2 Energy, Poverty, and Development

Convening Lead Authors (CLA)
Stephen Karekezi (AFREPREN/FWD, Kenya)
Susan McDade (United Nations Development Programme)

Lead Authors (LA)
Brenda Boardman (University of Oxford, UK)
John Kimani (AFREPREN/FWD, Kenya)

Review Editor
Nora Lustig (Tulane University, USA)

Contents

Executive Summary

There is often a two-way relationship between the lack of access to adequate and affordable energy services and poverty. The relationship is, in many respects, a vicious cycle in which people who lack access to cleaner and affordable energy are often trapped in a re-enforcing cycle of deprivation, lower incomes and the means to improve their living conditions while at the same time using significant amounts of their very limited income on expensive and unhealthy forms of energy that provide poor and/or unsafe services.

Access to cleaner and affordable energy options is essential for improving the livelihoods of the poor in developing countries. The link between energy and poverty is demonstrated by the fact that the poor in developing countries constitute the bulk of an estimated 2.7 billion people relying on traditional biomass for cooking and the overwhelming majority of the 1.4 billion without access to grid electricity. Most of the people still reliant on traditional biomass live in Africa and South Asia.

Limited access to modern and affordable energy services is an important contributor to the poverty levels in developing countries, particularly in sub-Saharan Africa and some parts of Asia. Access to modern forms of energy is essential to overcome poverty, promote economic growth and employment opportunities, support the provision of social services, and, in general, promote sustainable human development. It is also an essential input for achieving most Millennium Development Goals (MDGs) – a useful reference of progress against poverty by 2015 and a benchmark for possible progress much beyond that. Poverty alleviation and the achievement of the MDGs will not be possible as long as there are billions of people who do not have access to electricity and or to cleaner and better quality as well as adequate supplies of cooking fuels or with limited access to affordable and more efficient end-use energy devices such as improved cookstoves (those using traditional fuels but burning in a cleaner fashion), proper heating, more efficient lights, water pumps, low-cost agro-processing equipment as well as energy-efficient housing and transportation options.

The lack of modern and affordable forms of energy affects agricultural and economic productivity, time budgets, opportunities for income generation, and more generally the ability to improve living conditions. Low agricultural and economic productivity as well as diminished livelihood opportunities in turn result in malnourishment, low earnings, and no or little surplus cash. This contributes to the poor remaining poor, and consequently they cannot afford to pay for cleaner or improved forms of energy (often neither the fuels nor the equipment). In this sense the problem of poverty remains closely intertwined with a lack of cleaner and affordable energy services.

On the other hand, when the poor gain access to stable electricity supplies or cleaner fuels that can support job creation, trade, and value-adding activities within the family, they are able to accumulate the small levels of "surplus" or savings that facilitate access to education and health services, improved nutrition, or improved housing conditions that in turn enable them to gradually escape their poverty.

Cleaner affordable forms of energy and the energy services that they provide, reverses the aforementioned vicious cycle as they contribute to building a basis for supporting job creation, economic growth, agriculture, education, commerce, and health – the key areas that can contribute to overcoming poverty, as the following examples demonstrate:

- Energy plays a vital role in enhancing the food security of the poor through greater use of energy technologies for irrigation and water pumping. A number of these technologies not only ensure food supply throughout the year but also generate additional income for poor households, particularly in rural areas.

- Access to modern and affordable forms of energy is essential to creating employment, which can directly reduce poverty levels. Employment in formal and non-formal sector activities is positively correlated to increased access to cleaner energy options such as electricity, as is workers' productivity in value-adding processes.

- Increased access to modern forms of energy contribute to the transformation of agriculture-based economies – where significant animate energy is used – into industry-based economies, where modern forms of energy play a key role in the more-advanced value-added activities that characterize more industrialized economies.

- Improved low-cost cookstoves reduce the amount of fuel used, which translates into direct cash savings. They also reduce respiratory health problems associated with smoke emission from traditional biomass stoves and offer a better home and working environment. Other benefits include the alleviation of the burden placed on women and children in fuel collection, freeing up more time for women to engage in other activities, especially income-generating endeavors.

- Modern forms of energy play an important role in improving access to safe water and sanitation in developing countries.

- Modern health services (the facilities to provide them, and the professional and health sector workers who deliver them) are greatly enhanced by access to modern forms of energy and the services they provide, not only electricity for lighting, refrigeration and modern medical equipment but also heat-related services often linked to the availability of cleaner and affordable fuels for institutional uses.

- Access to modern forms of energy greatly improves the quality and availability of educational services and increases the likelihood that children will attend and complete schooling. Rural electrification helps retain good teachers in rural areas – a key lever for enhancing the quality of rural education.

- Gender parity and school enrollment of girls improve with greater access to cleaner and affordable energy options, especially in rural areas. Access to mechanical power for threshing and grinding grains help older girls stay in school by minimizing school absenteeism or desertion, while cleaner modern cooking systems reduce the time spent by girls on fuelwood collection for their families.

Universal access to electricity and modern as well as cleaner forms of energy for cooking provide a wide range of high-quality energy services even when the amount of energy used is modest. Given the important contribution of access to cleaner and affordable energy options to the improvement of livelihoods of poor people in developing countries, special attention should be paid to extending universal access to electricity and modern forms of energy for cooking in developing countries.

From a policy and public financing point of view, there is a need to alleviate the negative income effect of time use and family expenditure related to the use of traditional fuels and to overcome the barriers related to household energy. In developing countries, where poor people are highly dependent on traditional fuels that have incomplete combustion in inefficient devices, much greater emphasis must be given to increasing the availability and affordability of liquid and gaseous fuels and associated stove technologies. Special attention should also be paid to mechanical power solutions and labor-saving appliances that can provide homestead-based pumping, agro-processing, milling, and grinding, among other services. These are also critically important for gender and health reasons, as discussed later in this chapter.

The absence of mechanical options in many rural areas of the developing world, to provide access to mechanical power for water pumping, milling, or other household activities is also related to the absence of affordable and cleaner fuels or electricity to drive engines, mills, and pumps to supplement human labor (see Chapters 19, 23 and 25). The absence of mechanical power affects not only the poorest families, particularly girls and women, but often entire geographic areas due to the distances from electricity supply and cleaner fuel delivery systems.

Prioritizing access to electricity and energy-using technology for commercial/productive activities (as opposed to only low-load household activities) could increase employment opportunities that can contribute to income generation and the fight against poverty, especially for the working poor. Access to more efficient, cleaner and affordable energy options is an effective tool for combating extreme hunger by increasing food productivity and reducing post-harvest losses.

Low-cost energy-efficient transportation for both passengers and goods is crucial for economic development. This is particularly important for long-distance transit of passengers and goods. Rail transport is considered the least expensive energy-efficient land transport option for long-distance passenger travel and has been developed extensively in industrial countries in the form of surface and underground rail networks. For freight transportation, with the exception of India and China, many developing countries make limited use of lower-cost energy-efficient rail transport mainly due to its lack of sustained investment.

There are several health-related benefits associated with access to modern, cleaner and affordable energy options. Electricity in rural health centers, allows the provision of medical services at night, greater use of more advanced medical equipment, helps retain qualified staff in rural health centers among other benefits. In this regard, one of Global Energy Assessment (GEA)'s goals is achieving universal access to electricity and cleaner cooking by 2030. It should, however, be emphasized that access to electricity and cleaner cooking fuels constitute only a part of the desired policy objective of reducing poverty – they are a prerequisite, but electricity supply and cleaner cooking fuels, on their own, are not sufficient to move out of poverty.

Access to modern and affordable forms of energy can play an important role in improving access to safe water and sanitation in developing countries. Some of the energy solutions available are relatively affordable for the poor and do not require electricity or fossil fuels. Low-cost mechanical options can play an important role in ensuring access to safe water. For example, hand pumps and wind pumps are robust technologies that can dramatically expand access to safe water for domestic use as well as for irrigation and watering livestock.

The challenge of providing safe water and sanitation facilities is still immense particularly in sub-Saharan Africa where more than half the urban population lives in slums – a sizable part of the more than 825 million people living in urban dwellings without improved sources of drinking water and sanitation. Solar, wind, handpumps and biogas options can play an important role in enhanced access to safe water and sanitation in low-income peri-urban and urban of sub-Saharan Africa.

Prevailing energy systems in developing countries and associated economic and welfare policies need to be redesigned to ensure an emphatic pro-poor orientation that will move toward universal access to cleaner and affordable forms of energy in key economic sectors that the poor rely on such as health, water, education, agriculture and transport.

Access to electricity supply (both grid and non-grid) in many developing countries is almost an exclusive service enjoyed by the non-poor in urban areas. Even after two decades of energy sector reforms, initial indications from a wide range of developing countries indicate that few of the initiatives have resulted in significant improvement in the provision of electricity to the world's poor.

Experiences in developing countries point to an overarching conclusion: when power sector reforms were introduced with the sole intention of improving the performance of utilities, the expected and hoped-for social benefits did not necessarily follow. Where governments maintained a role as instigator or at least regulator of improved access to electricity by the poor, tariffs for poor households tended to decrease and levels and rates of electrification tended to increase.

In some cases, wide-scale deployment of renewable energy systems may provide the best options for providing access to cleaner and modern energy options while ensuring long-term sustainability. In the near term, however, cleaner fossil fuels such as liquefied petroleum gas (LPG) combined with more efficient and low-cost end-uses devices such as LPG cookstoves reduce a host of social, economic, and environmental barriers to overcoming poverty due to higher combustion efficiency.

The ongoing search for win-win solutions that are completely reliant on renewable energy must also put a time premium on overcoming social injustice and the conditions of inequality that entrench poverty and reproduce underdevelopment. From a policy point of view, it is unrealistic to support arguments for "near-term renewables only" options that delay the satisfaction of the basic needs of people who remain poor today and who constitute a negligible contributor to global historical and current carbon emissions. It is, therefore, important to retain cleaner fossil fuel options such as LPG combined with more efficient low-cost end-use devices in near-term priority action plans that would set the stage for eventually moving the poor to a fully sustainable path that they are able to rely more heavily on renewable energy.

2.1 Introduction

This chapter focuses on the situation of poor people – especially in developing countries – paying particular attention to their access to cleaner and affordable energy options. Poverty, as discussed in this chapter, includes concepts of both lack of access to income and inequality as well as limited access to services (such as access to cleaner energy options), opportunities and social exclusion, which are often intimately linked to inequality.

The chapter calls for setting of targets for bringing cleaner and affordable energy options to a wider proportion of the poor at affordable prices – plus the policy frameworks and the public and private investment needed to make this a reality.

The issue of access to cleaner and affordable energy options is emphasized here in line with the GEA goal of providing universal access to affordable electricity and affordable cleaner forms of energy for cooking by 2030. However, this 2030 goal requires substantial investments as well as a transition from the use of traditional solid fuels such as biomass and coal to cleaner energy carriers such as gas, electricity and liquid fuels. These investments and transition require sufficient time for low-income countries to establish the right institutions, regulation and policies that would enable mobilization and appropriate deployment of the required capital investments.

While the term "access" can simply refer to physical proximity to modern energy carriers such as electricity, natural gas, liquefied petroleum gas (LPG), biogas and ethanol, access also implies the availability of affordable improved and more efficient end-use energy devices such as improved cookstoves (those using traditional fuels but burning in a cleaner fashion), more efficient lights, water pumps, low-cost agro-processing equipment as well as energy-efficient housing and transportation options. In a much broader sense, access refers to the affordable and stable services of cleaner energy options that are delivered in a reliable fashion and ensure consistent quality (see also Chapter 19).

GEA considers universal energy access to refer to access to affordable modern energy carriers (e.g., electricity, natural gas, LPG, biogas, ethanol) including a wide array of efficient low-cost end-use options used by the poor in agro-processing, small-scale value addition processes, water pumping, housing and transportation as well as energy-efficient devices such as improved cookstoves and affordable, advanced stoves that use traditional fuels for cooking, by 2030.

This chapter focuses on developing countries for several reasons. The bulk of poor people in the world live in developing countries and require energy to support poverty alleviation, economic growth, social inclusion and development. The chapter focuses first on the concept of poverty: who are poor people and where they live.

It goes on to examine the historic worldwide relationship between access to energy services and development, arguing that developing countries also need to have access to improved energy services in order to overcome poverty, especially the most extreme forms faced by the lowest fifth of income earners around the world. The specific role of energy services – those provided by modern energy carriers such as electricity and fuels such as LPG, biogas and ethanol – is discussed in this chapter in relation to both household and productive energy applications. The essential role that energy plays in supporting job creation, economic growth, agriculture, transport, and commerce is reviewed, as these are key factors for overcoming poverty.

The importance of energy as an input to support the delivery of services such as education, health, and other social services is examined, followed by an analysis of the particular hardships faced by women in relation to traditional energy systems and their impacts on women's time use, literacy, and health. The importance of energy for the achievement of the Millennium Development Goals (MDGs) is also briefly illustrated by showing that energy is an essential input to each MDG. The local, regional, and global environmental impacts of energy use in developing countries are discussed, with an emphasis on the extremely small historical and current contribution made to global green house emissions by the poorest people in the world.

The chapter concludes that special emphasis must be given to extending universal access to electricity and modern forms of energy for cooking in developing countries and that the switch from traditional solid fuels to cleaner liquid fuels and combustion technologies constitute an essential step for overcoming poverty and supporting economic growth and sustainable human development. It is recommended that near-universal access is needed in developing countries due to the range of high-quality energy services that this carrier provides, even when it is available only in small amounts.

Specifically, with regard to electricity, this chapter argues that access to electricity as a carrier is only part of the desired policy objective of reducing poverty – it is a prerequisite, but electricity supply, in itself, is not sufficient for poor households to move out of poverty. The ultimate, well-being of people depends on the actual consumption of goods and services that electricity as a carrier can facilitate. Equally important is access to cleaner or modern forms of energy for cooking and fueling a wide array of energy efficient and low-cost end-use options and devices used by the poor in agro-processing, small scale value-addition processes, water pumping, housing and transportation.

Looking toward 2030, the need to focus on improving access to energy services in developing countries becomes even more crucial due to their higher population growth and their potential for higher economic growth rates, implying that the decisions taken regarding the nature of emerging energy systems in terms of energy sources, conversion technologies, and distribution and financing systems are important not only to developing countries but to the world as a whole throughout this century.

2.1.1 Poverty and Development

Economic growth is an essential prerequisite for overcoming poverty. No country has achieved sustained economic growth without improving access to cleaner and modern forms of energy and the services that they provide. It is also globally recognized – based on the experiences of most industrial countries – that policies to "share" the benefits of growth are needed to address inequality and combat poverty. Energy services to support economic growth and energy policies to combat inequality in human welfare are thus both critically important.

Using an absolute poverty line set at US_{2005}\$1.25 per day per capita (purchasing power parities (PPP)), the number of poor people worldwide fell from 1.8 billion in 1990 to 1.4 billion in 2005 (see Figure 2.1) in spite of population growth – a tremendous achievement based on the economic growth experienced worldwide during this period (UN, 2010a). According to the World Bank, the financial and food crises of recent years unfortunately pushed another 64 million people back into extreme poverty (World Bank, 2010a).

Table 2.1, provides a comparison of poverty trends in 1999, 2002 and 2005. It shows a substantial drop in poverty levels in East Asia and Pacific (particularly China) and highlights the continued high-levels of poverty in Sub-Saharan Africa and South Asia.

Using the multidimensional poverty index (MPI) recently developed jointly by Oxford University and United Nations Development Programme (UNDP), it is estimated that, worldwide, a larger proportion of humanity, about 1.75 billion, remains poor. The MPI is an advanced method of measuring poverty by determining the extent of deprivation among poor people across three key dimensions, namely: health, education and living standards. MPI also takes into account access to essential services such as electricity, water and sanitation in order to measure the magnitude of poverty (UNDP, 2010; Alkire et al., 2011).

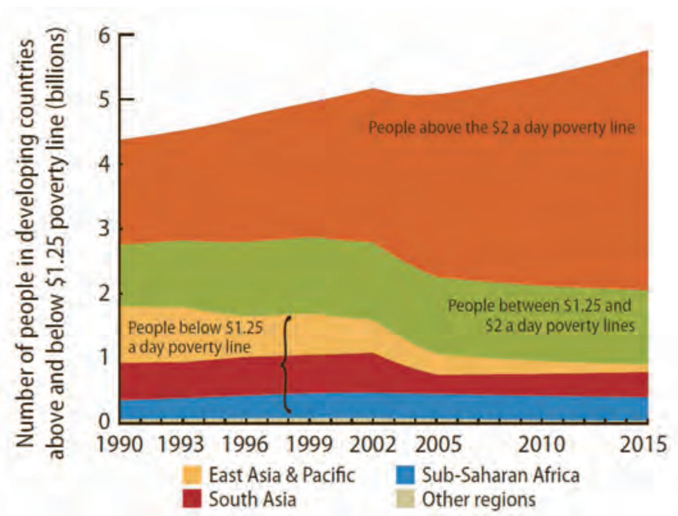

Figure 2.1 | Progress in poverty reduction. Source: World Bank, 2010a.

Table 2.1 | Proportion of people with incomes below US_{2005}\$1.25 per day PPP (%).

Region	Year		
	1999	2002	2005
Sub-Saharan Africa	58.4	55.0	50.9
South Asia	44.1	43.8	40.3
East Asia and Pacific	35.5	27.6	16.8
Latin America and Caribbean	11.0	10.7	8.1
Europe and Central Asia	5.1	4.6	3.7
Middle East and North Africa	4.2	3.6	3.6

Source: World Bank, 2011a.

Using the MPI methodology, available data (Figure 2.2) re-confirms the fact that the greatest concentrations of poor people live in the least developed countries of sub-Saharan Africa and South Asia.

Both income-defined and MPI poverty measurements leave out the fundamental issue of income distribution within countries. Today the World Bank, the United Nations system, and economists that work on poverty indicators at large argue that it is essential to look at not only the aspects of poverty expressed by income levels alone, but also at equity measures such as how the lowest 20% of the population (determined by income) fare in comparison to the top 20% in any given country. The more unequal the income distribution, the less likely it is that the poorest segment of the population will benefit from growth, although overall national statistics may show positive trends (UNDP, 2011).

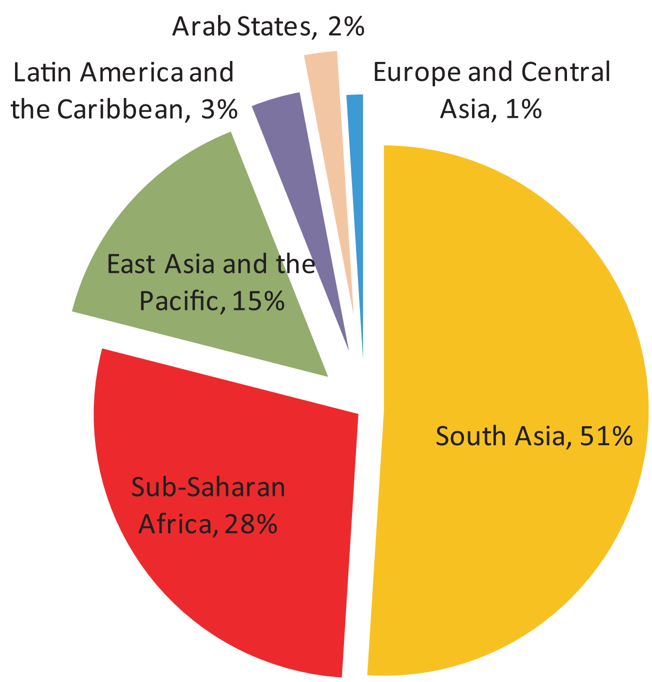

Figure 2.2 | Distribution of the poor (1.75 billion people) in developing countries (using multidimensional poverty measurement). Source: UNDP, 2010.

