. Indoor air pollution associated with biomass use is directly responsible for more deaths than malaria, almost as many as tuberculosis and almost half as many as HIV/AIDS. In developing countries, only malnutrition, unprotected sex, and lack of clean water and sanitation are greater health threats. Just as the extent of dependence on polluting fuels and inefficient stoves varies widely around the world, so does the death toll due to indoor smoke. The number of premature deaths is highest in southeast Asia and sub-Saharan Africa.

Women and children suffer most from indoor air pollution because they are traditionally responsible for cooking and other household chores, which involve spending hours by the cooking fire exposed to smoke. Young children are particularly susceptible to disease, which accounts for their predominance in the statistics for premature deaths due to the use of biomass for cooking. The effects of exposure to indoor air pollution depend on the source of pollution (fuel and stove type), how pollution is dispersed (housing and ventilation) and how much of their time household members spend indoors. The type of fuel used and individuals' participation in food preparation have consistently been the most important indicators. The prevalence of indoor air pollution is significantly higher where income is below a dollar per day per capita. As well as being much more dependent on biomass, poor households rely on low-quality cooking equipment and live in poorly ventilated housing, exacerbating the negative health impact, as there is incomplete combustion and non-dissipation of smoke.

Energy and economic development

The complementary relationship between energy use and economic growth is intuitively obvious. Less obvious is the extent to which constraints on the availability of energy and its affordability can affect economic development. In many poor countries, under-investment in public utilities, inefficient management, under-pricing and a generally unattractive climate for private investment cause energy shortages and hold back economic growth and development.

In developing regions reliant on biomass, women and children are responsible for fuel collection, a time-consuming and exhausting task. The average fuelwood load in

sub-Saharan Africa is around 20 kg but loads of 38 kg have also been recorded. In rural areas of Tanzania, the average distance travelled for fuelwood collection is highest in the central region of Singida, at over ten kilometres per day, followed by the western regions near Lake Tanganyika, where it is greater than five kilometres per day. Collection time has a significant opportunity cost, limiting the opportunity for children to improve their education and for women to engage in income-generating activities.

Modern energy services promote economic development by enhancing the productivity of labour and capital. More efficient technologies provide higher-quality energy services at lower costs and free up household time for more productive purposes. There are important development benefits to be gained from expanding access to modern energy services. The UN Millennium Project has emphasised that close links exist between energy and all eight of the Millennium Development Goals (MDGs). Modern energy services help reduce poverty (MDG 1) and can play a critical role in improving educational opportunities for children, empowering women and promoting gender equality (MDGs 2 and 3). The availability of adequate clean energy is important in reducing child mortality (MDG 4). Reducing the carrying of heavy loads of fuelwood improves maternal health (MDG 5). Inefficient combustion of fuelwood exacerbates respiratory illnesses and other diseases (MDG 6). Fuel substitution and improved stove efficiencies would help alleviate the environmental damage of biomass use (MDG 7). Finally, widespread substitution of modern energy for traditional biomass can be a rallying point for global partnerships (MDG 8).

Biomass for fuel or food?

Soaring global food prices have sparked riots in many countries, including Haiti, Côte d'Ivoire, Ethiopia, Madagascar, Philippines and Indonesia. Food prices accelerated sharply in 2008, with grain prices more than doubling since January 2006. Over 60 percent of the rise in food prices has occurred since January 2008. Competition from biofuels production is one of many factors contributing to higher food prices. Other factors include: increasing dietary demand for meat and milk products, with consequent increased demand for animal fodder; high energy prices, which pushed up the cost of fertilizer and other farm expenses, as well as food processing and distribution costs; poor harvests, due to extreme weather events such as droughts and destructive storms; the declining value of the US dollar; and international and national agricultural policies. The introduction of food-export restrictions by some nations has restricted global supply and aggravated food shortages.