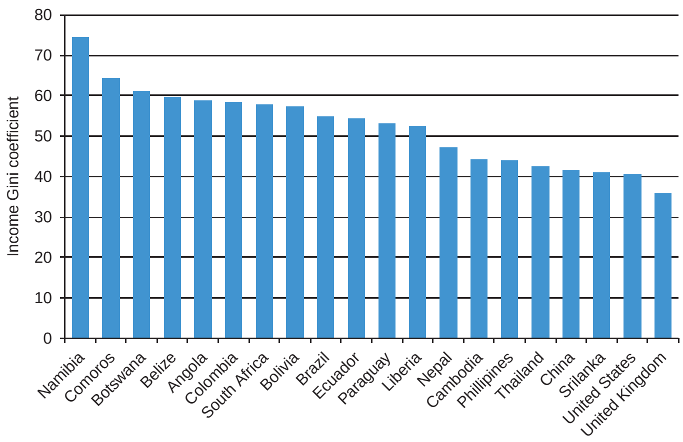

Figure 2.3 | Gini indices for selected developing countries (2000–2011*). Source: adapted from UNDP, 2010; 2011. *Data refer to the most recent year available during the period specified.

The Gini coefficient[1], which compares income levels among the richest and poorest segments of populations, is a useful indicator of inequality (see Figure 2.3). Comparing the lowest 20% of income earners to those who earn the most is also useful for understanding the role that inequality plays in defining country contexts. Inequality has been increasing alongside growth and economic development around the world triggering new development challenges – and therefore new energy challenges. Countries which have a higher coefficient, even in situations where energy access indicators show positive growth, the poorest segment of the population may not be benefiting from the growth. Currently, Latin America, the Caribbean region and Africa, are the most unequal regions in the world (Gasparin et al., 2009; Rosenthal, 2010; Gasparin and Lustig, 2011).

While many developing countries, particularly in Latin America, the Middle East, and Asia, have achieved significant growth and progress in development indicators over the last 20 years, progress has often not been evenly distributed across the population. As a result, inequality and increasingly unequal income distribution pushes more people into poverty thus creating new development as well as public financing and service delivery challenges for governments. Turkey, Gabon and South Africa, for instance, have made impressive advances in improving income per capita in the last decade, while levels of poverty and inequality have persisted (UNDP, 2010). As Andy Sumner notes in *Global Poverty and the New Bottom Billion*:

> The global poverty problem has changed because most of the world's poor no longer live in poor countries meaning low-income countries (LICs). In the past, poverty has been viewed as, predominantly, an LIC issue. Nowadays such simplistic assumptions/classifications can be misleading because a number of the large countries that have graduated into the middle-income countries (MIC) category still have large number of poor people. In 1990, we estimate that 93 per cent of the world's poor people lived in LICs. In contrast, in 2007–8 we estimate that three-quarters of the world's approximately 1.3 billion poor people now live in MICs and only about a quarter of the world's poor – about 370 million people live in the remaining 39 low-income countries, which are largely in sub-Saharan Africa (Sumner, 2010).

The largest number of poor people who "moved" from poor countries to middle-income ones are found in India, Nigeria, and Pakistan (Sumner, 2011). The two-tiered concept is itself questionable as it divides the world into developing and developed countries, which is contradicted by the emergence of the BRICS group, the rapidly growing and industrializing countries of Brazil, Russia, India, China, and South Africa (Sumner, 2011). The recent creation of the G-20 group of countries with industrialized or industrializing economies includes the BRICS as well as Argentina, Indonesia, Mexico, South Korea and Turkey.

Yet these emerging economic powers continue to have millions of poor people, with conditions of wealth and poverty[2] often existing side by side – sometimes only neighborhoods away and sometimes defined by the rural-urban divide. Thus, in terms of poverty, development, and growth, the world is more heterogeneous now than it was in 1990. And looking forward to 2050, many emerging economic powers historically viewed as "developing" will take on new roles while entire segments of poor people remain a feature of their national makeup. This is evident in urban areas of emerging economies where high numbers of population live in deplorable dwellings, i.e., slums, without access to basic services thus constituting a major challenge to urban governance and design in developing countries (GNESD, 2008).

It should, however, be emphasized that the poor in emerging economic powers of Latin America and Asia have better prospects for moving out of the poverty largely due to the significant and abundant economic, institutional and skill resources that are available in these countries plus their growing clout in re-arranging international economic relationships to protect their national interests.

In contrast, the prospects for the poor in Sub-Saharan Africa are significantly less promising (see Table 2.1) because of the very limited economic, institutional and skill resources that sub-Saharan African countries have combined with modest and more importantly "diminishing" ability to influence global economic relationships that are disadvantageous to the sub-Saharan Africa region. As shown in Table 2.1,

1 Gini coefficient measures the extent to which the distribution of income, (at times it includes consumption expenditure) among people or households within an economy deviates from a perfectly equal distribution. The values vary between 0, which reflects complete equality and 1, indicating a complete inequality situation, where one individual has all the income or consumption, while all the others have none).

2 These countries poverty conditions are in terms of relative poverty: this refers to lack of the usual or socially acceptable level of resources or income as compared with others within a society or country. On the other hand absolute poverty refers to a common international poverty line of: population living on less than $1.25 at 2005 PPP.

well over half of sub-Saharan Africa's population is poor – higher than any other region of the world.

Virtually all future poverty scenarios show substantial reductions in poverty levels in the large emerging economic powers of Latin America and Asia with virtually the whole of sub-Saharan Africa and parts of South Asia continuing to be the epicenters of global poverty.

In conclusion, poverty includes concepts of low income and inequality as well as limited access to services (such as access to cleaner energy options), opportunities and social exclusion, which are often intimately linked to inequality.

2.2 Energy and Development

Access to modern forms of energy is an essential pre-requisite for overcoming poverty, promoting economic growth, expanding employment opportunities, supporting the provision of social services, and, in general, promoting human development. It is also an essential input for achieving most MDGs, which are a reference of progress against poverty by 2015 and a benchmark for possible progress beyond that date. As mentioned earlier, it is, however, important to underline that access to electricity and cleaner cooking constitutes only part of the desired policy objective of reducing poverty. They are a pre-requisite, but electricity supply and cleaner cooking fuels, on their own, are not sufficient for poor households to move out of poverty.

Table 2.2 illustrates how energy can contribute to the MDGs targets. It also shows clearly how the lack of access to energy can be a major constraint to achieving the MDGs (Modi et al., 2006; UN-Energy, 2005; UNDP, 2005, DFID, 2002). One of GEA's goals is the provision of universal access to affordable electricity and clean cooking by 2030 – a key target that would contribute to reducing poverty levels.

Human well-being, poverty reduction, social inclusion, and economic improvement cannot be advanced without access to electricity, fuels, mechanical power, and the range of services that they provide. Countries with the highest levels of poverty and underemployment tend to be those that also lack access to adequate levels of energy services and the modern conveniences that they provide. This is most pronounced in Africa and South Asia, where the number of people who depend on traditional biomass for heating and cooking and who lack access to electricity are the greatest. As shown in Figure 2.4, based on the Energy Development Index (EDI) developed by the International Energy Agency (IEA), all sub-Saharan African countries, with the exception of South Africa, feature in the bottom half of the EDI ranking.

The EDI was developed to track the progress in country's or region's transition to the use of modern energy and to better understand the role that energy plays in human development. It is computed by factoring in the UNDP's Human Development Index (HDI) and is composed of four indicators; per capita commercial energy use, per capita electricity consumption, share of modern fuels in total residential sector energy use and share of population with access to electricity (Bazilian et al., 2010; IEA, 2010a; Nussbaumer et al., 2011).

Abundant cheap and highly polluting energy supplies, while providing essential inputs for economic growth in the short term, result in unsustainable local, regional, and global environmental and health effects over the medium and long term, as seen throughout the industrial world and now increasingly in China and India (UNDP, 2011). From a sustainable human development perspective, therefore, the key challenge is how to make available modern and cleaner forms of energy that can support economic growth and human well-being, helping to reduce poverty while not establishing long-term structural and negative environmental consequences in energy systems that will eventually undermine development itself.

For industrial countries, this challenge largely results in a focus on cleaner energy systems, energy efficiency, and the drive to diversify the energy supply mix to include more renewable sources to address global climate change concerns and rising or unstable global oil prices. For the least developed countries, which have significantly less installed energy infrastructure and where in many cases the vast majority of the population does not have access to either modern and cleaner forms of energy or electricity, the key near-term question is how to promote the development of energy systems that can provide accessible and affordable services using new models of production, financing, and distribution as well as introducing technologies that can avoid the limits to growth that traditional energy systems will eventually run into.

Energy as a key input to development is undeniable, but significant debate exists about how to go forward, and the models must differ from those put in place by industrial countries that have proved to be unsustainable. To move forward, it is essential to understand the multiple linkages between access to energy services and social, economic, and human development. These linkages shape emerging energy markets, define and often limit poor peoples' options to escape the cycle of poverty, and will determine the opportunities and limitations to key issues of pertaining to sustainability of development. Putting peoples' needs at the center of the development model that defines the energy services required to overcome poverty is a key starting point.

Currently there are almost one and a half billion people worldwide who do not have access to electricity (IEA, 2010a; see also Chapter 19). Most of these people live in Africa and South Asia. An estimated 3 billion people primarily rely on solid fuels (coal and traditional biomass) of which 2.7 billion people cook and heat their homes with traditional fuels and low-efficiency stoves (UNDP and WHO, 2009; IEA, 2010a; see also Chapter 19). For many millions of people, especially women and school-aged children, the lack of mechanical power for pumping water and grinding food grains results in hours of manual labor carrying fuel and water and undertaking repetitive pounding and grinding activities that pumps and mills could do so much more efficiently.

Table 2.2 | Energy and the MDGs.

Goal and target	Some direct and indirect contributions of cleaner/affordable energy options
MDG 1. Extreme poverty and hunger: To halve, between 1990 and 2015, the proportion of the world's people whose income is less than one dollar per day. To halve, between 1990 and 2015, the proportion of people who suffer from hunger.	• Cleaner burning fuels and electricity can reduce the large share of household income spent on cooking, lighting and heat. The bulk of staple foods (95%) need cooking before they can be eaten and need water for cooking. • Post-harvest losses can be reduced through improved electric-powered preservation (for example, drying and smoking) and chilling/freezing. • Energy technologies such as wind pumps and treadle pumps can be used for irrigation in order to increase food production and improve nutrition. Access to affordable energy options from gaseous and liquid fuels and electricity can assist enterprise development. • Electrically driven machinery can increase productivity and provide opportunities for income generation. • Local energy supplies can often be provided by small-scale, locally owned businesses creating employment.
MDG 2. Universal primary education: To ensure that, by 2015, children everywhere will be able to complete a full course of primary schooling.	• Lighting at homes (e.g., through solar lanterns) allows children to study after school hours, with a significant impact on learning outcomes. • Lighting in schools can assist in retaining teachers, especially if their houses are electrified. • Availability of electricity can enable access to educational media and communications in schools and, at home, can facilitate distance learning. • Access to energy can provide opportunities for using specialized equipment for teaching. • Cleaner energy systems and efficient building design can reduce heating/cooling costs and thus school fees. • Energy can help create more child-friendly environments, thus improving attendance at school and reducing dropout rates.
MDG 3. Gender equality and women's empowerment: To ensure that girls and boys have equal access to primary and secondary education, preferably by 2005, and to all levels of education no later than 2015.	• Availability of cleaner energy options can free girls' and young women's time from survival activities (gathering firewood, fetching water, etc.). • Good-quality lighting can facilitate home study and organization of evening classes for girls and women who are often housebound due to traditional family responsibilities. • Affordable and reliable energy options can broaden the scope for women's enterprises, thereby fostering employment and income generation among women. • National decision-making by women representatives, especially on energy use at household level, can be beneficial, hence improving energy access among the poor.
MDG 4. Child mortality: To reduce by two-thirds, between 1990 and 2015, the death rate for children under the age of five.	• GEA estimates for 2005 put the burden of disease caused by household air pollution at about 2.2 million premature deaths annually, mostly affecting children and women (see Chapters 4 and 17). Gathering and preparing traditional fuels exposes young children to health risks and can reduce time spent on childcare. • Cleaner energy options facilitate the provision of nutritious cooked food and space heating, while boiled water contributes to better health. • Improved energy options can provide access to better medical facilities for pediatric care, including vaccine refrigeration and equipment sterilization. • Energy can be used to purify water or pump clean groundwater locally, which can reduce the burden of water-borne diseases.
MDG 5. Maternal health: To reduce by three-quarters, between 1990 and 2015, the rate of maternal mortality.	• Clean cooking fuels and equipment can reduce pregnant women's exposure to indoor air pollution and improve health. • Improved energy options can provide access to better medical facilities for maternal care, including laboratory services, medicine refrigeration, equipment sterilization, and operating theatres, as well as safer caesarean sections. • Improved energy options can also help retain qualified medical personnel in remote rural areas. • Cleaner energy options can reduce excessive workloads and heavy manual labor (carrying heavy loads of fuelwood and water), which could adversely affect a pregnant woman's general health and well-being.
MDG 6. HIV/AIDS, malaria, and other major diseases: By 2015, to have halted and begun to reverse the spread of HIV/AIDS, malaria, and other major diseases that afflict humanity.	• Electricity in health centers can help provide medical services at night, retain qualified staff, and allow the use of more advanced medical equipment (e.g., sterilization). • Energy for refrigeration can facilitate vaccination and medicine storage for the prevention and treatment of diseases and infections. • Energy is needed to develop, manufacture, and distribute drugs, medicines, and vaccinations. • Electricity can enable access to health education media through information and communications technologies.
MDG 7. Environmental sustainability: To stop the unsustainable exploitation of natural resources. To halve, between 1990 and 2015, the proportion of people who are unable to reach or afford safe drinking water and sanitation.	• Increased agricultural productivity can be facilitated by the greater use of electric-powered machinery and irrigation, which in turn reduces the need to expand the amount of land under cultivation. • Increased renewable energy technology use can contribute greatly to alleviation of deforestation and reduction of green house emissions that lead to climate change. • Cleaner burning fuels can reduce greenhouse gas emissions, which contribute to climate change conversion technologies. • Simple cleaner energy solutions such as low-cost sterilization of drinking water can save many lives.
MDG 8. Global partnership for development	• Global and subregional partnerships are valuable for ensuring cross-border trade and exchange of skills in cleaner energy options as well as joint lower-cost development of transmission interconnections.

Source: adapted from Modi et al., 2006; DFID, 2002.

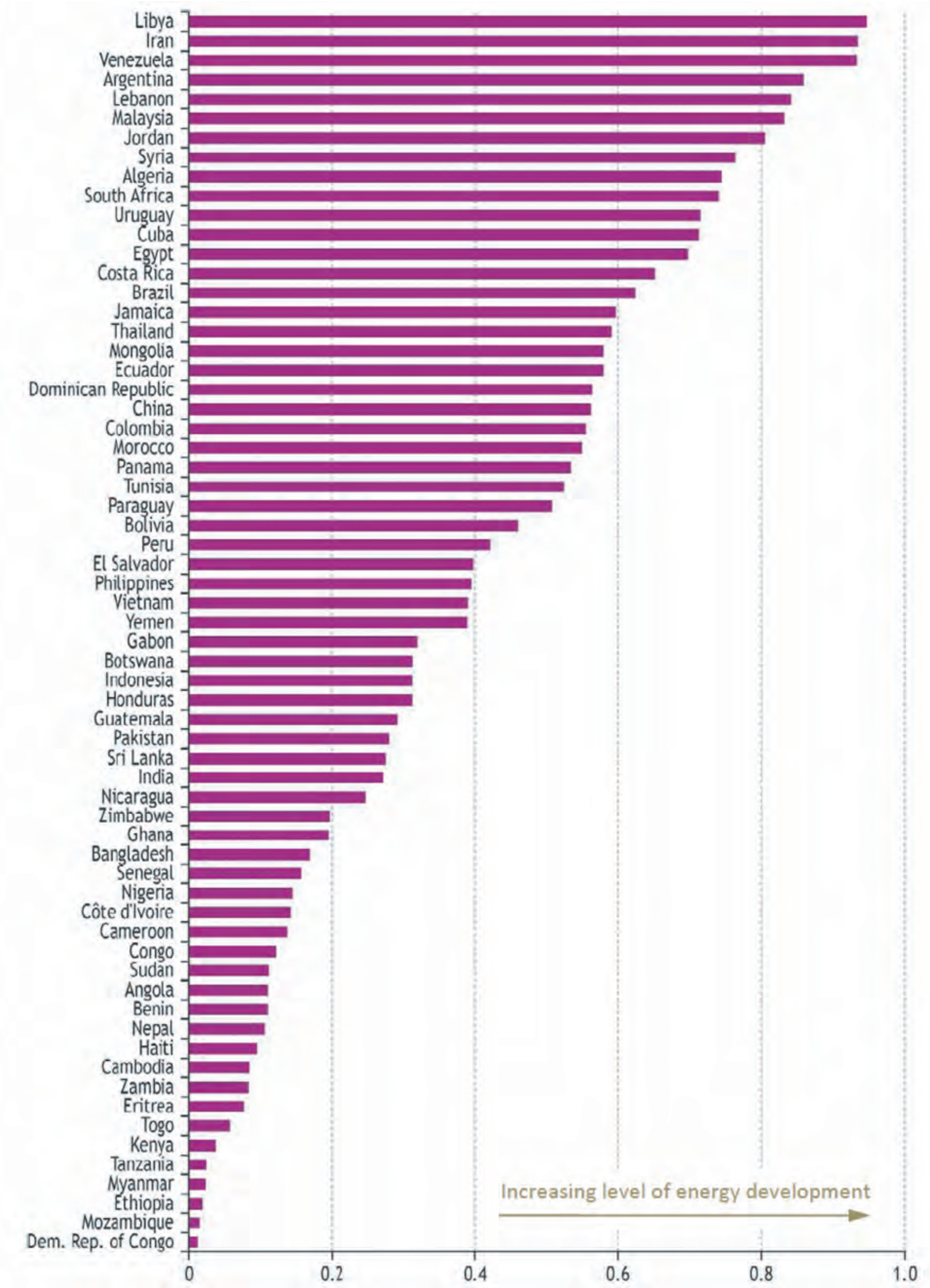

Figure 2.4 | Energy Development Index, 2009. Source: IEA, 2010a.

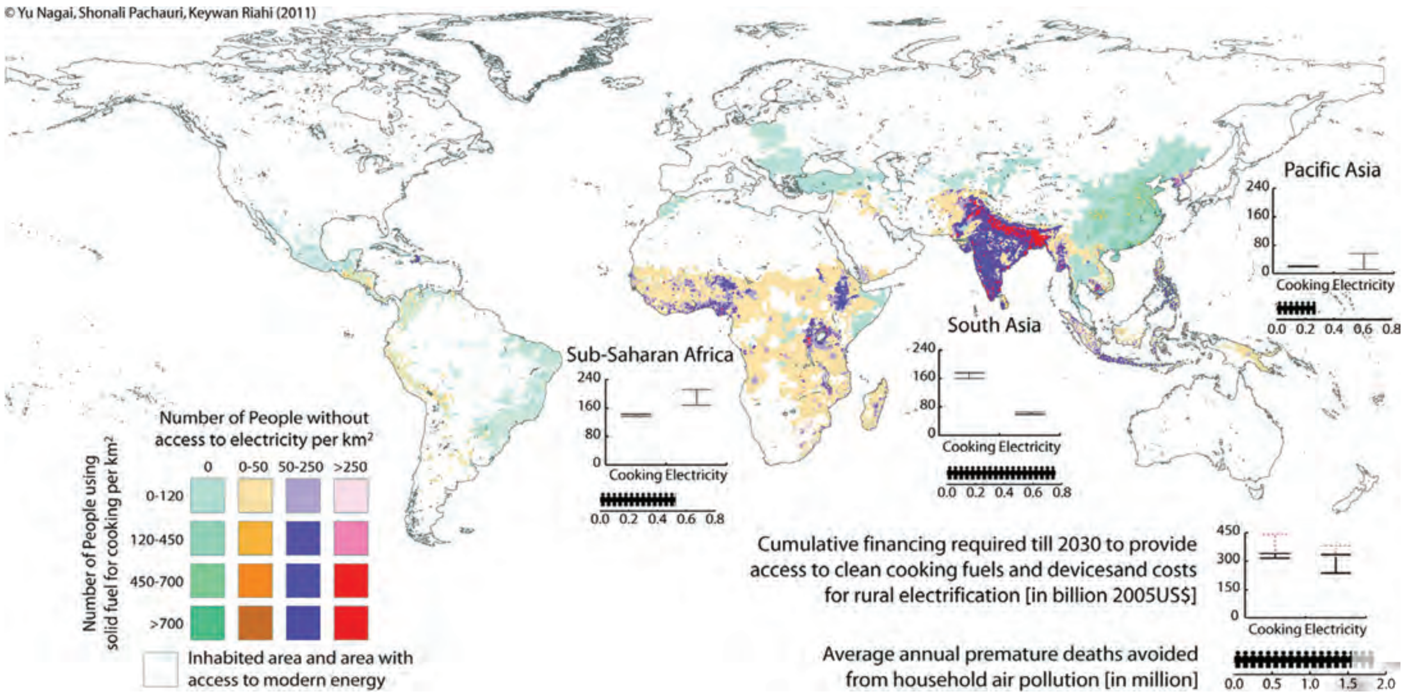

Figure 2.5 | Proportion of population without access to electricity and using solid fuels. Source: Compiled by IIASA using data from UNDP and WHO, 2009.