Agricultural commodities will see much less competition between food, fiber and biofuels supply if productivity continues to rise at the growth rate seen in the past five decades as a result of better farm management, new technologies and improved crop varieties. Since so much available arable land needs irrigation, increased biofuel production in some regions will have implications for water resources. The uneven global distribution of natural resources results in regional differences, with many countries experiencing major land and water shortages. These differences impact on which countries have a comparative advantage in biofuels production.

The amount of feedstock available for energy production from biomass over the long term will depend upon a wide range of government policies, including those in relation to land use and land-use change; avoidance of deforestation and protection of conservation areas; biodiversity; reclamation of degraded lands; genetically modified crops; soil carbon uptake; water use and quality; treatment of wastewater and solid wastes; local air pollution; sustainable development goals; health improvements; support for rural industries; transport; and the provision of low-cost energy to stimulate economic growth. The future uptake of biomass for energy will be determined by the impact such policies have on bioenergy projects. Policies supporting a greater uptake of bioenergy could be offset by others constraining it. For example, the growing demand for biofuels has already led to increased deforestation and the deterioration of wetlands and peat soil, which has increased CO_2 emissions.

Urbanisation and energy demand

Cities are a dynamic and vital part of global culture and are the main engines of social, economic and technological development. According to UN projections, by 2030, cities will house 60 percent of the world's population – equivalent to the total global population in 1986. The geographic distribution of urban population is set to change: while global urbanisation in the first half of the 20th century was dominated by European cities, the majority of urban residents today live in Asia, despite the relatively low proportion there of city residents. Some of the fastest-growing cities are in Africa. Increases in urbanisation through to 2030 are projected in the *World Energy Outlook* to drive up city energy demand. By 2030, cities are responsible for 73 percent of the world's energy use. Some 81 percent of the projected increase in energy use in cities between 2006 and 2030 comes from developing countries. City residents in China, for example, use almost twice as much energy per capita as the national average, due to higher average incomes and better access to modern energy services.

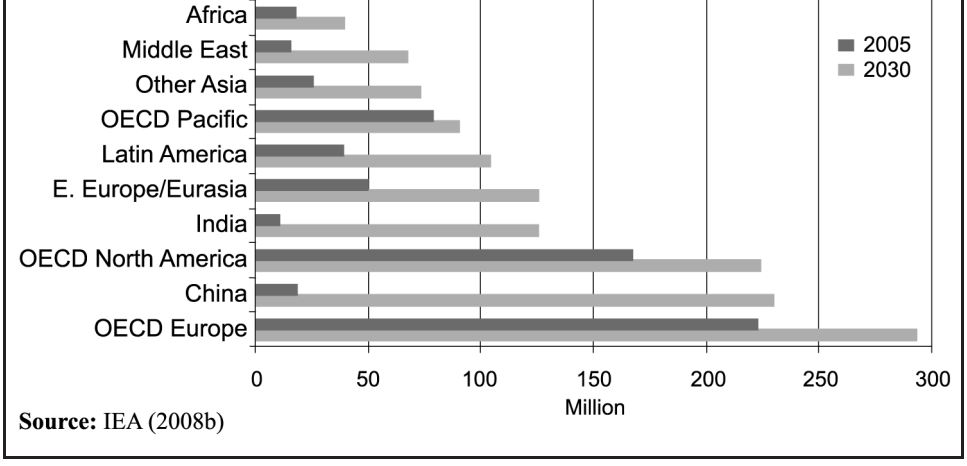
Transport energy demand

Around three-quarters of the projected increase in the *World Energy Outlook* in oil demand worldwide comes from the transport sector, the sector least responsive, in the short term, to price changes. Despite continuing improvements in average vehicle fuel efficiency, the sheer growth of the vehicle fleet – especially in developing countries – is expected to continue to push up total oil use for transport purposes. There is not expected to be any major shift away from conventionally fuelled vehicles before 2030, though the penetration of hybrid-electric cars, including plug-ins, is expected to rise, contributing to an overall improvement in fuel economy. The total light-duty vehicle stock rises from an estimated 650 million in 2005 to about 1.4 billion by 2030. The biggest increase in absolute terms is expected to occur in China, which accounts for almost one-third of the global increase in cars (Figure 5). Much of the rest of the increase comes from other developing countries. The average size and power of new cars in these countries is expected to be significantly lower than in the OECD at present, which accounts for part of the global improvement in fuel economy.