Figure 2.5 shows the proportion of people without electricity and using solid fuels for cooking. The figure indicates that, among developing countries, sub-Saharan Africa has the highest proportion of its population having a combination of low access to electricity and reliance on solid fuels (see also Table 2.4 and Table 2.6) while the absolute largest number of the people with limited access live in Asia. According to projections by IEA (2010a), the population without electricity will continue to rise in sub-Saharan Africa, unlike in other parts of the developing world, which still have pockets of underserved populations but which are projected to significantly increase access to electricity (e.g., Latin America and North Africa).

As shown in Table 2.3, within countries, there is a significant disparity in terms of access to electricity between rural and urban populations (IEA, 2010a).

As shown in Table 2.4, in many developing countries, especially those in sub-Saharan Africa and some parts of Asia, low electrification rates are compounded by very low levels of electricity consumption implying very limited use of this important and flexible energy service.

As mentioned earlier, while there are different approaches to defining poverty, there is a positive worldwide correlation between energy services and GDP per capita (approximately average personal income) as well as in relation to human development. As shown in Figure 2.6, there is a correlation between the level of well-being (shown by the HDI) and access to modern forms of energy (indicated by per capita electricity consumption). As the electricity consumption per capita increases, the HDI indicator increases, while an increase in income and electricity access has a direct relationship in the increase of electricity consumption per capita.

Table 2.3 | Urban and rural populations without access to electricity, 2009.

Region	Rural (million)	Urban (million)
Sub-Saharan Africa	465	120
China	8	–
India	381	23
Other developing countries in Asia	328	59
Latin America	27	4
Total	**1209**	**206**

Source: IEA, 2010a.

As mentioned earlier, provision of and access to modern, cleaner and affordable energy options *per se* does not, in itself, alleviate poverty. However, there is growing consensus that enhancing access to modern, cleaner and affordable energy options can play a key contributing role to reducing poverty, especially for the poorest people (the lowest fifth in a population) and the poorest countries. Figure 2.7 illustrates the link between high poverty levels and low access to electricity. Energy services therefore, are a means to facilitate development given that energy is an essential input for productive, household and social sectors.

It is, however, important to note that at higher levels of incomes, this correlation begins to break down at a national level – an important indicator of wasteful energy use which highlights the importance of energy efficiency in richer industrialized nations.

Table 2.4 | Snapshot of electricity access and consumption in developing countries, 2008.

Country	Population with electricity access (%)	Electricity consumption per person (kWh)
Africa		
South Africa	75.0	4532
Nigeria	50.6	121
Cameroon	48.7	271
Cote d'Ivoire	47.3	203
Senegal	42.0	196
Sudan	35.9	114
Eritrea	32.0	51
Angola	26.2	202
Benin	24.8	91
Togo	20.0	111
Ethiopia	17.0	46
Kenya	16.1	147
Tanzania	13.9	86
Mozambique	11.7	453
Congo, Democratic Republic of	11.1	104
Asia		
Singapore	100.0	7949
China	99.4	2631
Malaysia	99.4	3614
Thailand	99.3	2045
Vietnam	97.6	918
India	75.0	597
Indonesia	64.5	590
Pakistan	62.4	449
Cambodia	24.0	131
Myanmar	13.0	104
Latin America		
Venezuela	99.0	3152
Chile	98.5	3283
Brazil	98.3	2206
Paraguay	96.7	1056
Dominican Republic	95.9	1358
Colombia	93.6	1047
Ecuador	92.2	1115
El Salvador	86.4	845
Peru	85.7	1136
Guatemala	80.5	548
Bolivia	77.5	558
Honduras	70.3	678

Source: IEA, 2009; 2011; World Bank, 2011a.

The correlation between access to cleaner energy and poverty reduction is corroborated by a number of recent World Bank studies. For example,

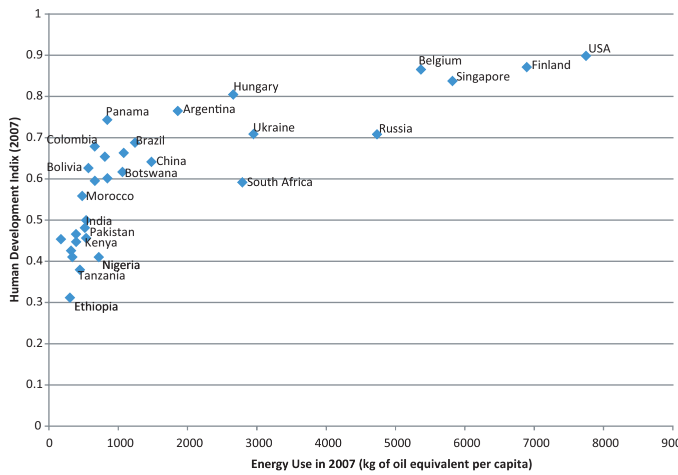

Figure 2.6 | Correlation between HDI and electricity consumption per capita. Source: adapted from UNDP, 2009; World Bank, 2007.

according to a study by Barnes et al. (2010), increased access to cleaner and affordable energy options contributes to monetary gains among the poor and leads to better quality of life, such as an improved diet and amount of food intake, the ability to afford better health and education facilities, etc.

There tends to be a two-way causal relationship between poverty and the lack of access to adequate and affordable energy forms. The relationship can be characterized as a vicious cycle because poor people who lack access to cleaner and affordable energy are often trapped in a repeating cycle of deprivation, limited incomes and the means to improve their living conditions while at the same time using significant amounts of their very scarce income on expensive and unhealthy forms of energy that provide poor or unsafe services such as dry cell batteries, rudimentary and inefficient kerosene lamps, charcoal and candles.

The lack of modern and affordable forms of energy affects agricultural and economic productivity, time budgets, opportunities for income generation, and more generally the ability to improve living conditions. Low agricultural and economic productivity as well as diminished livelihood opportunities in turn result in malnourishment, low earnings, and no or little surplus cash. This contributes to the poor remaining poor, and consequently they cannot afford to pay for cleaner or improved forms of energy (often neither the fuels nor the equipment). In this sense the problem of poverty remains closely intertwined with a lack of cleaner and affordable energy services.

On the other hand, when the poor gain access to stable electricity supplies or cleaner fuels that can support job creation, trade, and value-adding activities within the family, they are able to accumulate the small levels of "surplus" or savings that facilitate access to education and health services, improved nutrition, or improved housing conditions that in turn enable them to gradually escape their poverty (UNDP, 2006).

A number of developing countries have set targets for enhancing access to electricity, cleaner fuels, improved stoves, and mechanical power (see Table 2.5). In overall terms, however, the total number of developing countries with such targets is relatively small.

As shown in Figure 2.8, nearly all 140 countries assessed in a UNDP-WHO study have some data on electricity access/supply, but none had data on mechanical power.

Table 2.5 | Developing countries with access targets for modern energy availability.

Energy Source/ Application	Number of Developing Countries with Target	Number of Sub-Saharan African Countries with Target
Electricity	68	35
Modern fuels	17	13
Improved cookstoves	11	7
Mechanical Power	5	5

Source: adapted from UNDP and WHO, 2009.

2.3 Household Energy

For the poorest people in the world, especially those who live in the poorest countries, the most inelastic segment of demand for energy is that for cooking and heating to ensure basic survival. This "household

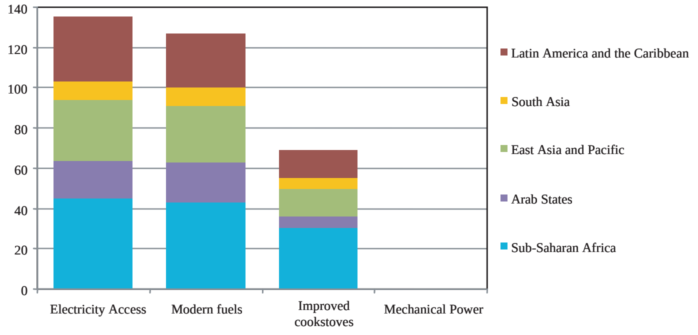

Figure 2.8 | Number of countries with data on energy sources and applications. Source: adapted from UNDP and WHO, 2009.

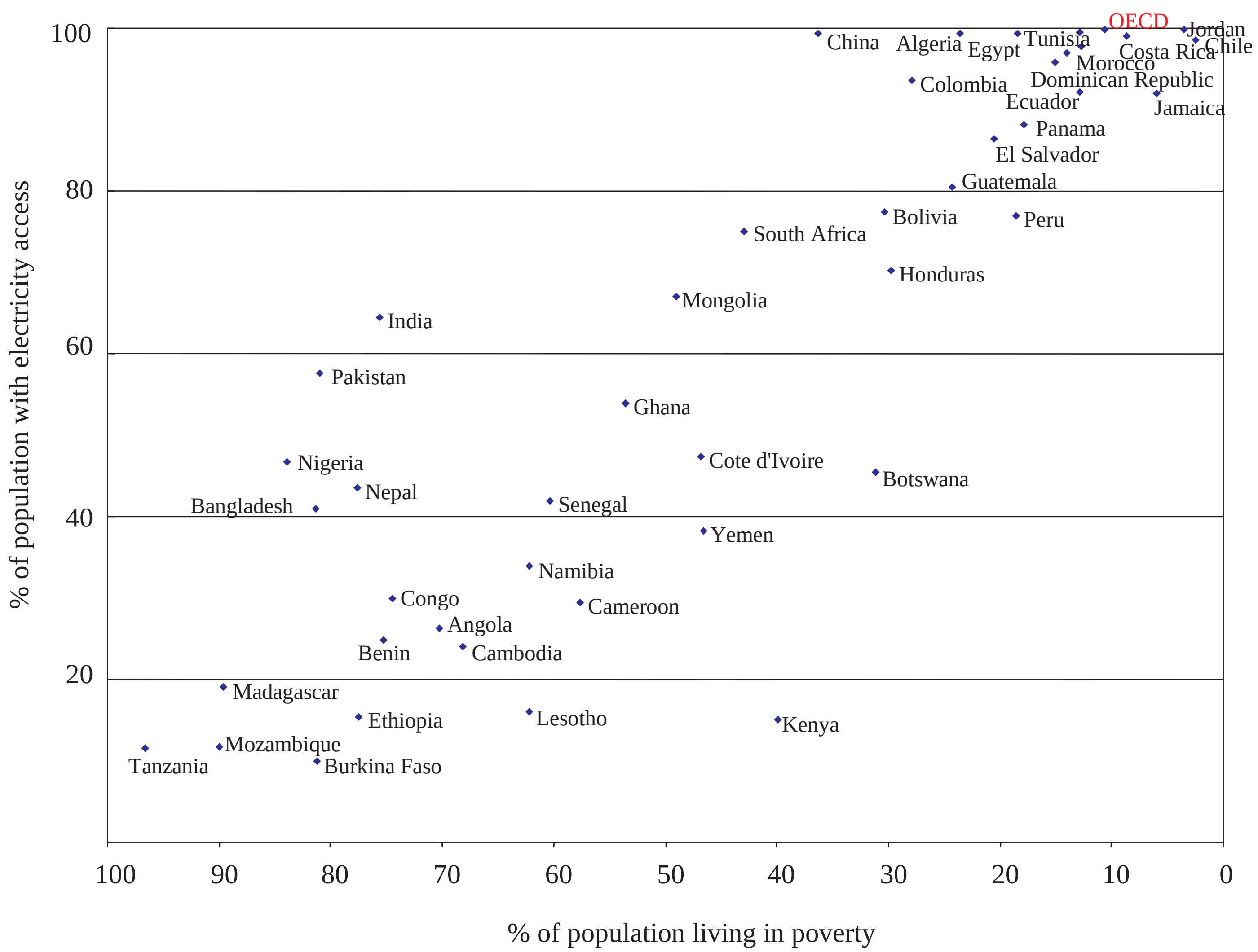

Figure 2.7 | Access to electricity versus poverty levels. Source: adapted from World Bank, 2011a; IEA, 2008.

energy" is often poorly understood by development planners at large, and within the energy sector it is often not considered in policies that historically have been focused on electricity supply rather than other household fuels. Even poor families do not have a choice of whether to use heat to cook their food because 95% of all basic staples must be converted to food through heat for cooking (ESMAP, 2004).

All families worldwide, rich or poor, depend on heat to cook their food, boil water, and, where the climate requires it, provide space heating. While traditional fuels such as wood, agricultural residues, or dung can be gathered locally, considerable time is spent collecting them (ESMAP, undated) (see Figure 2.19). As traditional fuels become scarcer due to overharvesting, agricultural decline, or increased competition among growing populations, more and more unpaid time is dedicated to fuel collection, leaving less time for income-earning activities.

In many poor countries, biomass, mainly for cooking, accounts for over 90% of household energy use. According to IEA (2010a) estimates, about 2.7 billion people rely on traditional biomass, such as fuelwood, charcoal, agricultural waste, and animal dung, to meet their energy needs for cooking. A significant proportion of these people are the majority of the poor, who live on less than US_{2005}\$2 a day (PPP).

As shown in the Table 2.6, sub-Saharan Africa and parts of Asia currently rely heavily on traditional biomass (IEA, 2010a). In all subregions of the developing world, people in rural areas account for the highest proportion of the population relying on traditional biomass, a key indication that rural areas in most developing countries have limited access to cleaner energy options, especially for cooking.

According to available data, if access to cleaner cooking fuels remains constrained, a large proportion of the population in sub-Saharan Africa and parts of South Asia will continue relying on traditional biomass for cooking for the next couple of decades. And as shown in Figure 2.9, in sub-Saharan Africa the number of people relying on traditional biomass for cooking is projected to increase at a much steeper pace than in other regions over the next two decades (Brew-Hammond, 2007) if current trends continue.

Unlike other regions and developing countries where traditional biomass energy use is expected to stagnate or decline, Africa's traditional biomass use is likely to increase sharply by 2030 unless there is a significant increase in access to cleaner and affordable energy carriers for cooking (IEA, 2006a). In the meantime, there is evidence that in areas where local prices of energy carriers have increased because of recent high international energy prices, the shift to cleaner and more efficient energy options for cooking has actually slowed and even reversed (IEA, 2006a; UNDP, 2007a; World Bank, 2010a).

Enhancing the poor's access to modern and cleaner forms of household energy is important due to its potential for increasing income levels for

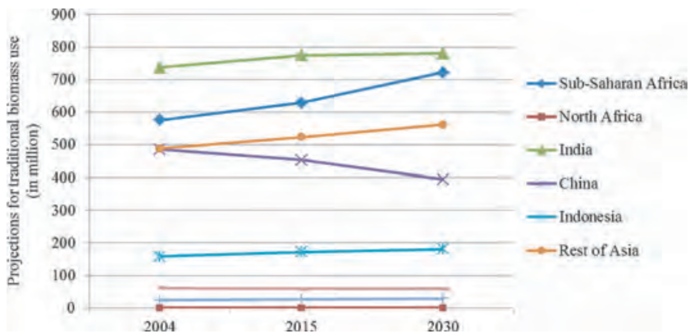

Figure 2.9 | Projections for traditional biomass use in developing regions (million people). Source: based on IEA, 2006a.

Table 2.6 | Rural and urban populations relying on traditional biomass as principal household energy option, by region and selected country.

Subregion	Total number of people relying on traditional biomass (million)			Proportions of population relying on biomass within subregion (%)		Population relying on biomass as share of subregion's population (%)
	Rural	Urban	Total	Rural	Urban	
Africa	481	176	657	73.2	26.8	67
Sub-Saharan Africa	477	176	653	73.1	26.9	80
Developing Asia	1694	243	1 937	87.5	12.5	55
China	377	47	423	89.1	11.1	32
India	765	90	855	89.5	10.5	75
Other Asia	553	106	659	83.9	16.1	63
Latin America	60	24	85	70.6	28.2	18
Developing countries*	**2235**	**444**	**2679**	**83.4**	**16.6**	**54**

*– Includes Middle East

Note: Traditional use of biomass refers to the basic technology used and not the resource itself. The people relying on traditional use of biomass refer to those households where biomass is the primary fuel for cooking. In addition to the number of people relying on biomass for cooking, some 0.4 billion people, mostly in China, rely on coal cooking.

Source: adapted from IEA, 2010a.

Table 2.7 | Share of household income expenditure on energy, selected countries (%).

Country	Date of data Publication	Bottom quintile	Top quintile
Armenia	2006	13.9 (electricity)	6.5 (electricity)
Djibouti	2005	18.2 (18.5)[a]	16.3 (13.4)[a]
Bolivia	2006	2.6 (LPG)	1.1 (LPG)
Georgia	2006	6.3 (electricity)	2.0 (electricity)
Ghana	2006	0.1 (petrol)	2.1 (petrol)
	2006	5.9 (kerosene)	1.6 (kerosene)
	2006	0.0 (LPG)	0.2 (LPG)
Hungary	2006	6.5 (electricity)	3.7 (electricity)
Jordan	2006	1.0 (kerosene)	0.3 (kerosene)
	2006	1.8 (LPG)	0.7 (LPG)
	2006	3.1 (electricity)	1.8 (electricity)
Kazakhstan	2006	0.9 (electricity)	0.6 (electricity)
Moldova	2006	6.3 (electricity)	3.0 (electricity)
	2006	0.4 (LPG)	0.4 (LPG)
Mongolia	2003	10.8 for the poor on heating (18% in winter months)	5.7% for the non-poor on heating (10.1% in winter months)
South Africa	2004	75.0 (housing, energy, clothing, and food)	33.3 (housing, energy, clothing, and food)
Poland	2006	5.8 (electricity)	2.9 (electricity)
Uganda	2002	15.0	9.5
Ethiopia	2002	10.0	7.0
India	2002	8.5	5.0
United Kingdom	2002	6.8	2.0

[a] Numbers are calculated for Djibouti Ville and shown in parenthesis for other towns.

Source: World Bank, 2008a.

this group. Just as important, however, is the need to reduce the poor's expenditure on energy services. As shown in Table 2.7, the poor spend a higher share of their income on energy than the non-poor, which underscores the need to ensure affordable energy options for people with lower incomes.

Traditional fuels are typically used in low-efficiency stove technology – for the poorest people, nothing more than stones or very basic stoves. Relatively poor-quality heat is derived from the use of traditional fuels. This is not the nature of the fuels themselves but a byproduct of stove technology.

Global analysis conducted by World Health Organization (WHO) evaluated different intervention scenarios if the number of people cooking with solid fuels were halved by providing them with access to LPG by 2015. The analysis, conducted in 11 WHO subregions, showed a payback of US_{2005}\$91 billion a year on an investment of US_{2005}\$13 billion a year (See Table 2.8).

In poor countries, due to scarcity, rural people are unable to collect all the fuels they need (UNDP, 2005; UN-Energy, 2005). Increasingly, traditional fuels including wood, charcoal, and other biomass are bought in commercial markets. The share of poor families' incomes spent on fuels is a significant portion of their total expenditures and can sometimes overtake other essential items such as schooling and health costs when local fuel prices rise (Modi et al., 2006; UNDP, 2005). This is also true for the urban poor, who rely on traditional fuels for cooking and heating and who must buy such fuels.

It is essential to put to rest two myths regarding the use of traditional fuels. The first myth is that all traditional fuels are free or available at no monetary cost (even those that are harvested locally for family consumption are not free as they involve a high opportunity cost based on the time spent on their collection). The second is that traditional fuels are mainly used in households in rural areas in terms of absolute numbers of consumers. In sub-Saharan Africa, much of the rural deforestation and overharvesting of fuelwood can, in part, be traced to trees cut down for feedstock for the charcoal industry. This is not to supply rural consumers with energy but to provide a steady supply of cheap fuels for cooking and household energy use for urban dwellers, as indicated by the thriving charcoal markets throughout the African continent (AFREPREN/FWD, 2006a).

Table 2.8 | Remarkable returns from investing in household energy. Benefits of household energy and health interventions (US$_{2005}$\$ million), by type of benefit, 2005.

	If 50% of the population cooking with solid fuels in 2005 switch to cooking with liquefied petroleum gas by 2015	If 50% of the population cooking with solid fuels in 2005 switch to cooking with modern forms of biofuels by 2015	If 50% of the population cooking with solid fuels in 2005 switch to cooking on an improved stove by 2015
Health care savings	384	384	65
Time savings due to childhood and adult illness prevented: school attendance days gained for children and productivity gains for children and adults	1460	1460	510
Time savings due to less time spent on fuel collection and cooking: productivity gains	43,980	43,980	88,100
Value of deaths averted among children and adults	38,730	38,730	13,560
Environmental benefits	6070	5610	2320
Total benefits	**90,624**	**90,164**	**104,555**

Note: Costs and benefits of different intervention scenarios were estimated using 2005 as the base year and a 10-year time horizon, taking into account demographic changes over this period. The analysis was conducted for 11 WHO subregions to reflect variations in (i) the availability, use and cost of different fuels and stoves; (ii) disease prevalence; (iii) health care seeking as well as quality and cost of health care; (iv) the amount of time spent on fuel collection and cooking; (v) the value of productive time based on Gross National Income per capita; and (vi) variations in environmental and climatic conditions. A 3% discount rate was applied to all costs and benefits.

Source: WHO, 2006.

A reduction in energy expenditure or time spent collecting fuel can liberate much-needed financial resources for other important expenses, such as increasing the quantity and quality of food or investing in new income-generating activities or expanding existing income-generating activities – thereby enhancing income as well as creating employment. For example, by switching from traditional to improved cookstoves, the poor can significantly reduce their expenditure on fuel and also save time spent in fuel collection (Galitsky et al., 2006). Improved charcoal cookstoves modelled on the Kenya Ceramic Jiko (KCJ) can cut charcoal consumption by up to half. The money thereby saved can be reinvested in more or better-quality food, partially contributing to minimizing extreme hunger, or in an income-generating activity. The KCJ reduces emissions and particulate matter, the latter of which contributes to acute respiratory infection among women and infants under the age of five. The relevance of the KCJ experience in Kenya is demonstrated by its introduction into Burkina Faso, Ethiopia, Ghana, Malawi, Mali, Rwanda, Senegal, Sudan, Tanzania, and Uganda, to mention just a few countries. Other successful improved biomass cookstoves as well as ethanol cookstoves are also being disseminated in Asia and Latin America.

Liquid and gaseous fuels can provide better cooking and heating options due to the combustion efficiency and quality of heat they provide. Unfortunately, fuels such as kerosene and LPG are often not available in local markets, especially in rural areas. In addition, due to their higher costs, they cannot compete with traditional biomass-based fuels. Poor people also face challenges associated with the upfront cost of stoves. For example, families who would be able to afford the recurring fuel costs of LPG versus charcoal may not be able to afford the requisite LPG stove, thereby eliminating the possibility of switching fuels (Quansah et al., 2003).

In most developing countries, there has been a significant increase in the use of LPG over the past decade (Karekezi et al., 2008b), but this has occurred among people with higher disposable incomes except in countries where active interventions to reach the poor are in place. In Senegal, for example, about 90% of Dakar's inhabitants rely on LPG for cooking (ANSD, 2006; Schlag and Zuzarte, 2008; Fall et al., 2008). To reach the poor, a number of LPG distributors have promoted smaller LPG cylinders, thus lowering upfront costs. India and Brazil have registered impressive progress in promoting LPG use through the use of subsidies to promote market wide changes in consumption patterns (Shankar, 2007; Coelho, 2009). However, world oil prices are highly variable, and in a time of increasing resource scarcity, a significant price increase is likely to erode some of the gains made in LPG use among the poor.

Socioeconomic determinants can be expected to have a significant influence on fuel or other intervention choices (such as improved stoves or improved household ventilation). Household fuel demands have been shown to account for more than half of the total energy demand in most countries with per capita incomes under US$_{2005}$\$1000 (PPP), while accounting for less than 2% in industrial countries (UNDP, 2007b). While it is known that households switch to cleaner, more-efficient energy systems for their domestic energy needs as per capita incomes increase (i.e., they move up the "energy ladder"), these changes have largely been due to increases in affordability, demand for greater convenience, and energy efficiency (IEA, 2010a). Figure 2.10 is a partial depiction of a typical "energy ladder" with regard to some of the fuels associated with cooking.

From a policy and public financing point of view, there is a need to alleviate the negative income effect of time use and family expenditure related to the use of traditional fuels and to overcome the barriers

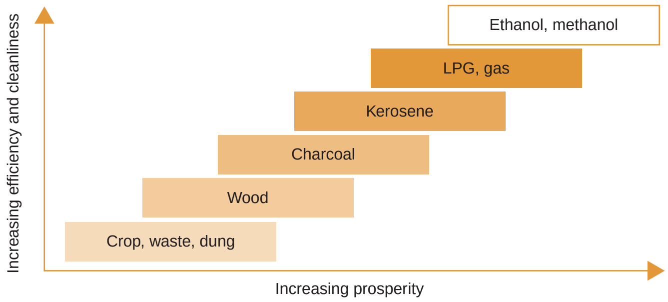

Figure 2.10 | Typical "energy ladder" for cooking fuels[3]. Source: UNDP, 2007b.

related to household energy. In developing countries, where poor people are highly dependent on traditional fuels that are poorly combusted in inefficient devices, much greater emphasis must be given to increasing the availability and affordability of liquid and gaseous fuels and associated stove technologies. Special attention should also be paid to mechanical power solutions and labor-saving appliances that can provide homestead-based pumping, agro-processing, milling, and grinding, among other services. These are also critically important for gender and health reasons, as discussed later in this chapter.

The absence of mechanical options in many rural areas of the developing world, to provide access to mechanical power for water pumping, milling, or other household activities is also related to the absence of affordable and cleaner fuels or electricity to drive engines, mills, and pumps to supplement human labor (see Chapters 19, 23, and 25). The absence of mechanical power affects not only the poorest families, particularly girls and women, but often entire geographic areas due to the distances from electricity supply and cleaner fuel delivery systems (UN Energy, 2005; UNDP, 2005). Overcoming the mechanical power deficit that affects the household energy balance is also related to the appliances (pumps, mills, and engines) that convert energy carriers into the service of mechanical power. In this sense, it has many similarities with the cooking and heating challenges in the household energy mix.

2.4 Energy and Production

Virtually all value-adding activities, both paid and unpaid, require energy as an input in the production process (Modi et al., 2006; UN-Energy, 2005). In its simplest form it can be human or animal energy transporting goods, doing manual work, or providing manual power through simple machines such as mills. As greater degrees of technology are applied in the production process, different forms of energy are used. This could be heat energy in manufacturing processes requiring ovens or kilns and therefore fuels, in which case the quality of the heat, access, and affordability of the fuels and efficiency of the ovens used all affect the final product (from bread to bricks). Other productive processes require motors, machines, or other tools that often use liquid fuels (such as petrol for motors) or electricity (for sewing machines, welders, etc.) to power them. Table 2.9 illustrates various mechanical power technologies and applications that could help minimize the amount of human energy spent on different productive activities.

In addition to production activities in which energy and machines are applied to raw materials and other inputs to produce final products, service industries also require energy as inputs. This includes telephones, computers, other information technology, or air conditioners, specialized equipment, or security systems – all of which consume electricity.

In short, from the simplest manufacturing industries to the most complex technology-intensive ones, energy – whether electricity or fuels – is an essential input. It therefore would seem obvious that there is a link between energy and the development objectives of achieving full and productive employment and decent work for all. Yet while many countries have active programs to promote employment through workers' training or other skills-building activities, sources of energy for machines or financing schemes to get access to the energy-using equipment itself is often not part of the job creation agenda.

Many working conditions, especially for the poorest people, are hazardous or life-threatening. In countries where a work-related injury can greatly reduce the economic conditions of entire families due their vulnerability to a range of factors beyond their control (food and fuel price rises, access to affordable housing, increases in education or health service fees), access to decent work is a key determinant of the ability of people, communities, and entire countries to overcome conditions of poverty. Cleaner energy options can enhance working conditions and open opportunities to generate livelihoods, increase the number of jobs, and provide decent work for entire populations are directly related to access to energy services for value-adding processes, whether this be in manufacturing, the services sector, government, or social services (Modi et al., 2006; UN-Energy, 2005).

Employment in formal and non-formal sector activities is positively correlated to access to cleaner energy options such as electricity, as is workers' productivity in value-adding processes. In addition, increased access to cleaner energy contributes to the transformation of economies from being agriculture-based – where significant animate energy is consumed – to industry-based, where cleaner energy plays a key role in the production of commodities. Figure 2.11 illustrates that economies with relatively high cleaner energy use (due to high access levels) have lower contributions of agriculture to the GDP implying that reliance on agriculture is inversely proportional to cleaner energy use as more non-agricultural industries are established contributing to economic development. Conversely, economies with very low cleaner energy use show relatively high levels of contribution of agriculture to GDP, as their industrial sector is not developed, in part, due to an inadequate supply of cleaner energy options (Modi et al., 2006; UN-Energy, 2005; UNDP, 2005).

3 Electricity represents the highest rung on the 'energy ladder' and produces different energy services than fuels.

Table 2.9 | Mechanical power technologies and applications.

Activity	Service	Traditional technology	Mechanical power alternative
Water supply	Drinking	Container (bucket) for lifting/carrying water	Diesel pump Treadle pump Rope pump Ram pump Persian wheel Hand pump River turbine Wind pump
	Irrigation		
	Livestock watering		
Agriculture	Tillage/plowing	Animal-drawn tiller/hand hoe	Power tiller/ two-wheel tractor
	Harvesting	Scythe Animal-drawn mower Manual practices	Harvester
	Seeding	Hand planting	Bed planter Row planter Seed drill
Agro-processing	Milling/Pressing	Hand ground/Flail	Powered mill Oil expellers
	Cutting/Shredding	Knife	Sawmills Powered shredder
	Winnowing/Decorticating	Winnowing basket	Powered shaker Grinder
	Spinning	Manual spin	Powered spinner
	Drying	Handheld fan Sun drying	Powered fan Solar dryer
Natural resource extraction	Small-scale mining	Shovel Chisel Hammer Pickax	Manual percussion drill Petrol-powered drill Expandable tube with hydraulic pump
		Hand washing	Hand /fuel/water-powered water jet
		Hand screen	Hand/fuel/water-powered shaker
	Lumbering	Hand saw	Powered saw (saw mill, chain saw)
Small-scale manufacturing	Metal working	Hammer	Sheet metal/pipe bender Hole puncher
	Woodworking/Carpentry	Hand saw	Sawmill Treadle lathe
	Briquetting/brick pressing	None	Hand/foot-powered pressers
	Textile making	Hand-woven	Treadle loom
	Papermaking	Mould and deckle	Paper press Pulp mill
	Pottery	Hand powered potter's wheel	Treadle pottery's wheel
Lifting and crossing	Lifting	Manual labor (climbing, lifting)	Chain/rope hoist
	Crossing	Manual labor (swimming, walking)	Gravity ropeway Tuin (aerial tramway in Himalaya)

Source: adapted from Bates et al., 2009.

In the countries with the least access to electricity countrywide, or in specific geographic areas within national borders that have limited electricity access or an unreliable supply, limits to productive employment and income generation are also likely to be present. The cost, reliability, and ease of access to energy services are also factors in creating conditions for jobs creation, production, and decent work.

For example, lack of reliable electricity supply in sub-Saharan Africa has significant impacts on job security, especially among casual laborers in industry. On annual basis, cumulative time of electrical supply interruptions is equivalent to about three months of production time lost (IEA, 2010a), a significant duration that implies little or no production, thereby risking loss of jobs. In addition, it is estimated that businesses lose production worth 6.1% of their turnover due to electrical outages (IEA, 2010a). Table 2.10 summarizes the reliability of electricity supply in sub-Saharan Africa and developing countries in general.

At the macroeconomic level, lack of a reliable supply of electricity is estimated to have a significant impact on economic growth and productivity. Figure 2.12 shows the proportion of GDP lost to unreliable electricity supply in some countries in sub-Saharan Africa.

Table 2.10 | Summary of electricity supply reliability in sub-Saharan Africa and developing countries.

Indicator	Sub-Saharan Africa	Developing Countries
Cumulative electrical interruptions (days/year)	90.9	28.7
Lost Production (% of turnover)	6.1	4.4
Firms owning/sharing generators (% of total)	47.5	31.8
Number of days for new electrical connection	79.9	27.5

Source: World Bank & IBRD, 2008.

Access to modern and affordable forms of energy options is essential for creating employment, thereby contributing to a reduction in poverty levels. According to a survey of a rural Indian village by Hiremath and

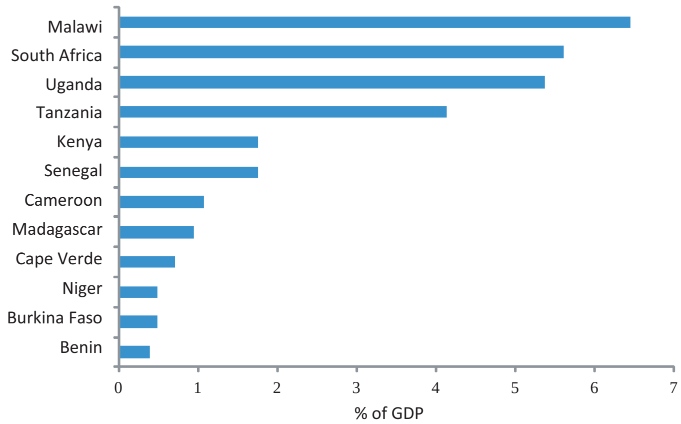

Figure 2.12 | Proportion of GDP lost due to unreliable power supply in 2007. Source: Vivien and Briceno-Garmendia, 2010.

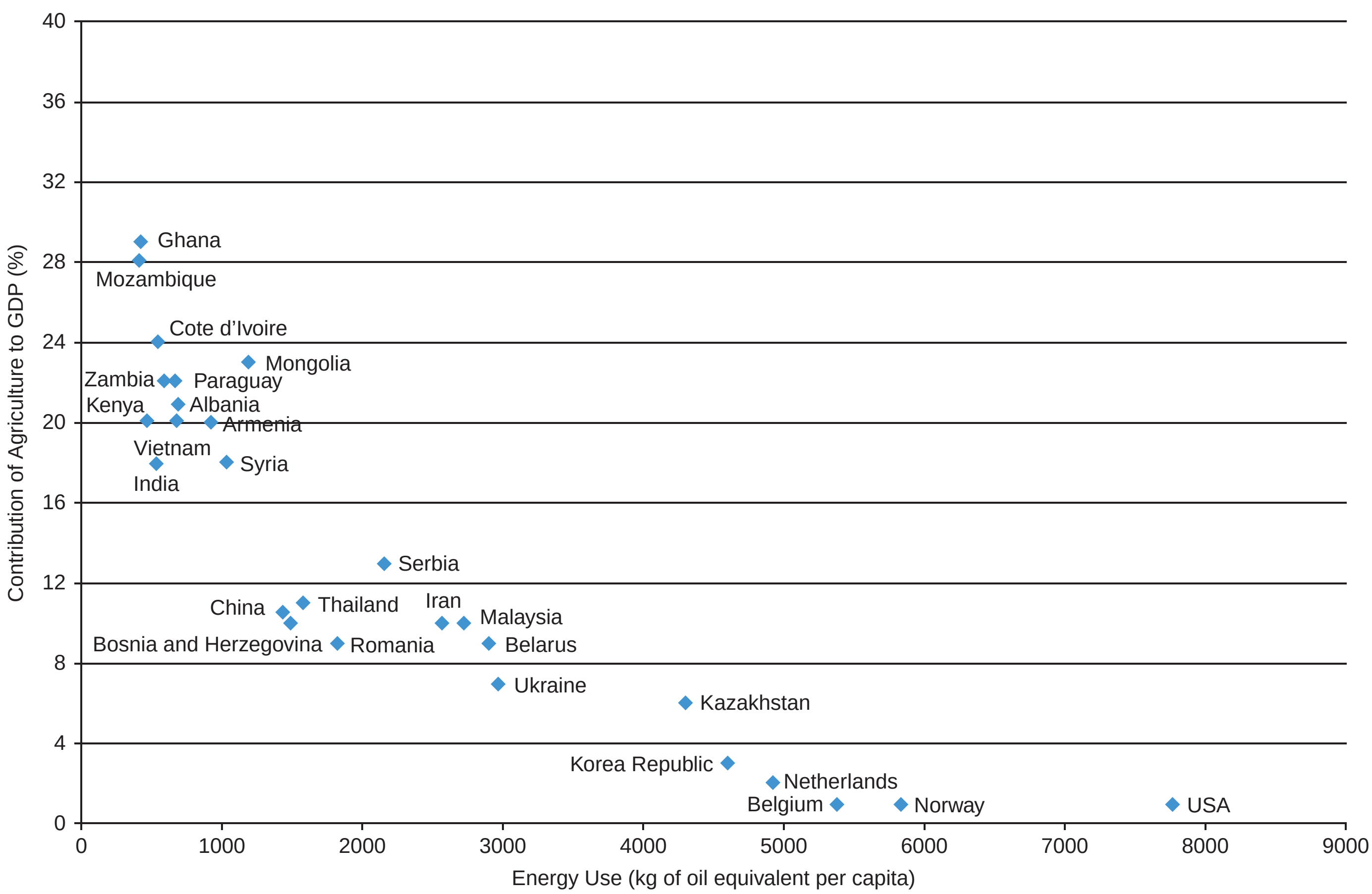

Figure 2.11 | Correlation between cleaner and modern forms of energy use and contribution of agriculture to GDP, 2007. Source: adapted from World Bank, 2011a.

Misra (2009), modern forms of bioenergy systems can create opportunities for 25–45 jobs in one village alone. The jobs would arise from developing forests for feedstock, preparing wood feedstock, collecting cattle dung or leaves, operating and maintaining biogas/gasifier systems, etc., as well as the operation, repair, and maintenance of associated equipment such as generators, pumps, flour mills, diesel engines, and domestic appliances.

World Bank studies in Asia have attempted to quantify the benefits of rural electrification. For example, a survey in Bangladesh revealed that rural electrification could lead to an increase of income in the range of 9–30% (Khandker et al., 2009). The value of benefits of rural electrification accrued by households in the Philippines is shown in Table 2.11 (World Bank, 2008b), which are substantial in comparison to Philippine's per capita GDP of US$146 in 2009.

Thus although the presence of electricity or fuels does not, on its own, guarantee full employment or enough value-adding jobs to ensure decent work and poverty elimination, access to electricity and fuels for formal and informal sector work expands the range of employment options in both urban and rural areas, with the most dramatic effects being seen in the countryside. This is not because of the electricity or the fuel itself but because of the expansion in the range of services for manufacturing, communication, mechanical power, and illumination that they provide.