4. The impact of climate change on the energy sector

As well as playing a leading role in causing global warming, the energy sector could itself be substantially affected by a change in the global climate. Worryingly, some sources of renewable energy – one of the main climate-change mitigation options – could be adversely affected. Hydropower is the world's largest renewable source of electricity, generating 3.035 TWh in 2006, around 16 percent of total electricity. The unexploited potential is large,

Figure 5 Projections for the global light-duty vehicle fleet



Source: IEA (2008b)

particularly in developing countries. However, although hydropower is a key mitigation option, climate change may have an overall net negative impact on water resources and therefore affect its future generation potential. Growing concerns about competition for water supply, as well as other environmental and social concerns, may constrain some project developments. Where climate-change impacts result in water scarcity, the need for adaptation may result in improved water-use efficiency through metering and incremental pricing, increased withdrawal of water for irrigation and the trading of water rights. There could be some adverse effects on local hydropower plant operation and costs. Climate change is also likely to alter river discharge rates and hence water availability for in-stream uses, including hydropower, navigation, fisheries and recreation, as well as for out-of-stream demands, such as irrigation, municipal use, industrial use and cooling.

The overall effect on hydropower production potential would be mixed. In alpine areas, run-off may decrease in summer and increase in winter, exacerbating sedimentation problems but perhaps also making the management of water storage easier. There may be less storage as snow and ice in winter, thereby adversely affecting river flows in summer and autumn. In Nepal, China and elsewhere, storage of water as ice in glaciers may decrease and seasonal discharge rates change. Hydrological regimes driven more by precipitation than by snow and glacier-melt processes could experience increased year-to-year variability of mean annual discharges, thus adversely affecting the hydropower generation potential. Sudden discharge outbursts from lakes formed by rapidly melting glaciers have already created surges of water and debris sufficient to damage hydropower facilities and threaten local communities. Some hydropower generators have already adjusted their production forecasts downwards to reflect changing precipitation projections, thus affecting the economics over the lifetime of a plant.

The prospect of climate change introduces uncertainties which could affect virtually all forms of renewable energy. Wind resource intensity and duration can affect turbine capacity factors and extreme gales may damage turbines and shorten their working life. Solar radiation levels are subject to reductions of up to 20 percent in some regions, due to increased cloud cover, and there is a risk of damage to solar collection facilities from extreme weather conditions, such as hail. In addition, higher ambient temperatures can reduce the output and life of photovoltaic cells. Biomass may experience lower crop yields due to water shortages and increased warming, though higher atmospheric CO_2 levels will increase crop and forest growth rates. There could be effects on biomass use for traditional cooking and heating purposes as well as on biofuel production for transport fuels. Longer frost-free periods and fewer freezes can benefit some crops more than others, and there will be regional differences, with Africa and southern Asia more likely to be adversely affected than other regions.

Local and regional air pollution

Rising energy consumption, increasing mobility and continuing reliance on fossil fuels are damaging ambient air quality in many developing countries. Emissions of SO2, NOx, CO and particulate matter are harmful to human health as well as being the cause of environmental problems, such as acid rain, reduced visibility and ground-level ozone formation, though they can also reduce the overall warming impact of greenhouse-gas emissions.

Air pollution remains a major public health issue in cities across the developing world, notably in China and India, where ambient air quality continues to deteriorate. In addition to the local consequences of unabated emissions, the effects of air pollution are felt beyond national borders. For example, when monsoon winds are prevalent, the citizens of Bangladesh and Pakistan suffer from pollutants generated in India. Likewise, the air quality in Pakistan and Bangladesh affects the citizens of India and other border countries.