Prioritizing access to electricity and energy-using technology for commercial activities (as opposed to only low-load household activities) could increase employment opportunities that can contribute to income generation and the fight against poverty, especially for the working poor.

2.5 Energy and Agriculture

Most of the caloric intake of the poorest people worldwide comes from basic grains such as rice, corn, millets, and wheat. In all cases not only do basic grains need to be cooked to be consumed, which requires heat energy, but their very production, harvest, and processing require energy inputs for cultivation, irrigation, transport, and, for some foodstuffs, preservation.

Table 2.11 | Quantifying electrification benefits for typical households in rural Philippines.

Benefits	Value of benefits (US$/month)	Beneficiary
Less expensive and expanded use of lighting	36.6	Household
Less expensive and expanded use of radio and television	19.6	Household
Improved returns on education and wage income	37.1	Wage earner
Time savings for household chores	24.5	Household
Improved productivity of existing home business	34.0	Business
Productivity of new home business	75.0	Business

Source: adapted from World Bank, 2008b.

By facilitating irrigation, cleaner and affordable energy options can help ensure food security among the poor in spite of increasingly frequent drought conditions in many countries. As shown in Table 2.12, irrigation is still an embryonic practice in sub-Saharan African countries but it is widely practiced in Asia (FAO, 2011). Most of the Asian countries represented in Table 2.12 source more than half of their grain production from irrigated land. In comparison, in most of sub-Saharan African countries, grain production from irrigated land accounts for around 20% or less (FAO, 2011).

Energy can play a vital role in enhancing food security among the poor through technologies that can be used for irrigation and water pumping. Energy for mechanical power (water pumping or distribution) can come from grid-connected electricity, local motors using fuels, or renewable-energy-derived water-lifting devices.

Some irrigation and water pumping technologies have significant potential for not only ensuring food supply throughout the year but also generating additional income for households (Karekezi et al., 2005). Table 2.13 provides estimates of the initial investment required to buy and install various irrigation or water pumping technologies. However, where farmers are supplied with excessively subsidized or extremely low-cost electricity there are possibilities of misusing it, for example by use

Table 2.12 | Proportion of grain production from irrigated land (%).

Country	%
ASIA	
Japan	98.0
Vietnam	94.5
Tajikistan	84.5
Malaysia	70.0
China	67.0
Uzbekistan	61.5
India	56.0
Bangladesh	47.0
AFRICA	
Madagascar	67.0
Namibia	43.9
Mali	22.4
Gambia	19.6
Nigeria	14.2
Burkina Faso	3.2
Botswana	2.6
Malawi	2.0
Mozambique	2.0

Source: FAO, 2011.

Table 2.13 | Initial investment and specific cost of irrigation water, various technologies.

Component	Treadle pumps[4]	Hydrams (hydraulic ram pumps)	Wind pump	Diesel pump
Cost + installation (US$)	171	295	2981	2,000
Lifetime (years)	6	40	20	10
Rate of discharge (m^3/hour)	4.3	4.5	7.5	10.0
Specific cost of water (US$/$m^3$/year)	0.03	0.05	0.29	0.18

Note: The costs in the table assume that the requisite renewable energy resources are available at the site where the pump is located and also that the water source is within a reasonable distance for the pump to operate at its optimum.

Source: Karekezi et al., 2005; Karekezi et al., 2008a.

of inefficient pumps, which leads to increased electricity consumption as well as wasteful use of water which can lower water table levels.

As Table 2.13 indicates, not all technologies may be affordable to poor households due to high upfront cost. However, the treadle pump appears to have the least upfront cost and is likely to be the most attractive option for the poor. This technology – widely used in Asia and parts of sub-Saharan Africa – is reportedly very effective in enhancing food production.

Many sub-Saharan African farmers are still irrigating very small plots of land using bucket-lifting technologies, which are slow, cumbersome, and labor-intensive, especially for women. Small-scale irrigation is usually developed privately by farmers in response to family and local market requirements, often with limited government interventions.

Small-scale irrigation using treadle pumps is one of the success stories in many countries in Africa at a time when large-scale water developments have failed to meet expectations. Case studies from Kenya, Niger, Zambia, and Zimbabwe show that by using animate energy-driven treadle pumps instead of bucket irrigation, farmers can increase irrigated land, reduce work time, improve crop quality, grow new crops, and increase the number of cropping cycles (AFREPREN/FWD, 2006b). Treadle pumps make it easier for farmers, especially women, to retrieve water for their fields or vegetable gardens, and they are cheap and easy to handle. Treadle pump technology has enabled poor rural farmers, especially women, to increase their incomes by selling surplus produce in the local market.

In some cases, cropping intensity has been extended to three crops per year. In Zimbabwe, treadle pumps are mostly used for irrigation of small vegetable gardens. And because these pumps usually reach water only within five meters, they do not deplete valuable groundwater resources. It is noted that the local water table would drop only if a large number of farmers were operating in the same area.

In Kenya, treadle pumps were introduced in 1991 and have generated a wide range of benefits for users, manufacturers, promoters, and retailers. The low-income owners in Kenya purchase them mainly through their savings as well as from the sale of crops and livestock and use of retirement benefits. While men own 84% of the treadle pumps, women manage nearly three-quarters of them, which are mainly used for irrigating crops and to some extent for supplying water for household use and animals (Karekezi et al., 2005).

According to available data, the areas under irrigation increased among users by 700% from an average of 0.03–0.24 ha in 1999 to 0.59 ha in 2004 (Karekezi et al., 2005). For farmers not involved in irrigation previously, the number of crop cycles increased from 1.2 to an average of 2.3. One advantage associated with an increased number of crop cycles is the timing of cropping, in order to harvest when the crop fetches higher prices from the market.

If pumps are produced locally, they can also create jobs and income – the pumps cost less than US_{2005}\$200 and can be built with ordinary workshop equipment (AFREPREN/FWD, 2006b). Some 186,804 pumps are reported to have been sold across West, East, and Southern Africa since 1991 (Kickstart, 2011).

Wind pumping technologies can supply water for irrigation as well as for household use and livestock (Harries, 2002). The wind speeds in most regions (even in sub-Saharan Africa, which is located in a generally low wind-speed zone that straddles the equator) are sufficient for windpumps. In sub-Saharan Africa, South Africa and Namibia possess large numbers of wind pumps. An estimated 400,000 wind pumps are in operation in South Africa (Karekezi et al., 2009) and are believed to have played a major role in the past in supporting irrigated agriculture and transforming South Africa into a food-surplus country.

Another key area in which better energy options can help combat hunger is post-harvest losses. These are related to inadequate facilities for food harvest, storage, and transport; a lack of conversion technologies to preserve or otherwise extend the life of food products; and the lack of protection from pests, disease, and other threats to the quality and quantity to harvested food products.

FAO estimates that post harvest losses among food grains in developing countries account for 15–50 % (FAO, 2009). However, more alarming are the post-harvest losses of fruits and vegetables (such as tomatoes, bananas, and citrus fruit) as well as of sweet potatoes and plantains, which can be as high as 50% (Farm Radio International, 2006a). It is also estimated that between 20% and 50% of the fish caught in Africa are lost after capture (Farm Radio International 2006b).

The impact of high post-harvest losses on the poor is twofold: first, it implies that less nutritious food is available, which exposes the poor to undernourishment. Second, post-harvest losses equate lost potential income. This means that the poor end up with less income from the sale of food crops. In addition, lower income erodes any potential cushioning

4 A treadle pump is a human-muscle powered irrigation device.

Table 2.14 | Various options for low-cost options for minimizing post-harvest losses and the requisite energy inputs.

Fruit/vegetable	Post-harvest transformation	Type of energy inputs required
Most fruits & vegetables	Dried fruits and vegetables	Solar thermal using solar drier
African locust bean	Traditional mustard	Heat for cooking
Peanuts	Peanut butter	Heat for cooking and animate energy for grinding
Tomato	Tomato paste	Heat for cooking
Most fruits	Jams and sauces	Heat for cooking and sterilizing storage containers

Source: adapted from Farm Radio International, 2008.

against food price hikes as well as reduces poor people's ability to afford better-quality food.

Several modern, cleaner and affordable forms of energy options could reduce post-harvest losses of fruits and vegetables. One important technology directly linked to energy services is transportation, especially on-time transportation to get harvested foods to markets and processing centers. In rural areas with difficult terrain, the use of motorized transportation can be a significant challenge. Alternative and low-cost options for such areas include animate energy and the use of mechanical ropeways[5]. In parts of Nepal, ropeways have dramatically reduced transportation of farm produce from 3–4 hours to a mere five minutes (Bates et al., 2009).

Processing options involve transforming fruits and vegetables into other forms of foodstuff with longer life spans (see Table 2.14). Energy for cooking and drying (solar drying) is an important input for transforming fruits and vegetables into longer-lasting food products that can go on the shelf or to market, thereby extending consumers' access and increasing the income of small scale poor rural farmers. However, it is noteworthy that for more-sophisticated industrial-level food processing, during which food is transformed into high-value products such as canned food, a significant amount of modern forms of energy are required, such as electricity and steam. Due to the limited access to modern forms of energy in rural areas, where most food is grown, most advanced food processing plants in developing countries are located in urban areas, in some cases far away from where the crops are grown, thereby denying rural areas of employment opportunities.

Industrial-scale agricultural production, while in some cases providing less local employment, has also contributed to increasing overall food production. In the case of basic grains, the globalization of markets for rice, soya, wheat, maize, and other staples implies that the benefits of energy inputs in one country can benefit consumers in other countries due to global trading systems. Without exception, these systems have relied on energy inputs for fertilizer production, irrigation, harvesting, and the transport of their products.

Energy technologies required to increase food production and reduce post-harvest losses, can be produced locally, are relatively affordable, and in many cases may not require electricity to operate. For example, pico and micro hydro for shaft power can be used to process agricultural produce and increase its value for a prolonged period, thereby improving food security. Low-cost efficient hand tools and animal-drawn implements can increase the agricultural productivity of rural areas in the developing world.

In conclusion, access to more efficient, cleaner and affordable energy options is an effective tool for combating extreme hunger by increasing food productivity and reducing post-harvest losses.

2.6 Energy and Transport

Mobility is an essential requirement that ensures the delivery of goods and services. For the poor, it is an essential factor in providing options for employment, production, and livelihoods. The more limited the transport options, often due to lack of access to energy, the more limited the livelihood options.

In recent years, the high cost of motorized transport due to rising oil prices is a major challenge, especially for the poor in developing countries who need to transport to take their agricultural produce to the market and to take up employment.

In rural areas, poor road conditions and networks limit the availability of motorized transport. Consequently, in some rural areas of sub-Saharan Africa, Asia, and Latin America, people walk 10 kilometers a day one way to attend to their chores (e.g., fuelwood or water collection, farm work) as well as attend school or visit health facilities (See Chapter 9).

In urban areas, the high cost of public transport has a negative impact on the poor. Table 2.15 shows the proportion of income spent by the poor on motorized transport in selected cities.

In poorer parts of the developing world, particularly sub-Saharan Africa and some parts of Asia, the urban poor cannot afford motorized transport and largely rely on walking. The relatively high cost of motorized transport for the urban poor is partially linked to the limited attention

Table 2.15 | Proportion of urban poor's income spent on motorized transport in four cities.

City	Share of income spent on motorized transport (%)
Colombo	21
Mumbai	15
Manila	14
São Paulo	8

Source: Chapter 9; Gomide, 2008; Kumarage, 2007; Baker et al., 2005.

5 A ropeway is a form of lifting device used to transport light goods across rivers or ravines.

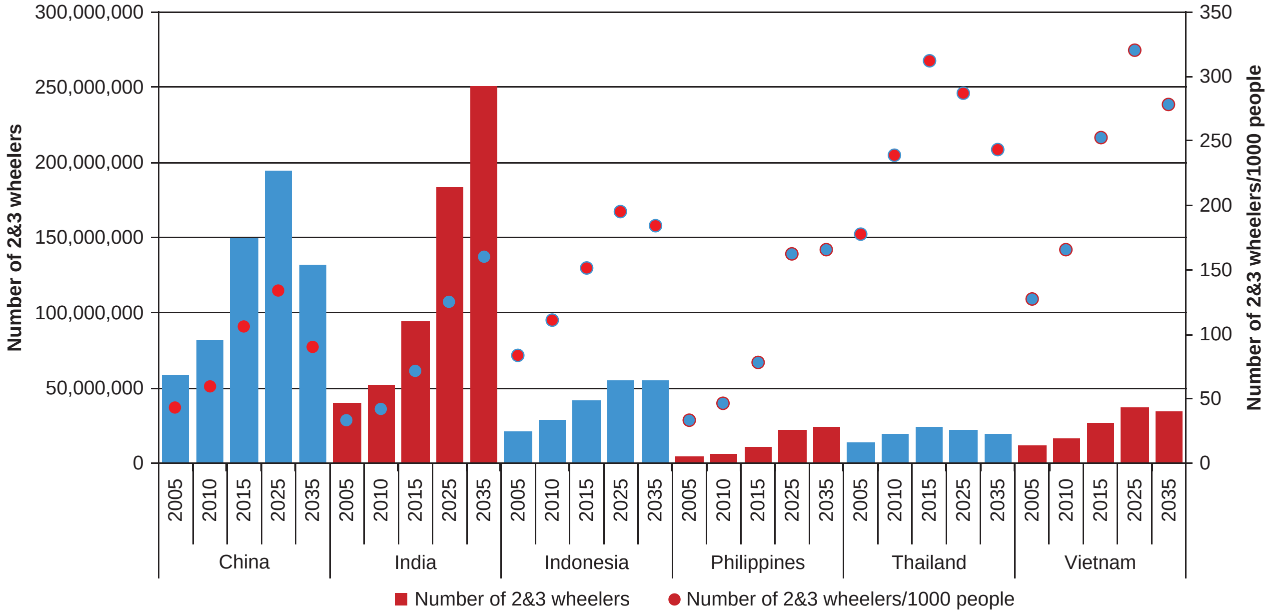

Figure 2.13 | Population of 2 and 3-wheelers in selected Asian countries[6]. Source: CAI-Asia, 2011.

being paid to the development of energy-efficient non-motorized transport options and of low-cost efficient mass transit systems in cities of developing countries. Most road network systems and infrastructure in these cities appear to favor the convenience of private motorized transport, although most people use either non-motorized transport or motorized public transport.

In the cities, the increased demand for low-cost motorized transport, especially for short trips, has led to a sharp increase of two- and three-wheelers in developing countries, especially in Asia (see Figure 2.13). In Asia more than two-thirds of the total vehicle population consists of two- and three-wheelers in many countries (Hook and Nadal, 2011).

The relatively high uptake of two- and three-wheelers in developing countries is mainly linked to their low upfront cost compared with cars. In certain parts of the developing world, however, such as in sub-Saharan Africa, two- and three-wheelers have received a mixed reception. Among the poor in both urban and rural areas these vehicles are perceived as a lucrative source of employment as well as an affordable and convenient form of motorized transport. But in urban areas of sub-Saharan Africa, the high rates of fatal accidents linked to undisciplined driving and absence of dedicated lanes has discouraged use of 2 and 3-wheelers in many sub-Saharan African countries.

Low-cost energy-efficient transportation for both passengers and goods is crucial for economic development. This is particularly important for long-distance transit of passengers and goods. Rail transport is considered the least expensive energy-efficient land transport option for long-distance passenger travel and has been developed extensively in industrial countries in the form of surface and underground rail networks. For freight transportation, with the exception of India and China, many developing countries make limited use of lower-cost energy-efficient rail transport mainly due to its lack of sustained investment.

6 In Asian cities 2 and 3-wheelers account for 50–90% of total vehicle fleet.

2.7 Energy and Education

While basic educational services and basic literacy can be achieved without the use of cleaner energy inputs, access to energy services can improve the quality and availability of educational services and increase the likelihood that children will attend and complete school (IEA, 2010a; UNDP, 2005; UN-Energy, 2005).

Global education goals place emphasis on the primary education due to its long-lasting impact on literacy and social inclusion. According to recent estimates of the World Bank (2010a), about 50 developing countries have already achieved the goal of universal primary education. Although seven others are likely to attain the goal by 2015, nearly 40 developing countries, mostly in sub-Saharan Africa, are very unlikely to achieve universal primary education by 2015 (World Bank, 2010a). This is clearly indicated in Figure 2.14. Sub-Saharan Africa has the highest proportion of countries seriously off track in making progress toward universal primary education.

Modern, cleaner and affordable energy options can help create a more child-friendly environment that encourages school attendance and reduces the significant dropout rates experienced in many low-income countries (Mapako, 2010; UNEP, undated). For example, cleaner and affordable energy can enhance access to clean water, sanitation,

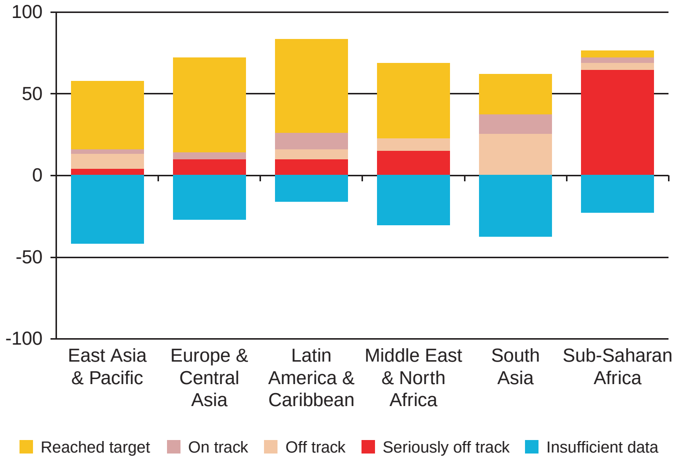

Figure 2.14 | Status of progress (%) on achieving universal primary education. Source: World Bank, 2010a.

lighting, space heating/cooling, and energy for cooking lunch (and other meals in the case of boarding schools).

There is growing evidence of the positive impact of rural electrification (particularly grid extension to rural schools) on the retention of the math and science teachers who are much sought after in rural areas. When the general quality of life increases due to the rural electrification, teachers are willing to relocate to rural schools thus mitigating the problem of shortage of teachers in rural areas (AllAfrica, 2004; Cabraal et al., 2005; World Bank, 2008a; Harsdorff and Peters, 2010).

Electricity can facilitate access to educational media and communications in schools and in homes. It can increase use of distance-learning modules. Access to electricity provides the opportunity to use more sophisticated equipment for teaching (such as overhead projectors, computers, printers, photocopiers, and science equipment), which allows wider access to more-specialized teaching materials and courses (Mapako, 2010).

In addition, cleaner energy systems and efficiently designed buildings reduce heating/cooling costs and thus school fees thus increasing the poor's access to education. As discussed in more detail in Chapter 6, education is the key for higher world economic growth. Education is a long-term investment associated with near-term costs, but in the long-term it is arguably one of the best investments societies can make for their future.

One of the indicators for monitoring progress in universal primary education is the proportion of pupils who start grade one and reach the last grade of primary school. Often children, especially girls, face family pressure to contribute to household energy supplies through the collection of wood and other fuels and of water for home heating and cooking purposes. Access to cleaner fuels, efficient stoves, and alternative fuelwood management practices can reduce fuel collection times significantly, which can translate into increased time for education of rural children.

Table 2.16 | Impact of rural electrification on children's study time in Bhutan (number of children).

Electrification status	Study hours of children in the evenings			Total (children)
	< 1 hour	1–2 hours	>2 hours	
Electrified	67	23	21	111
Non-electrified	71	32	7	110
Total (children)	138	55	28	221

Source: Bhandari, 2006.

When families make the hard decision as to which children to keep home from school to help with such activities as fuel and water fetching and basic cooking and cleaning, preference is often given to boys' education over that for girls, whose traditional roles mean these tasks fall disproportionately on them and they are withdrawn from school before completing the full primary cycle (UNDP, 2004). (See also Section 2.10 on Energy and Women.)