What policies and measures should be considered?

National policies and measures in developing countries, which may not initially have quantified country-wide obligations under a post-2012 climate framework, will be a

necessary component of effective international abatement action. The 450 and 550 Policy Scenarios both assume that a comprehensive set of national policies and measures, across all sectors, is adopted in developing countries.

It is important that countries' emissions-reduction strategies take full account of their development needs, thereby fitting the Bali Action Plan description of ''nationally appropriate mitigation actions...in the context of sustainable development''. One of the most prominent proposals is the Sustainable Development Policies and Measures (SD-PAMs) model, which offers an opportunity for developing countries to reduce emissions through tailored, development-focused policies, guided by domestic priorities. In the energy sector, policies 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 without damaging the welfare of poorer sections of society.

Formalising the place of such national policies and measures in a global post-2012 framework would help to ensure progress towards a global emissions goal. Such an approach would give full recognition to countries' domestic actions and could help to direct technology financing and capacity-building. It could be an interim step towards country-wide, quantified emission-limitation commitments, based on the sound integration of climate-policy objectives into domestic policy.

Maximising the potential from technology diffusion

There are a number of barriers to address in order to maximise the potential from technologies. These include imperfect information, high transactions costs, risk, financing, complex regulatory frameworks and other trade and market barriers. Consequently, there are actions that can be taken to improve the potential for technology transfer. At the most fundamental level, this involves continuing to promote free trade and undistorted, competitive global markets. An important first step in this regard would be the removal of energy-related subsidies in many countries and the establishment of a global carbon market. To overcome information barriers, international knowledge sharing is likely to play a key role. It is important that all countries have effective intellectual property laws, to provide countries and companies with the confidence to export high-tech, energy-efficient technologies and expertise to the regions where abatement needs to take place.

Effective intellectual property laws are important to facilitate technology diffusion. While such laws are generally well advanced in OECD countries, they are less well established in some non-OECD countries. The poorest countries, because they lack resources to imitate and reproduce existing technology, tend to give low priority to strong intellectual property laws. However, an effective intellectual property system is important for enabling countries to attract the transfer of new technologies. Where intellectual property cannot be safeguarded, because laws are weak or are not enforced, foreigners have less incentive to share new technologies, both supply-side and demand-side. This constrains efficient global abatement and energy technology development. An OECD empirical study found that strong intellectual property laws stimulate innovation and diffusion (particularly of technology-intensive goods, as is typical in the energy sector). The study also showed a strong correlation between robust intellectual property laws and foreign direct investment, both for developing and developed countries.

As a consequence, it is essential for the global abatement effort that the international community addresses the issue of more robust intellectual property laws in developing countries. The WTO's 1995 Agreement in Trade-Related Aspects of Intellectual Property Rights (TRIPS), requiring WTO members to ensure that intellectual property rights do not become barriers to trade, is clearly a step in the right direction. TRIPS itself says little in relation to technology transfer, requiring only that its member countries provide incentives to industry to promote and encourage technology transfer to the WTO's least-developed member countries.

Given that technologies will need to be deployed worldwide, this must be taken into account during the research and development phase. Technologies need to cater for multiple markets. As most research currently takes place in OECD countries, it will be important to take into account the needs of other regions. This can in part be ensured by promoting an effective global carbon market, which will provide incentives to develop such technologies, but can be further encouraged by international public sector collaboration, including with developing countries, during the technology development phase. There already exist a number of substantial funds and institutions to support technology diffusion. In 2008, the World Bank created the Climate Investment Funds, to provide interim, scaled-up funding to help developing countries mitigate their greenhouse-gas emissions.