When girls who do go to school help their mothers in the kitchen, they lose valuable study time (Mapako, 2010). In addition, inhalation of kitchen smoke exposes them to illnesses associated with the respiratory system, which can lead to significant school absenteeism from poor health. Cleaner energy options, especially in rural areas, can free up time for girls to study and improve their academic performance.

For both boys and girls, modern energy options can provide quality lighting for comfortable night-time studying (Mapako, 2010). A study in Bhutan found that with modern forms of energy options such as electricity, children can study much later in the evening (see Table 2.16). In addition, good lighting reduces risks to children's eyesight (WHO, 2011a). In many rural areas of the developing world, energy for transportation is also essential if children are to reach schools that are beyond walking distance.

One of the suitable ways to enhance access to cleaner and affordable energy in schools and other institutions of learning is to piggy-back on existing school-related programs. For example, the World Food Programme has introduced "school feeding" initiatives in many developing countries. These focus on poverty-stricken areas as a means of encouraging primary school attendance through the incentive of onsite meals, thus combating malnutrition among the poor (WFP, 2010). Use of improved biomass stoves in the school feeding initiatives reduces cost as well as provides live demonstrations of improved cookstoves and encourages local people to adopt cleaner and more-efficient stoves.

To sum up, access to cleaner and affordable energy options can contribute to achieving universal primary education as well as enhance the quality of education (Meisen and Akin, 2008; Mapako, 2010; Harsdorff and Peters, 2010):

- Providing improved cookstoves that reduce the cost of school feeding programs, which is instrumental in maintaining high attendance levels in rural primary schools;

- Helping to create a more child-friendly environment (access to clean water, sanitation, lighting, and space heating or cooling), thus improving attendance at school and reducing dropout rates;
- Introducing cleaner energy systems and efficient building design that reduce heating/cooling costs and thus school fees which, in turn, expands the poor's access to education;
- Retaining qualified teachers in rural areas by providing electricity for their residences;
- Providing the opportunity to use advanced teaching aids and equipment (overhead projector, computer, and science equipment);
- Enabling access to educational media and communication in schools and at home, hence increasing education opportunities and allow distance learning;
- Allowing children to study after school hours, which can have a significant impact on learning outcomes; and
- Saving girls' time doing household chores, thereby giving them time to study at home and also attend school.

2.8 Energy and Health

Modern health services, the facilities to provide them, and the professional and health sector workers who deliver them require access to energy options in the form of electricity and cleaner and affordable fuels for both institutional and household use. Detailed energy-related health issues are covered in greater depth in Chapter 4.

Public expenditures on health care provision in developing countries have typically been low. When public-sector spending on health services increases, urban and peri-urban areas are often been given priority, leaving the rural poor with inadequate health care options that are distant and of poor quality as well as often unaffordable. Access to health care services varies based not only on the rural-urban divide but also on the income bracket of the people and families in question.

From a human development point of view, the most grievous negative health effects are loss of life, especially among the youngest and most vulnerable, as well as shortened life spans due to poor overall living conditions. Global efforts have prioritized reducing infant mortality in recent years. While deaths of children below the age of five dropped in developing countries by more than 25% between 1990 and 2008, the absolute number of children dying before age five increased (UN, 2010a; World Bank 2010a). Sub-Saharan Africa appears to have made the least progress in terms of reducing child mortality (see Figure 2.15) with one child in seven there dying before the age of five (World Bank, 2010a).

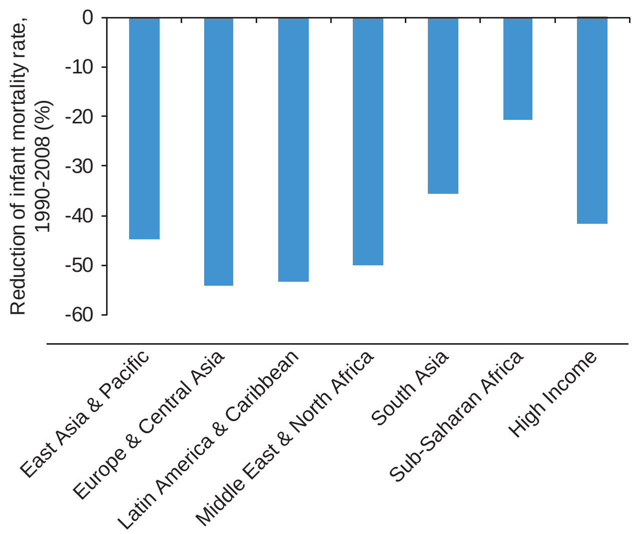

Figure 2.15 | Reduction of infant mortality rate. Source: World Bank, 2010a.

The leading causes of under-five child mortality worldwide (after neonatal causes) are diarrhea and pneumonia (14% each), both of which can be directly linked to inadequate access to cleaner and affordable energy options (UN 2010a).

In the case of waterborne diseases such as diarrhea that has a particularly detrimental impact on children's health, the contributing factors that are energy-related include lack of pumping systems from clean water sources, lack of energy or fuels to boil water, and lack of industrial processes for water treatment and purification.

Pneumonia cases among children under the age of five from poor households are mainly linked to household air pollution due to reliance on traditional biomass for cooking (WHO, 2006). The inefficient burning of solid fuels in an open fire or traditional stove indoors creates a dangerous cocktail of hundreds of pollutants, primarily carbon monoxide and small particles, but also nitrogen oxides, benzene, butadiene, formaldehyde, polyaromatic hydrocarbons, and many other health-damaging chemicals. Day in and day out, for hours at a time, women and small children breathe in amounts of smoke equivalent to consuming two packs of cigarettes per day. Where coal is used, additional contaminants such as sulfur, arsenic, and fluorine may also be present in the air – see Chapter 4 for a more detailed assessment of the health impacts of using solid fuels.

As shown in Figure 2.16, the prevalence of tuberculosis is highest in developing countries that predominantly use traditional biomass energy for cooking. As noted earlier, modern, cleaner and affordable energy options for cooking can play a significant role in reducing acute respiratory infections such as tuberculosis by improving the kitchen environment where women and infants spend a significant amount of time (WHO, 2006; see also Chapter 4). Examples of energy options

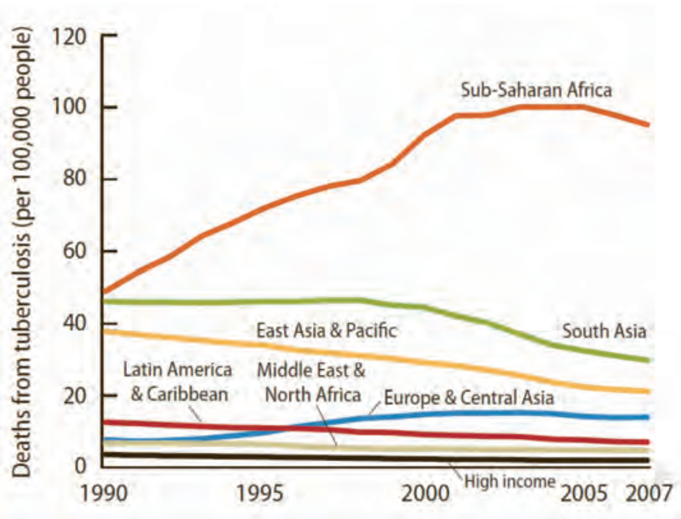

Figure 2.16 | Tuberculosis prevalence by region. Source: WHO, 2011b.

that could replace the traditional biomass energy for cooking include improved fuelwood and charcoal cookstoves, kerosene, LPG, ethanol, and biogas.

The quality of the medical care available in health care institutions can be determined by access to energy services. Examples include electricity for illumination and communication, to power diagnostic machines and provide refrigeration for medicines, fuels for hot water and sterilization processes to maintain sanitary conditions, and fuels to provide space heating or cooking.

One of the critical moments in a person's life for access to health care facilities is during pregnancy and birth. Every year, hundreds of thousands of women die from complications related to pregnancy or childbirth, most of which are preventable. About 99 percent of these deaths occur in developing countries. Indeed, childbirth and complications during childbirth are still the leading cause of death among women aged 20 to 45 in developing countries (UNFPA, 2005). In some areas, one in every seven pregnant women dies in childbirth (WHO, 2008).

Access to health care in the first trimester of pregnancy and having doctors attend births is directly correlated with improved maternal health and reduced infant mortality (UNFPA, 2009). In rural areas of sub-Sahara Africa, women often deliver without skilled care. About a third of maternal deaths are due to hemorrhage that could be stopped by skilled medical personnel.

Many complications associated with pregnancy can be detected and rectified early with the use of advanced technologies such as ultrasound equipment, which needs a reliable source of electrical power. The absence of electricity in rural areas denies rural women such essential health services. Thus both directly (through support the provision of health services) and indirectly (by removing barriers to attracting medical personnel), access to electricity in rural areas can contribute to averting needless maternal deaths.

In some sub-Saharan African countries, life expectancy has actually reverted to below 1970 levels over the last two decades. Largely due to deaths from Human Immunodeficiency Virus /Acquired Immune Deficiency Syndrome (HIV/AIDS), this is the case in the Democratic Republic of Congo, Lesotho, South Africa, Swaziland, Zambia, and Zimbabwe (UNDP, 2010). The HIV pandemic appears to be disproportionately affecting women, tragically highlighted by the phenomenon of AIDS orphans being raised by grandmothers – a common occurrence in many parts of sub-Saharan Africa (UN, 2011a). Although the global spread of HIV has finally begun to slow worldwide, combating this global pandemic requires energy services in a variety of applications. For example, safe disposal of used hypodermic syringes by incineration prevents re-use and the potential further spread of HIV/AIDS.

Education, prevention, condom use, and reproductive health services for women and men are key ingredients to combating new AIDS infections. These require communication campaigns, distribution routes for condoms, and health workers to reach at-risk populations, all of which benefit from energy services in terms of transportation and communication. When HIV infections occur, quality of life and longevity are directly related to access to medical services, anti-retroviral drugs, and overall health maintenance, including good nutrition. Clean energy options for the poor can contribute to improving access to health services and ensure better nutrition.

The challenging nexus of energy, poverty, and health can also be found in industrial countries. The symptoms of energy problems of the poor in richer industrialized economies include high levels of debt to the energy utilities, disconnections from supply because of debt, cold homes in winter, and an increase of cold-related ill health and death. During hot weather periods, energy is needed to power fans and home conditioning. Inadequate access can lead to increased ill health and death of elderly people. The 2003 heat wave in Western Europe led to 35,000 deaths (Bhattacharya, 2003).

A concerted international effort to meet the globally agreed development goals related to human health is starting to make inroads, but more resources need to be allocated to cleaner low-cost energy options for powering for pro-poor health services.

To sum up, there are several health-related benefits associated with access to modern, cleaner and affordable energy options. Electricity in health centers allows the provision of medical services at night, greater use of more advanced medical equipment as well as helps retain qualified staff in rural health centers. Energy for refrigeration can facilitate vaccination and medicine storage for the prevention and treatment of diseases and infections. Energy is needed to generate and maintain basic sanitary conditions to support health services. Finally, energy is needed to develop, manufacture, and distribute drugs, medicines, and vaccinations as well as to provide access to health education media through information and communications technologies.

2.9 Energy and Water

Sanitation and access to improved water in developing nations are key environmental concerns of the poor. Recent estimates indicate that about 1.2 billion people lack access to safe water (IAEA, 2007; UN Women, 2011) and about 2.6 billion people lack access to toilets, latrines, and other forms of improved sanitation in developing countries (UN, 2011). Progress has been slowest in South Asia and sub-Saharan Africa. To halve the proportion of people without basic sanitation by 2015, more than 1.3 billion people would have to gain access to an improved facility (World Bank, 2010a).

On the positive side, rapid progress is being made in improving access to safe water, especially in East Asia, where access to drinking water increased by 30% between 1990 and 2008 (UN, 2010a) to reach 89% of the population. Access to safe water in Latin America in 2008 reached 93%, while for developing countries as a whole the figure was 84% (UN, 2010a). These encouraging indicators of progress are marred by the appalling situation in sub-Saharan Africa where only 48% of rural households have access to piped clean water (World Bank, 2011a).

The higher safe water access that characterize richer developing countries hide a continuing rural-urban divide. Figure 2.17 compares access to improved water supply in rural and urban areas in selected developing countries. In most developing countries, a much larger proportion of the urban population enjoys access to improved sources of water (which includes household piped water connection, public standpipe, borehole, protected well or spring, and rainwater collection).

Inadequate supplies of safe water and poor sanitation, particularly in rural areas accounts for nearly 80% of all illnesses in developing countries (BPN, 2010). In addition, patients with waterborne ailments account for half of the people in hospital beds (TWP, 2010; BPN, 2010). Some of these ailments include cholera, typhus, and dysentery, which account for an annual death toll of 1.6 million deaths (SODIS, 2010b).

Access to water is key to not only improved health but also to increased agricultural output through irrigation

Lack of sanitation facilities in many developing countries contributes to a loss of a sense of dignity, especially among the poor. Inadequate access to sanitation has a disproportionate large impact on women and girls, especially during menstruation. Lack of adequate sanitation in schools in many developing countries has been reported as a key contributor to absenteeism and even school dropouts among one in ten girls at the puberty stage (IMW, 2008; WaterAid, 2009).

Access to modern and affordable forms of energy can play a vital role in improving access to safe water and sanitation in developing countries. Some of the energy solutions available are very low-cost and do not require electricity or fossil fuels. For example, solar water disinfection (SODIS) only requires a clear glass or plastic polyethylene terephthalate bottle, which is filled with water and placed on the roof in the sun for at least six hours to eliminate most disease-causing pathogens (Wegelin and Sommer, 1997; EAWAG/SANDEC, 2002; Foran, 2007; SODIS, 2010a).

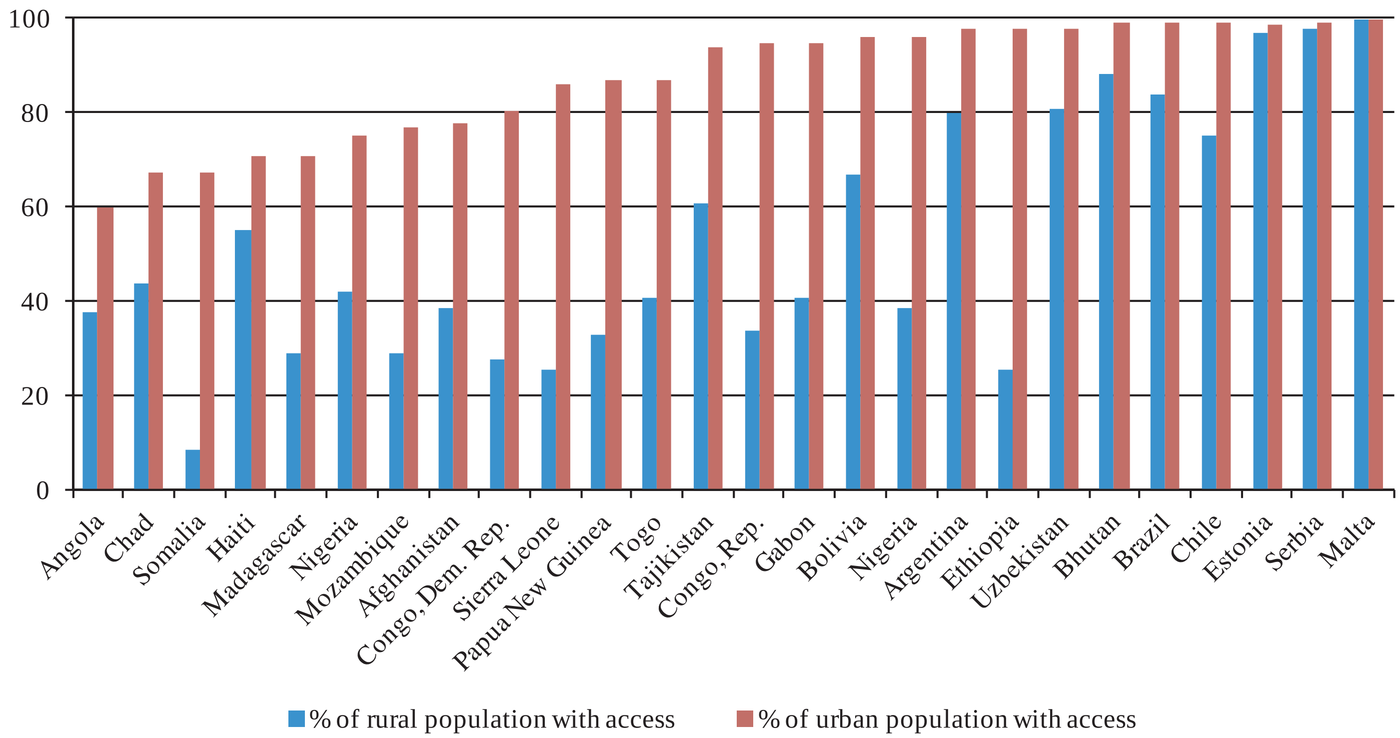

Figure 2.17 | Access to improved sources of water (%), selected developing countries, 2008. Source: adapted from World Bank, 2011a.

Table 2.17 | Scientific results of solar water disinfection technology.

Bacteria	Disease caused by bacteria	Reduction with SODIS method (6h, 40°C)
Escherichia coli	Indicator for water quality & enteritis	99.999%
Vibrio cholera	Cholera	99.999%
Salmonella species	Typhus	99.999%
Shigella flexneri	Dysentery	99.999%
Campylobacter jejuni	Dysentery	99.999%
Yersinia enterocolitica	Diarrhea	99.999%
Virus	**Disease caused by virus**	**Reduction with SODIS method (6h, 40°C)**
Rotavirus	Diarrhea, dysentery	90%
Polio virus	Polio	99.99%
Hepatitis virus	Hepatitis	Reports from users
Parasites	**Disease caused by parasite**	**Reduction with SODIS method (6h, 40°C)**
Giardia species	Giardiasis	Cysts rendered inactive
Cryptosporidium species	Cryptosporidiasis	Cysts rendered inactive after >10h exposure
Amoeba species	Amibiasis	Not rendered inactive Water temperature must be above 50 °C for at least 1h to render inactive

Notes: 1) The SODIS method needs relatively clear water. The source of the water (well, surface water) does not matter. 2) Relative levels of pathogens used in tests.

Source: SODIS, 2009.

As shown in table 2.17, through heat and ultraviolet radiation from the sun, SODIS can reduce diarrhea-related cases in developing countries by nearly 40% (Wegelin and Sommer, 1997; EAWAG/SANDEC, 2002; Foran, 2007; Heaselgrave et al., 2006; SODIS, 2010a).

Low-cost mechanical options can play an important role in ensuring access to safe water. For example, hand pumps and wind pumps are robust technologies that can dramatically expand access to safe water for domestic use as well as for irrigation and watering livestock. Hand-pumps and wind-pumps are well suited for rural areas as they are robust and their maintenance is relatively simple. The ease-of-maintenance of hand-pumps has been demonstrated in Uttar Pradesh, India, where women have successfully repaired hand pumps, thereby ensuring a continuous flow of clean water (WaterAid, 2009).

There are other cleaner energy options but somewhat higher-cost cleaner energy options that can address problems of sanitation and at the same time provide energy. For example, a biogas digester linked to a toilet can be an effective means of treating sewage (Karekezi and Ranja, 1997), while the methane gas produced can be used for heating applications such as cooking or running a genset[7] to produce electricity. This technology is widely used in Asian countries, especially in Bangladesh, Bhutan, China, India, Laos, Nepal, and Sri Lanka (SNV 2007).

Biogas technology can also be used to improve sanitary conditions in large institutions such as schools, hospitals, and prisons. In Africa, prisons in Rwanda and Kenya have used large-scale biogas plants resolve long-standing sanitation challenges (Ashden Awards for Sustainable Energy, 2005). The gas is used for cooking, thereby reducing woodfuel consumption by half. Similar applications, but at a smaller scale, have been reported in other African and Asian countries, where biogas technology has been adopted in schools and mainly used for cooking (Huba and Paul, 2007; AFREPREN/FWD, 2010).