5. Pro-poor solutions

The challenges are enormous, but the steps necessary to avoid the unsustainable path that we are on are clear. Yet even if the long-term energy and climate change objectives are met, the world will not be in a better place unless we can ensure that the poorest citizens do not suffer from the adverse impacts that are sure to come in the near term. How can we guarantee that they will also benefit?

Targeted subsidies

Kerosene and LPG are often heavily subsidised in developing countries, with the intended aim of shifting fuel consumption patterns away from biomass to cleaner, more efficient fuels. Since it is mostly poor households that rely on biomass and live in rural areas, the subsidies are designed to support energy access for the poor. However, in practice, this objective has not been met. Subsidy schemes give greater benefit to the urban sector and richer households and for the most part fail to shift fuel consumption patterns away from biomass in rural areas. In India, for example, an estimated 40 percent of the subsidies for LPG and kerosene benefits the richest 7 percent of the population. In per-capita terms, urban areas consume 20 percent more subsidised kerosene than rural areas. As the per-unit subsidy is largely the same across sectors, this means that urban areas receive more subsidy than rural areas in per-capita terms.

Subsidies may be justified in some cases in order to combat poverty. They should be resorted to under specific conditions: be properly targeted and affordable; deliver quantifiable benefits; be easily administered and not cause large economic distortions; and be transparent and limited in duration. The way a subsidy is applied is critical to how effective it is and to its cost. Subsidies should normally be restricted to energy services provided through fixed networks: electricity, natural gas or district heat. Subsidies to other forms of energy, such as oil products, can never be properly limited to poor households, because those fuels are freely traded. Policies should target the poor very precisely so that the mechanism for subsidising a particular fuel does not allow richer households to benefit from the subsidy.

The case for subsidising electrification in poor developing countries is widely accepted in principle, since the developmental benefits are often judged to exceed the long-run costs involved in providing subsidised electricity. Where high up-front connection charges prevent poor people from gaining access to electricity, ''lifeline rates'' – special low rates for small users – can be a cost effective way of making services affordable to poor households. Alternatively, governments can finance part of the connection charge or oblige utilities to spread the cost out over time. The challenge is to ensure that electricity subsidies increase access for the poor at the lowest cost, while ensuring that electricity utilities are still able to make money and to continue to invest. That means limiting the size of subsidies and the number of recipients, and compensating the utility for any loss of revenue. This can be done either through higher charges for other customer categories or direct financial transfers from the government budget (Box 2).

Box 2. Success stories – pro-poor responses

- In Brazil, 98 percent of households (including 93 percent of rural households) have access to LPG – a situation that can be attributed to government policy that has promoted the development of an LPG delivery infrastructure in all regions, including rural regions, and subsidies to LPG users. During the period 1973-2001, retail LPG prices were set at the same level in all regions and the average level of the subsidy amounted to 18 percent of the retail price. In May 2001, end-user prices were liberalised, as part of a process of deregulating the petroleum sector. At the same time, the government introduced an Auxilio-Gas (''gas assistance'') programme to enable qualifying low-income households to purchase LPG. Qualifying families were those with incomes less than half the minimum wage (an average daily per-capita income of $0.34 a day in 2003). The total programme cost in 2002 was about half that of price subsidisation. This programme now forms part of the Bolsa Familia, by far the largest conditional cash transfer programme in the developing world.
- In Kenya, the government introduced a number of measures to improve access to and the affordability of LPG. Households' access to credit was improved, largely through the Kenyan Union of Savings and Credit Co-operatives, an umbrella organisation for nearly 4 900 agricultural co-operatives in Kenya. Rapid growth of LPG followed the decision to remove the VAT and import duty on LPG, and to set standards for LPG stoves, cylinders and accessories. Lack of standardised LPG cylinders, with inter-changeable valves and regulators, had previously been a major obstacle to the development of efficient and competitive LPG retail markets in Kenya. The acceleration in the penetration of LPG in Kenya demonstrates the facilitating role governments can play, providing a policy and regulatory framework attractive to prospective energy and financial investors, and to users.
- The Deepam Scheme, launched in 1998 by the state government in Andhra Pradesh, India, provides LPG connections free of charge to poor households. About 1.4 million households have benefited. The oil companies who supply the refill canisters had expected demand for an average of eight to nine refills a year, but most households have been able to afford only two or three. The state government provides a subsidy of Rs 1,000 ($25) towards the connection, but does not subsidise the cost of a refill, which is around Rs 250 ($6) per cylinder. The state government has introduced smaller, 5-kg LPG cylinders, which require a deposit of only Rs 500 ($12) and a refill cost of Rs 100 to Rs 150 ($2.50 to $3.70). It is hoped that the smaller cylinders will lead to more regular consumption of LPG by the poor, especially in rural areas, at a lower cost to the government for subsidies.
- The Tunisian government expanded electricity access from 37 percent in the early 1970s to an impressive 99 percent in 2006. The government laid out its targets in five-year plans aimed at overall rural development. Renewable-energy projects were selected at the regional level as part of rural development plans, which covered health, education, water and other infrastructure. Success was attributed to efficient central direction, decentralised implementation, transparent norms and guidelines, and innovative technical decisions, such as the use of single-wire earth systems. Private sector participation in construction and the participation of the local supply industry were also important. But national political commitment is widely regarded as the key factor in the success of the programme.

Microfinance

Microfinance institutions allow households and villages to mobilise the capital needed to make small energy investments. Microfinance is particularly important in rural areas where farmers have no income for long periods of the year. Notably, women's access to such financial services has increased in the past decade. Worldwide, four out of five micro-borrowers are women. In India, for example, the Indian Renewable Energy Development Agency in the Ministry of New and Renewable Energy has been tasked with increasing the participation of poor rural women in integrated approaches to cooking and health. Micro-credit for women is less widely available in India than in Bangladesh and Nepal.

One of the principal barriers to the penetration of modern cooking fuels is the high initial cost of the cylinder purchase (in the case of LPG) and the stove. An option to overcome up-front costs is for a bank or financial institution to offer financing for the cylinder and appliance over

a year or more. There are strong arguments for using the community as a vehicle for this financing and making it jointly and individually responsible for repayment.

Capacity building

There is an urgent need to develop capacity for formulating and implementing energy policies at the national, regional and local level in developing countries. Effective and targeted policies would do much to expand access to electricity and clean cooking fuels. There is also a need to monitor and evaluate policies after they are in place. This is a long-term, iterative process that should involve learning from feedback. Capacity building in this area will contribute to improvements in governance more generally, which is the real key to development of energy resources and the alleviation of poverty.

Aligning energy development and climate change goals

Policies and incentives need to be well formulated so investments are made to serve poor citizens. Aligning climate policy more closely with development interests engages important stakeholders and decision-makers, and combining development and climate policy enables and promotes wider international support for both sets of goals. This includes the steering of larger sources of finance than are likely to be available for climate change actions alone.

Droughts and flooding, intensified by climate change, can lead to famine and loss or contamination of water supplies. Deforestation due to population pressures or fuelwood requirements can accelerate land degradation, increasing the vulnerability of the poorest communities. Without significant worldwide changes in energy production and consumption, social inequities will increase, environmental problems such as climate change and ecosystem degradation will accelerate, and global economic growth will be jeopardised. Governments need to adopt new policies that encourage the delivery of energy services in cleaner and more efficient ways (see Figure 6).

Integrated policy approaches

Many rural households would not be able to afford modern energy services, even with microfinance or subsidised capital investment. The challenge is especially daunting for those dependent on agriculture. In such cases, efforts to tackle energy poverty would clearly need to go hand in hand with broader policies aimed at alleviating poverty more generally and promoting economic development. Clean-cooking initiatives would ideally be carried out in parallel with programmes for education, rural electrification and industrialisation, which would also enable time freed up to be productively reallocated. In general, income-support or social welfare programmes are a far more effective way of addressing poverty than subsidies to the fuels themselves. Governments need to engage in a more integrated approach to rural development by coordinating with other bodies, including those covering health, education, agriculture and environment.