The challenge of providing safe water and sanitation facilities is still immense particularly in sub-Saharan Africa where more than half the urban population lives in slums; a sizable part of the more than 825 million people living in urban dwellings without improved sources of drinking water and sanitation (World Bank, 2010a). Solar, wind, handpumps and biogas options can play an important role in enhanced access to safe water and sanitation in low-income peri-urban and urban of sub-Saharan Africa.

2.10 Energy and Women

Promoting gender equality and empowering women is an agreed national and global priority and is reflected in major global conferences and intergovernmental agreements on the need to enhance the status of women, including in economic and political life (CEDAW, 2011). In 1979, the UN General Assembly adopted the Convention on the Elimination of All Forms of Discrimination against Women to protect fundamental human rights and equality for women around the world (CEDAW, 2011).

Global studies indicate that a higher percentage of women than men live in poverty (UNECA, 2010). Gender-related studies of the poor in sub-Saharan Africa, parts of South Asia, and Latin America and the Caribbean demonstrate that poverty affects women and men differently, with women often experiencing the most severe levels of deprivation, in part, demonstrated by inadequate access to cleaner energy options (Karekezi et al., 2002).

Gender equality and empowering women are also important issues because they foster progress toward other development outcomes, such as reducing poverty, hunger, and disease and improving access to education and maternal health. Educational opportunities for girls have expanded since 1990. Enrollment patterns in upper-middle-income countries now resemble those in high-income countries, and those in lower-middle-income countries are nearing equity. However, gender gaps remain large in low-income countries, especially at the primary and secondary levels in sub-Saharan Africa (World Bank, 2010a).

Girls in poor households and rural areas are least likely to be enrolled in school. Cultural attitudes and practices also pose formidable obstacles

7 A "genset" is also known as an "engine-generator," which is a machine used to generate electricity.

to gender parity. Currently, 64 developing countries have achieved gender parity in primary schools and 21 others are on track to achieving the target. However, about 29 countries (more than two-thirds of them in sub-Saharan Africa) are seriously off track and unlikely to achieve parity by 2015 if current trends prevail (World Bank, 2010a).

Wider access to cleaner and affordable energy options can improve gender parity and school enrollment of girls. For example, access to cleaner energy options (electricity for lighting in schools and cleaner cooking fuels at home such as LPG) can extend studying hours for girls by reducing the time they spent collecting fuel. Access to pumped water can reduce the time that girls spend carrying water for household use.

Ensuring girls in developing countries are educated is important for their future life as mothers. Global evidence has shown that better-educated women will chose to have fewer children and have more access to family planning methods, while illiterate women overall are the least well able to gain access to health services and medical care at large (UNFPA, 2008; SIL International, 2011). The cycle of exclusion from education and literacy arising from preoccupation with household chores of collecting fuel, water, cooking, cleaning and looking after younger children can lead to early onset of reproduction and a higher risk for maternal health caused by frequent multiple pregnancies. According to Population Action International (2001), teenage mothers face twice the risk of dying from childbirth as women in their twenties. In addition, their children are more vulnerable to health risks.

Although most rural households use biomass, women in poor households will spend more time searching for firewood than those in households with higher incomes (Energia, 2008). In areas where there is decreased vegetation cover, women and children are required to walk longer distances to collect firewood (Ekouevi, 2001; Kammen et al., 2001; Ward, 2002; ESMAP, 2003; BIC, 2009). As shown in Figure 2.18, in Africa this can take up to four hours a day (Njenga, 2001; WHO, 2006) – and these distances increase as wood from stressed ecosystems.

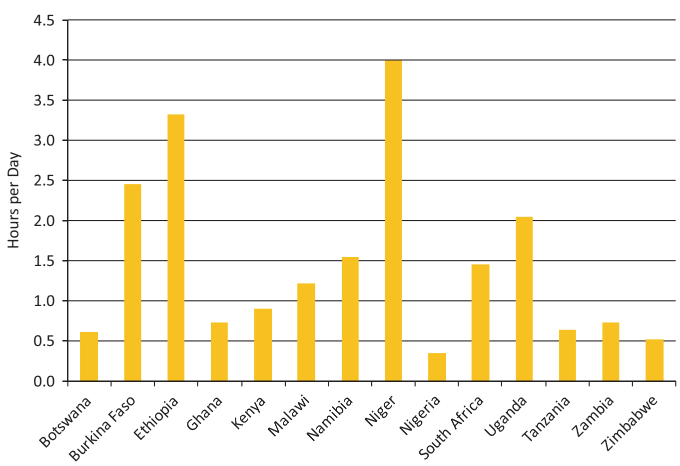

Figure 2.18 | Time ticking away: daily hours that women spend collecting fuel in different African geographical settings, by country, 1990–2003. Source: WHO, 2006.

The energy that women and girls expend fetching water, carrying fuel, and preparing food has received virtually no treatment in traditional energy sector policies because, as it is not traded, it has no "price" as determined by the market and therefore is considered "free." The time people spend carrying water that is not transported by pumping systems or fuels that have been harvested or bought locally, or pounding and grinding maize, wheat, rice, sorghum, or other basic staples, has an opportunity cost. It is time that could otherwise be spent on more economically productive or socially beneficial activities such as paid agricultural work, commercial activities, pursuit of education, or physical rest to preserve the health of women, especially the poorest women.

Access to mechanical power for threshing and grinding grains can help older girls stay in school by minimizing school absenteeism and drop-out rates among girls. It is difficult to change cultural practices where food preparation is assumed to be the responsibility of women and girls. With mechanical power, however, food preparation can be made easier and faster, which liberates valuable time for girls to study and attend school.

Lack of close proximity to safe water places a huge burden on women and girls in many developing countries. For example, on average, women travel 6 kilometers daily in search of water (IAEA, 2007; BPN, 2010). In rural areas, the distances walked by women can be as high as 16 kilometers; during drought, the distance could be at least twice as long (IMW, 2008).

The long distances travelled carrying a load of approximately 20kg pose serious long-term health risks for women, including spine and pelvic deformities that can create complications during childbirth (WaterAid, 2009). In addition, these distances imply that a significant amount of time is spent obtaining this precious commodity, especially in rural areas. According to WaterAid (2009), in rural Africa, about 26% of women's time is spent fetching water. In rural Ghana, a study by Costa et al. (2009) revealed that women spend far more time than men fetching water (see Figure 2.19).

As noted earlier, fuelwood is not always collected. Often it is a commercial commodity bought and sold through markets like any other fuel. This is especially the case in urban areas, where cleaner liquid fuels are either unavailable or unaffordable for poor families. Here, too, women must spend time on the purchase and transport of traditional fuels for household use. And this too has an opportunity cost for women.

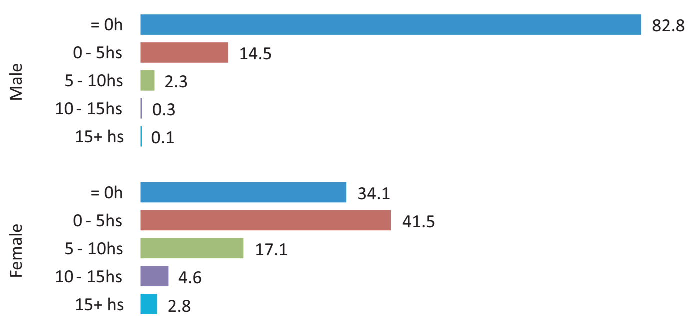

Figure 2.19 | Comparison of time spent by men and women fetching water in rural Ghana (hours/week). Source: Costa et al., 2009.

While improved biomass energy technologies such as cookstoves have several benefits for poor women, a more pronounced switch to cleaner fuels and more efficient cooking devices can lead to increased economic, health, and environmental benefits. As shown in Table 2.18, for example, in India, using a typical LPG stove for cooking can reduce cooking time by slightly over 1 hour compared with a conventional woodstove (Kanagawa and Nakata, 2005). Similar benefits can also be accrued from use of ethanol stoves.

The use of improved cookstoves can result in savings in the amount of fuel used, which translates into direct cash savings. They can also reduce respiratory health problems associated with smoke emission from biomass stoves and offer a better home and working environment for rural housewives and cooks/operators in institutions.

The production and dissemination of improved biomass energy technologies and associated sustainable fuel supply initiatives provide employment opportunities for a significant proportion of the population, particularly women. In Senegal, for example, the sustainable forestry subsector earns the country about US_{2004}\$12.5 million a year, with women in control of one-third of this revenue stream (World Bank, 2010a).

The development linkages between women and energy are not limited to cooking fuels and water collection challenges, although policy and analysis in development debates often stops there. Women are disproportionately affected by the lack of cleaner and affordable energy options for maintaining households and enterprises that can be a source of income (Energia, 2008). This is particularly perverse given that the best means to combat absolute poverty is through the stimulation and increase in women's income – either through productive activities or targeted state transfers aimed at women. Women have a relatively higher propensity to reinvest in family welfare expenditures such as food, education, and health, especially for their dependent children.

Women are key users of energy for productive activities, and as is the case for productive employment for men, access to labor-saving energy-using technologies allows the amount of time spent on non-paid work to be reduced in favor of time spent on paid work, which greatly improves the overall welfare of women, their families, and especially their children. The limited access to cleaner energy and labor-saving technological options therefore has a double negative effect on women: first through limiting the opportunities to generate income and second through the forgone benefits that the additional income could bring to poor families when spent by women on inputs and services that benefit the family.

Table 2.18 | Comparison of cooking times (in hours) of woodstove and LPG in India.

	Time spent on cooking-related activities		
	Fuel collection[a]	Food preparation and cooking	Total time
Woodstove	0.67	2.73	3.4
Gas Stove	-	2.30	2.30
Time saved by gas stoves	0.67	0.43	1.10

[a] The time spent taking gas cylinders for refilling is negligible when spread over the time the newly refilled gas cylinder is used.

Source: adapted from Kanagawa and Nakata, 2005.

Affordable and reliable energy options can broaden the scope of women's enterprises. In West Africa, for example, mechanical power to grind grains and other agricultural products through a fee-for-service model not only was able to meet household grain consumption processing needs but also freed up women's time for other household and agricultural activities (Morris and Kirubi, 2009). In addition, the volumes of milled grain produced surpluses that could be marketed, thereby supplementing limited family cash income that was used to support children's schooling.

The upfront cost of cleaner and affordable energy options is in most cases beyond the reach of the rural poor. This affects women who are the major collectors, managers, and users of traditional energy sources for household activities (BIC, 2009). In developing countries, since many women lack the money to pay for energy services, small-scale food production and processing – a large component of which is often dominated by women – largely relies on human and animal energy (Clancy, 2004) – further discussion on this issue is found in Chapter 20.

An important approach for enhancing access to cleaner and affordable energy for women is to develop programs specifically aimed at financing the upfront costs of energy using equipment for household use as well as targeting income-generating activities that involve a high number of women or women's groups. A number of financing institutions in developing countries have emerged focusing solely on financing women. In Bangladesh, for example, the Grameen Bank has a credit program in which 98% of its borrowers are women (Giridharas and Bradsher, 2006). These funds could be used to mechanize farming and the water supply, hence reducing the burden on women, as well as improving lighting and cooking energy technologies at the household level.

Since in many areas women are the primary users of energy, especially for cooking, it makes sense for them to be involved in designing and implementing policies and projects to meet their own energy needs. Globally, as more women obtain positions of political leadership, it is anticipated that the increased political representation by women will have significant policy implications. For example, it is expected that women politicians are more likely to push for increased access to cleaner and affordable energy options that would benefit women and cleaner cooking fuels such as LPG, ethanol stoves, and improved biomass stoves. Other modern energy options that benefit women are summarized in Table 2.19.

To sum up, access to cleaner and affordable energy options can play an important role in gender equality and women empowerment:

- Available energy services can free girls' and young women's time from household activities (gathering firewood, fetching water, cooking inefficiently, crop processing by hand, manual farming work). This

Table 2.19 | Summary of some energy options favoring women.

Energy Option	Benefits for women
Electricity	Radio, TV, and telecommunications can improve access to the outside world and provide useful information for women.
	Street lighting improves safety for women, especially in slum areas, and enables them to trade after dark.
	In urban areas, electricity helps women to cope with modern lifestyles.
	Availability of electricity enables women to operate specialized enterprises such as hair dressing.
Mechanical power	Women can irrigate crops and water livestock, thereby enhancing food security and nutrition.
	Mechanized tillage and weeding can contribute to higher crop yields.
	Briquette presses can help women obtain cleaner and sustainable biomass fuel supplies.
	Oil presses can help women earn more from agriculture by selling a higher-value product.

Sources: adapted from Bates et al., 2009; UNDP, 2007a.

time can be productively used to generate more income or acquire education.

- Cleaner cooking fuels and equipment can reduce exposure to indoor air pollution and improve health.
- Street lighting can improve women's safety.
- Modern, cleaner and affordable energy options can broaden the scope for women's enterprises, thereby fostering employment and income generation among women.
- Representation of women at the national level can influence energy policies and investments to ensure wider access to cleaner and affordable energy options that benefit women.
- Specific policy initiatives that prioritize "women's" or household energy needs, especially for fuels and mechanical power, can provide a balance to the focus on rural electrification, bringing about a host of family welfare benefits.

2.11 Energy and Environment

This section briefly discusses energy and environmental sustainability in the context of development, while the broader issue is covered in depth in Chapters 3, 4, and 20.

Many of the world's poor depend on forests for their livelihoods as well as to meet their energy needs for cooking. In sub-Saharan Africa about 80% of the population relies on biomass (IEA, 2010a). Although the major cause of deforestation comes from land use change, excessive harvesting of biomass fuel, especially from forests, also contributes to this deforestation. The loss of forests threatens the livelihoods of the poor, destroys habitats that harbor biodiversity, and eliminates important carbon sinks that offset global warming. Since 1990, forest losses have been substantial (more than 1.4 million square kilometers), especially in Latin America and the Caribbean, East Asia and the Pacific, and sub-Saharan Africa (World Bank, 2010a). Some of this deforestation is due to excessive harvesting of biomass fuel.

As mentioned earlier, much of the rural deforestation and overharvesting of fuelwood experienced in sub-Saharan Africa, can, in part, be traced to trees cut down for feedstock for the charcoal industry. This is not to supply rural consumers with energy but to provide a steady supply of cheap fuels for cooking and household energy use for urban dwellers, as indicated by the thriving charcoal markets throughout the African continent (AFREPREN/FWD, 2006a). Important options for addressing the charcoal and deforestation challenge include dissemination of proven improved cookstoves such as the charcoal-burning KCJ that can cut charcoal consumption by half and switching to LPG.

As shown in the Figure 2.20, biomass – mainly traditional biomass biofuels – accounts for about 44% of the world's final renewable energy use. The bulk of this supply is from developing countries.

Poor households using open fires and traditional biomass stoves for cooking, tend to be highly inefficient due to incomplete combustion of the biomass. Consequently, methane, a more potent greenhouse gas than carbon dioxide (CO_2), is released. The use of traditional and unsustainable biomass cooking energy fuels has significantly higher greenhouse gas (GHG) emissions compared to fuels such as LPG and biogas (see Chapter 19). Use of cleaner cooking fuels and technologies can reduce the GHGs of developing countries.

Although developing countries emit fewer emissions on a per capita basis, in gross terms and, if one ignores, historical emissions or per capita emissions, some emerging industrializing countries account for a significant share of current global GHGs emissions comparable to those of industrialized countries. For example, China's CO_2 emissions in 2008 exceeded those of the entire European continent and compare with those of the United States, Canada, and Mexico combined (see

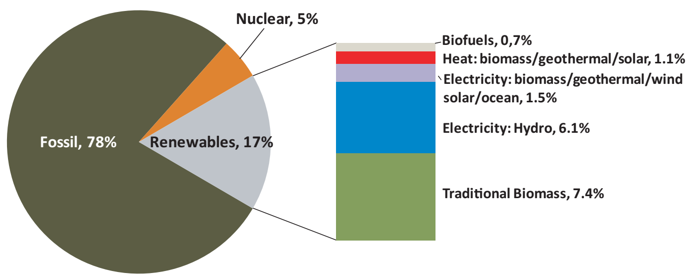

Figure 2.20 | Renewable share of final energy use in 2009 (528 EJ). Source: fossil and nuclear fuel use: IEA 2011b; renewables: Chapter 11.

Chapter 3). However, the picture changes dramatically if historical and per capita emissions are included. Wealthy western countries of Europe and North America account for a dominant share of historical emissions and are by far the highest emitters of GHGs on a per capita basis.

It can therefore be argued that the poor in developing countries should not be restricted when the current high GHGs emissions levels are still largely a result historical and of high per capita emissions of industrialized countries of North America and Europe.

On a per capita basis, poor people and poor countries in the world generate fewer GHGs than either the people who are well-off in poor countries or the inhabitants of industrialized countries. The poor contributions to global greenhouse gas emissions is negligible. For example, Africa has very low levels of access to GHGs-intensive energy options and, as a result, the continent generates only 3% of the global aggregate GHG emissions (UNIDO, 2009; IEA, 2010b). But lifting the poor out of poverty through improving access to jobs, social services, and improved living conditions requires greater energy inputs, as has been argued throughout this chapter, which would inevitably result in increasing emissions further from the developing countries. Replacement of traditional biomass (with incomplete combustion) with LPG could lead to lower overall GHG emissions especially when particulate matter is accounted for.

In some cases, wide-scale deployment of renewable energy systems may provide the best options for providing access to cleaner and modern energy options while reducing GHGs emissions. In the near term, however, cleaner fossil fuels such as LPG combined with more efficient and low-cost end-uses devices such as LPG cookstoves reduce a host of social, economic, and environmental barriers to overcoming poverty due to higher combustion efficiency.

The ongoing search for win-win solutions in low-income areas of poor developing countries that are completely reliant on renewable energy must also put a time premium on overcoming social injustice and the conditions of inequality that entrench poverty and reproduce underdevelopment. As mentioned earlier, from a policy point of view, it is unrealistic to support arguments for "near-term renewables only" options that delay the satisfaction of the basic needs of people who remain poor today and who constitute a negligible contributor to global historical and current carbon emissions. It is, therefore, important to retain cleaner fossil fuel options such as LPG combined with more efficient low-cost end-use devices in near-term priority action plans that would set the stage for eventually moving the poor to a fully sustainable path that relies more heavily on renewable energy.

There is, however, a growing interest on the part of energy decision makers in developing countries in examining efficient, environmentally sound, climate-friendly energy options that also deliver substantial development benefits and reduce the climate risk profile of their energy industries. Studies indicate that many of these options (such as demand-side management, renewable energy use and efficient energy end-user devices such as tube lights, compact fluorescent lamps, biomass cogeneration, ethanol, etc.) are not as capital-intensive as conventional centralized energy options (DuPont, 2009).

2.12 Conclusions and the Way Forward

The intrinsic link and positive relationship between energy and overcoming poverty – whether income-defined poverty or poverty linked to inequality in income distribution within countries – is very strong in developing countries. It is clearly demonstrated by the fact that poor people constitute the bulk of the estimated 3 billion people primarily relying on solid fuels (coal and traditional biomass) of which 2.7 billion people cook and heat their homes with traditional fuels and low-efficiency stoves (UNDP and WHO, 2009; IEA, 2010a; see also Chapter 19) and almost one and a half a billion without access to electricity (IEA, 2010a; see also Chapter 19).

Access to electricity supply (both grid and non-grid) in many developing countries is almost an exclusive service enjoyed by the non-poor in urban areas. Even after two decades of energy sector reforms, initial indications from a wide range of developing countries indicate that few of the initiatives have resulted in significant improvement in the provision of electricity to the world's poor (GNESD, 2010; Karekezi and Sihag, 2004; IMF, 2008). Access to modern and cleaner forms of energy improves the livelihoods[8] of the poor in developing countries. As discussed in earlier sections, increased access to cleaner energy in rural areas opens up these regions to greater economic productivity.