The economic, social and environmental benefits of expanding access to modern energy services are so large as to justify an integrated approach that cuts across all sectors. The challenge of scaling up successful pilot projects is huge, first involving systematic evaluation of advantages to identify the most successful and then widespread communication of the results. More efforts are necessary to delegate to local governments, local communities and women the responsibility for delivering energy services.

Improving data and statistics

Detailed, accurate statistics on energy supply and consumption are essential for proper policy and market analysis. Efforts are under way to improve regular data collection through international surveys such as the Living Standards Measurement Study and the Multiple Indicators Cluster Surveys. Greater coverage, both geographical and temporal, is needed and more resources should be devoted to achieving this. Better information on markets and technologies is also needed.

Governments can also support efforts to expand energy access by developing national databases which include information on the population to be served, potential fuels, stoves,

Figure 6 Busting silos

the infrastructure and potential providers, together with cost analyses and estimates of the ability and willingness to pay, as a function of income. In particular, there is very little information on energy use in slums worldwide. Slum areas in major cities in India, for example, are growing. Despite this, there is no specific federal programme in place for extending energy access to the urban poor. The first-ever census of slums in India was undertaken in 2001. The census is a step in the right direction, but more information is needed. Sound policy requires more knowledge of slum energy demand and of energy use of the poorest citizens in general.

6. Using foresight to initiate change

Decisive action is needed to accelerate energy development and to arrest the potential impacts of climate change in poor countries. We have a very good idea of what *must* be done to meet global long-term environmental and energy sustainability goals – a radical and fundamental change in current energy systems. Promoting energy efficiency is a first step

but ultimately we need to decarbonise the global power sector, widely deploy CCS and switch to hybrid and electric vehicles in the transport sector. We also know that all nations will need to be involved in this transformation in a fair and proportionate manner. All governments must agree on mandatory emissions reductions.

It is not so clear what *can* be done in the near term to ensure that these goals are ultimately met without catastrophic implications for the world's poorest citizens.

Developing countries face urgent and legitimate development priorities that make climate change a low political priority. These countries face difficult choices in allocating scarce resources among pressing development needs, and climate change is often viewed as a longer-term concern that must be traded off to address short-term needs. Dealing with these trade-offs require participatory and transparent policies to ensure their long-term effectiveness.

Poor people must be seen as part of the solution, rather than part of the problem. Environmental quality of growth matters to the poor. Moreover, environmental management cannot be treated separately from other development concerns.

Good governance in the energy sector is critical to attracting infrastructure investment. In resource-rich countries, an improvement in the efficiency of revenue allocation and the accountability of governments in the use of public funds would improve the likelihood of oil and gas revenues being used to alleviate poverty. Tackling energy poverty requires comprehensive and co-ordinated economic and social development plans and policies, with a much greater focus on effective management of the wealth generated by hydrocarbon resources. A first requirement is to make oil and gas revenues transparent to the public. They will ultimately hold governments accountable for the allocation of these revenues. Poverty issues must be integrated into national development frameworks, and the decentralisation of environmental management must be strengthened, by empowering civil society, in particular marginal groups, and by addressing gender dimensions of poverty issues.

Laws and regulations that impede energy trade and investment have to be reformed, and various measures to attract private capital should be considered. Public policies aimed at improving both the quantity and quality of energy services need to be backed by broader policies to promote investment, growth and productive employment. These include rural infrastructure development, training and education, and support for microfinance programmes. More generally, efforts are needed to strengthen the overall legal, institutional and regulatory framework, including the protection of land and property rights. Existing laws and regulations need to be enforced more effectively.

Foreign direct investment needs to be more pro-poor and the contribution of multilateral environmental agreements to poverty reduction needs to be improved. And importantly the effectiveness of development cooperation and debt relief should be enhanced. Reforms are needed to make the current global trading regime more inclusive and balanced in terms of developing country needs. At the national level, a sound and supportive domestic policy and regulatory framework is needed. The accepted goal of 0.7 percent of GDP of OECD countries for official development assistance has not been met. Eradicating poverty will demand a much more ambitious effort and the financial flows most be received with efficiency and accountability to be effective.

Effective policies will need to be locally designed, since there are substantial differences between and even within countries. Long-term commitments are needed from development partners to scale up energy investments, transfer knowledge and deploy financing instruments which will leverage private capital, particularly in countries with the largest concentration of the energy-poor, such as those in sub-Saharan Africa and south Asia.

Investments in programs that are tailored to promoting development and addressing climate change simultaneously have been successfully employed in some developing countries. For example, the promotion of biofuels for transport has reduced the economic impact of oil imports and supported the rural economy. Other initiatives include renewable energy for rural electrification; support for mass transit which avoids urban congestion and reduces oil

demand; and the use of locally produced bioenergy to fuel generators for mobile phone recharging and for performing mechanical tasks, such as hulling, pressing and milling.

Cost-reflective pricing is a critical priority to meet long-term economic development objectives. Removal of price subsidies does not need to be undertaken in one painful step. A phased schedule that sets a medium-term goal for removal of the subsidies is necessary. The phased schedule must be widely publicised well in advance of price increases, and these increases need to be accompanied by well targeted social measures. Higher price impacts on the poor can be ameliorated by targeted direct compensation payments.

Policy reforms and development priorities must be tailored to each country's situation. In the poorest African and Asian countries, relying predominantly on private capital to develop energy infrastructure from scratch is unlikely to succeed, because of the risks involved. One way forward for these countries may be to establish public-private partnerships between host-country governments, donors, multi-lateral development banks, non-governmental organisations and private companies. The rich industrialised countries have obvious long-term economic, political and energy-security interests in helping developing countries along the path to energy development. For, so long as poverty, hunger and disease persist, the poorest regions will remain vulnerable to social and political instability and to humanitarian disasters. The cost of providing assistance to poor countries may turn out to be far less than that of dealing with the instability and insecurity that poverty breeds.

Notes

1. These projections are based on the assumption that the IEA crude oil import price averages $100 per barrel (in real year-2007 dollars) over the period 2008-2015, rising to over $120 in 2030.
2. GDP grows by 6.3 percent per year on average in the Reference Scenario and by 7.8 percent per year in the High Growth Scenario.

References

International Energy Agency (IEA) (2007), *World Energy Outlook 2007: China and India Insights*, OECD/IEA, Paris.

International Energy Agency (IEA) (2008a), *Energy Technology Perspectives 2008: Scenarios and Strategies to 2050*, OECD/IEA, Paris.

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

About the author

Teresa Malyshev is a senior energy analyst at the International Energy Agency in Paris, France. She provides insights and analyses on energy and poverty issues, and in particular biomass demand and supply in developing countries. She has been a lead author for many IEA publications, including seven *World Energy Outlooks*; *Energy Technology Perspectives: Scenarios to 2050*; *Angola: Towards an Energy Strategy*; and *Renewable Energy: Market Policy Trends in IEA Countries*. She has worked in the Renewable Energy Unit of the IEA where she was responsible for researching bioenergy technologies, policies and legislation. Ms Malyshev organised a high-level workshop in Maputo, Mozambique and a Biofuels Seminar at the IEA, with participation from Ministers in developing countries. Throughout her tenure at the IEA, she has contributed to studies on energy poverty, energy efficiency, environment and economics. She has also spent time as a consultant in Cameroon. Ms Malyshev received a PhD in economics from Duke University in 1991 and started her career at the OECD as a Young Professional the following year. Teresa Malyshev can be contacted at: Teresa.MALYSHEV@iea.org