In most cases, market-led reforms were primarily designed to improve the financial health of electricity companies and were introduced into countries where a large sector of the potential "market" consisted of very poor people not served by national grids or who resided in geographic areas with low levels of energy use. Expanding access to electricity to the poor meant attempting to service low-income consumers whose incomes may well be highly unstable and who often live in isolated areas that are difficult to access or in urban areas that are characterized by high degrees of informality. To provide electricity services, the "reformed" companies had to cover operating and investment costs (required by market-oriented reforms) while providing expensive transmission lines and connections as well as maintenance, billing, and collection services in a market where return on investment was far from assured. In the majority of the countries, these contradictory demands proved to be irreconcilable. It is therefore not surprising that newly privatized or reformed electricity companies tended to "cherry pick" the most lucrative markets (i.e., non-poor urban areas), raised their tariffs, and virtually ignored widening of their networks to poorer consumers.

8 Livelihood refers to "means of support, subsistence or securing the necessities of life." Livelihoods can be improved through increased agricultural production, better social welfare – including increased income among other factors.

Thus, experiences in developing countries point to an overarching conclusion: when power sector reforms were introduced with the sole intention of improving the performance of utilities, the expected and hoped-for social benefits did not necessarily follow. Where governments maintained a role as instigator or at least regulator of improved access to electricity by the poor, tariffs for poor households tended to decrease and levels and rates of electrification tended to increase.

The excessive reliance on private sector-driven approaches that have proven detrimental to widening access to electricity in many parts of the developing world, especially sub-Saharan Africa and some parts of Asia, are also becoming prevalent in efforts to disseminate improved cookstoves and scale up the use of renewables in developing countries. There is heavy emphasis on bottom-of-the-pyramid profit-driven approaches with limited attention being paid to the important role of public interventions that have the resources and long-term horizon to engineer the scale-up required to reach millions of the unelectrified homes in the developing world that currently rely on inefficient and traditional biomass-based cookstoves to meet their cooking and heating needs. A more balanced approach is needed that judiciously combines large-scale and long-term public initiatives with innovative pilot private sector based programs that rely on the bottom-of-the-pyramid profit-driven small and medium scale enterprises.

In order to ensure that modern, cleaner and affordable forms of energy are accessed by poor people, the right choice of energy supply has to be made. For example, large-scale renewable energy technologies have lower running costs, hence might be, in the long-term, the most attractive options. In addition, some fossil fuels such as LPG can also be attractive due to their cleaner combustion and higher efficiency characteristics.

Based on political and policy considerations, there is need to minimize any delays to the satisfying the basic need of the poor. Therefore, appropriate solutions to overcoming social injustice and the conditions of inequality that entrench poverty and reproduce underdevelopment must be achieved within the shortest possible time. It is for this reason that GEA shares a goal with the UN proposed targets of achieving universal access to electricity and cleaner cooking fuels by 2030 (UN, 2010b). Current estimates indicate that achieving the aforementioned goal will require significant investment (see Chapter 17) and political commitment (see Chapters 19 and 23). In addition, the relationship between poverty and energy requires a better understanding of the demand profile of this segment of the energy market and the recognition that poor people are energy users. This is demonstrated by the fact that, for example, at current electrification rates it is estimated that about 15% of the world population will not have access to electricity in 2030 (IEA, 2010a). As shown in Table 2.20, most of these people will be in sub-Saharan Africa and some parts of Asia. However, it is noted that the IEA baseline contrasts with GEA pathways of achieving universal access by 2030.

In order for national leaders in developing countries to deliver the much-needed political commitment required to address the access question, approaches to dealing with the issue need to be "homegrown." The rationale for this approach is that policymakers in developing countries have successfully used a similar quantified campaign strategy with the MDGs to accelerate the pursuit of globally agreed social indicators fundamental to overcoming underdevelopment and poverty. The community of nations should adopt global goals for minimum levels of energy services, especially universal access to electricity and cleaner cooking fuels, to address poverty and support sustainable human development.

It is worth pointing out that while promoting access to electricity is generally given more attention due to the services it typically provides, such as communications, lighting, refrigeration, and motor power, equally important is the role that nonelectric forms of energy, in particular fuels and mechanical power, play in both the household and the social sectors. This second set of energy issues has been given much less attention in energy sector planning, especially in developing countries. In order to ensure that modern, cleaner and affordable forms of energy are accessed by poor people, the right choice of energy supply has to be made. For example, large-scale renewable energy technologies have lower running costs, hence might be, in the long-term, the most attractive options. More challenging still is that while power sector reform has received much attention in developing countries, energy policies addressed at fuel switching and improving heating and cooking systems, especially in rural areas, have received very little policy attention in energy sector reform. Electricity is not synonymous with energy, a concept which is much broader. Some fossil fuels such as LPG can

Table 2.20 | Current and projected electrification levels in developing countries.

Region/Country	2009		2030	
	Unelectrified population (million)	Proportion of all unelectrified (%)	Unelectrified population (million)	Proportion of all unelectrified (%)
Latin America	31	2.2	10	0.8
Sub-Saharan Africa	585	40.7	652	53.8
North Africa	2	0.1	2	0.2
South & East Asia	812	56.5	549	45.3
China	8	0.6	0	0
Total	1438	100.0	1213	100.0

Source: adapted from IEA, 2010a; 2010c.

also be attractive due to their cleaner combustion and higher efficiency characteristics and therefore it is crucially important that all fuel options are given consideration when designing energy sector strategies. Finally many of the energy issues treated here fall outside the energy sector per se and are intimately linked with service and supply decisions taken in other sectors and policy frameworks including those in education, health, agriculture, water, housing etc.

As this chapter indicates, for the poorest segments of the population and especially for poor women and their children, the role of cleaner energy carriers for cooking, household use and homestead-based productive activities are disproportionately more important in reducing the day-to-day barriers to education, health, and family food security. Access to modern and cleaner forms of energy contribute to a general improvement in social welfare – including increased income – due to improved health, sanitation, education, etc. For example, in Bangladesh, an impact assessment of its rural electrification revealed that 63% of electrified households surveyed reported an increase of income as a direct result of electrification (Berthaud et al., 2004). In Lao PDR rural electrification using solar systems has demonstrated the viability of decentralized renewable energy systems in enhancing rural livelihoods through increased income, improved healthcare and access to information (Theuambounmy, 2007).

In short, to ensure the poor's access to cleaner and affordable energy options, energy policy must see the poor as a consuming market that, when better served, will generate income and opportunities for value-adding activities that can have benefits at the family, community and sector wide levels. However, the excessive reliance on private sector-driven approaches that have proven detrimental to widening access to electricity in many parts of the developing world, especially sub-Saharan Africa and some parts of Asia, should not become the only route to expand poor's access to cleaner energy options. The almost exclusive recourse to private sector-driven approaches to disseminate improved cookstoves and scale up the use of renewables in developing countries is of some concern. There is heavy emphasis on bottom-of-the-pyramid profit-driven approaches with limited attention being paid to the important role of public interventions that have the resources and long-term horizon to engineer the scale-up required to reach millions of the unelectrified homes in the developing world that currently rely on inefficient and traditional biomass-based cookstoves to meet their cooking and heating needs. A more balanced approach is needed that judiciously combine large-scale and long-term public initiatives with innovative pilot private sector based programs that rely on the bottom-of-the-pyramid profit-driven small and medium scale enterprises.

Prevailing energy systems in developing countries need transformational change in order to have a pro-poor orientation as well as to ensure universal access to modern forms of energy and energy services in key economic sectors providing livelihoods to poor people. In addition, universal access serves both to advance education and all other concerns, and to avoid the detrimental effects of dependence on traditional fuels in terms of women's time, health effects, pollution, global warming etc. Chapters 17, 19, and 23 discuss how universal access, especially of electricity and cleaner cooking fuels, could be achieved. All GEA pathways lead to universal access to electricity and cleaner cooking fuels by 2030.

References

AFREPREN/FWD, 2006a: *Report of the ADB FINESSE Training Course on Renewable Energy and Energy Efficiency for Poverty Reduction*, 19–23 June, Volume III: Write-Ups. Energy, Environment and Development Network for Africa (AFREPREN/FWD), Nairobi.

AFREPREN/FWD, 2006b: *Renewables for Poverty Reduction in Africa*. Energy. Environment and Development Network for Africa (AFREPREN/FWD), Nairobi.

AFREPREN/FWD, 2010: *Arusha Field Visit to SMES Dealing With Renewable Energy Report*. Energy. Environment and Development Network for Africa (AFREPREN/FWD), Nairobi.

Alkire, S., J.M. Roche, M.E. Santos, and S. Seth, 2011: *Multidimensional Poverty Index: 2011 Data*. Oxford Poverty and Human Development Initiative. www.ophi.org.uk/policy/multidimensional-poverty-index/ (accessed 4 March 2010).

AllAfrica, 2004: Zimbabwe: Infrastructure improvement key to teacher retention in rural areas – Chigwedere. *The Herald*, 21 May.

ANSD, 2006: *Sénégal: resultats du troisième recensement général de la population et de l'habitat (2002): rapport National de presentation*. Agence Nationale de la Statistique et de la Demographie (ANSD), Senegal.

Ashden Awards for Sustainable Energy, 2005: *Case-study: Large-scale biogas for sanitation. Kigali Institute of Science*, Technology and Management (KIST), London.

Baker, J., R. Basu, M. Cropper, S. Lall, and A. Takeuchi, 2005: *Urban Poverty and Transport: The Case of Mumbai*. Policy Research Working Paper No. 3693. World Bank, Washington, DC.

BIC, 2009: *Ugandan environmentalist speaks out on large dams, renewable energy, and poverty alleviation*. Bank Information Center (BIC) Update. Washington, DC.

Barnes, D. F., A. Hussain, A. H. Samad, and R. S. Khandker, 2010: *Energy Access, Efficiency and Poverty: How Many Households are Energy Poor in Bangladesh?* Policy Research Working Paper No. 5332. World Bank, Washington, DC.

Bates, L., S. Hunt, S. Khennas, and N. Sastrawinat, 2009: *Expanding Energy Access in Developing Countries: The Role of Mechanical Power*. Practical Action, Rugby.

Bazilian, M., P. Nussbaumer, A. Cabraal, R. Centurelli, R. Detchon, D. Gielen, H. Rogner, H. McMahon, V. Modi, N. Nakicenovic, B. O'Gallachoir, M. Radka, K. Rijal, M. Takada, and F. Ziegler, 2010: *Measuring Energy Access: Supporting a Global Target*. The Earth Institute, Columbia University, New York.

Berthaud, A., A. Delescluse, D. Deligiorgis, K. Kumar, S. Mane, S. Miyamoto, W. Ofosu-Amaah, L. Storm, and M. Yee. 2004: *Integrating Gender in Energy Provision: Case Study of Bangladesh*. International Bank for Reconstruction and Development/The World Bank, Washington, DC.

Bhandari, O., 2006: *Socio-Economic Impacts of Rural Electrification in Bhutan*. Master's thesis, Asian Institute of Technology, Bangkok.

Bhattacharya, S., 2003: *European heatwave caused 35,000 deaths*. New Scientist, 10 October.

BPN, 2010: *The Facts About the Global Drinking Water Crisis*. Blue Planet Network (BPN). blueplanetnetwork.org/water/facts (accessed 22 November 2010).

Brew-Hammond, A., 2007: *Challenges to Increasing Access to Modern Energy Services in Africa*. Background Paper Prepared for the Forum of Energy Ministers of Africa Conference on Energy Security and Sustainability, 28–30 March, Maputo, Mozambique.

Cabraal, R. A., D. F. Barnes, and S. G. Agarwal, 2005: Productive uses of energy for rural development. *Annual Review of Environment and Resources,* 30:117–44.

CAI-Asia, 2011: *Managing Two and Three-Wheelers in Asia*. Clean Air Initiative for Asian Cities (CAI-Asia), Manila and Partnership for Clean Fuels and Vehicle, Nairobi.

CEDAW, 2011: *About CEDAW*. Convention on the Elimination of All Forms of Discrimination against Women (CEDAW). www.cedaw2010.org/index.php/about-cedaw (accessed 3December 2011).

Clancy, J., 2004: *Urban Poor Livelihoods: Understanding the Role of Energy Services*. University of Twente, Enschede.

Coelho, S., 2009: *Energy Access in Brazil*. PowerPoint presentation at Taller Latinoamericano y del Caribe: Pobreza y el Acceso a la Energía. Brazilian Reference Center on Biomass (CENBIO), University of São Paulo. October 2009, Santiago.

Costa, J., D. Hailu, E. Silva, and R. Tsukada, 2009: *Water supply and women's time use in rural Ghana*. Poverty in Focus No. 18, International Policy Centre for Inclusive Growth (IPC-IG). Brasilia.

DFID, 2002: *Energy for the poor: Underpinning the Millennium Development Goals*. Department for International Development (DFID), Crown, London.

DuPont, P. 2009*: Case Study of Energy Efficiency in Asia and Internationally: Some Examples and Food for Thought*. USAID-Asia, PowerPoint presentation at First Mekong Energy and Ecology Training, 14 May, Bangkok.

EAWAG/SANDEC, 2002. *Solar Water Disinfection: A Guide for the Application of SODIS*. Swiss Federal Institute of Environmental Science and Technology (EAWAG)/Department of Water and Sanitation in Developing Countries (SANDEC), Duebendorf.

Ekouevi, K., 2001: An overview of biomass energy issues in sub-Saharan Africa. In *Proceedings of the African High-Level Regional Meeting on Energy and Sustainable Development for the Ninth Session on the Commission on Sustainable Development*. N. Wamukonya (ed.), United Nations Environment Programme, Risoe Centre, Roskilde, pp.102–08.

Energia, 2008: *Turning Information into Empowerment: Strengthening Gender and Energy Network in Africa*. TIE-ENERGIA Project.

ESMAP, undated: *Fighting Poverty through Decentralized Renewable Energy*. Energy Sector Management Assistance Program (ESMAP), World Bank, Washington, DC.

ESMAP, 2003: *Energy and Poverty: How Can Modern Energy Services Contribute to Poverty Reduction? Proceedings of a Multi-Sector Workshop*, 23–25 October, Addis Ababa.

ESMAP, 2004: *Renewable Energy for Development – The Role of the World Bank Group*. World Bank, Washington, DC.

Fall, A., S. Sarr, T. Dafrallah and A. Ndour, 2008: Modern Energy Access in Peri-Urban Areas of West Africa: The Case of Dakar, Senegal. *Energy for Sustainable Development*, 12(4): 22–37.

Farm Radio International, 2006a: Increasing post-harvest success for smallholder farmers. *Voices Newsletter*, No. 79. Ontario.

Farm Radio International, 2006b: *Three fishing ladies with a message about solar dryers*. Radio Scripts. Package 79, Script 6. www.farmradio.org/english/radio-scripts/79–6script_En.asp (accessed 17 February 2011).

Farm Radio International, 2008: *Food processing and storage.* Radio Scripts by Subject. www.farmradio.org/english/radio-scripts/food.asp (accessed 17 February 2011).

FAO, 2009: *Post-harvest Losses Aggravate Hunger – Improved Technology and Training Show Success in Reducing Losses*. Food and Agriculture Organization

(FAO) of the United Nations, Rome. www.fao.org/news/story/en/item/36844/icode/ (accessed 16 October 2011).

FAO, 2011: *AQUASTAT Online Database: Percentage of total grain production irrigated (%).* www.fao.org/nr/water/aquastat/data/query/index.html (accessed 20 June 2011).

Foran, M. M., 2007: *An analysis of the time to disinfection and the source water and environmental challenges to implementing a solar disinfection technology (SolAgua)*. Harvard School of Public Health, Harvard University, Boston.

Galitsky, C., A. Gadgil, M. Jacobs, and Y. Lee, 2006: *Fuel efficient stoves for Darfur IDP camps: Report of field trip to North and South Darfur*. 16 November – 17 December, 2005. Lawrence Berkeley National Laboratory, Berkeley, CA.

Gasparini, L., and N. Lustig, 2011: *The Rise and Fall of Income Inequality in Latin America*. Tulane Economics Working Paper No. 1110. Tulane University, New Orleans.

Gasparini, L., G. Cruces, L. Tornarolli, and M. Marchionni, 2009: *A Turning Point? Recent Developments on Inequality in Latin America and the Caribbean*. Centro de Estudios Distributivos, Laborales y Sociales, Universidad Nacional de La Plata, Buenos Aires.

Giridharas, A., and K. Bradsher, 2006: Microloan pioneer and his bank win Nobel Peace Prize. *New York Times*, 13 October.

GNESD, 2008. *Clean Energy for the Urban Poor: An Urgent Issue*. Global Network on Energy for Sustainable Development (GNESD), Roskilde.

GNESD, 2010. *Energy Access – Making Power Sector Reform Work for the Poor*. Global Network on Energy for Sustainable Development (GNESD), Roskilde.

Gomide A., 2008: Mobility and the urban poor. *Urban Age*. Newspaper essay, South America, December 2008.

Harries, M., 2002: Disseminating wind pumps in rural Kenya: Meeting rural water needs using locally manufactured wind pumps. *Energy Policy,* 30(11–12).

Harsdorff, M., and J. Peters, 2010: *On-Grid Rural Electrification in Benin*. RWI Materialien, Germany.

Heaselgrave, W., N. Patel, S. Kilvington, S.C. Kehoe and K.G. McGuigan, 2006: Solar disinfection of poliovirus and Acanthamoeba polyphaga cysts in water—a laboratory study using simulated sunlight. *Letters in Applied Microbiology*, 43(2):125–130.

Hiremath, B. N., and H. Misra, 2009: *Management of livelihood centric rural development projects: A systemic view*. Second National Conference on Agro-Informatics and Precision Farming, University of Agricultural Sciences, Raichur, organized by INSAIT, Dharwad, 2–3 December.

Hook, W., and L. Nadal, 2011: *Motorized Two and Three Wheeler Design and Regulation*. PowerPoint presentation. Institute for Transportation & Development Policy. www.itdp.org/index.php/library/publications (accessed 27 November 2011).

Huba, E-M., and E. Paul, 2007: *National Domestic Biogas Programme Rwanda: Baseline Study Report*. Netherlands Development Organisation, German Technical Cooperation, and Ministry of Infrastructure.

IAEA, 2007: *Top Stories & Features: Women & Water*. International Atomic Energy Agency (IAEA). www.iaea.org/newscenter/news/2007/womenday2007.html (accessed 6 October 2011).

IEA, 2006: *World Energy Outlook 2006*. International Energy Agency (IEA), Paris.

IEA, 2008: *World Energy Outlook: Energy and Development*. International Energy Agency (IEA), Paris.

IEA, 2009: *The Electricity Access Database*. International Energy Agency (IEA), Paris. www.iea.org/weo/database_Electricity/electricity_access_database.htm (accessed 18 April 2011).

IEA, 2010a: *Energy Poverty – How to Make Modern Energy Access Universal? World Energy Outlook 2010*. International Energy Agency (IEA), Paris.

IEA, 2010b: *CO_2 Emissions from Fuel Combustion – Highlights*. International Energy Agency (IEA), Paris.

IEA, 2010c: *The Electricity Access Database*. International Energy Agency (IEA), Paris. www.iea.org/weo/database_Electricity10/electricity_database_web_2010.htm (accessed 27 November 2010).

IEA, 2011a: *Energy and Development Methodology*. International Energy Agency (IEA), Paris.

IEA, 2011b: *Energy Balances of Non-OECD Countries 2011*. International Energy Agency (IEA), Paris.

IMF, 2008: *Africa's power supply crisis: Unraveling the paradoxes*. International Monetary Fund (IMF) Survey Magazine, 22 May.

IMW, 2008: Water Woes: Women Fetch the World's Water. Online Exhibition. International Museum of Women (IMW). www.imow.org/wpp/stories/viewStory?storyId=1308 (accessed 16 May 2011).

Kammen, D. M., R. Bailis, and A. V. Herzog, 2001: *Clean Energy for Development and Economic Growth: Biomass and Other Renewable Energy Options to Meet Energy and Development Needs in Poor Nations*. University of California, Berkeley, CA.

Kanagawa, M. and T. Nakata, 2005: *Analysis of the Energy Access Improvement and Its Socio-Economic Impacts in Rural Areas of Developing Countries*. Tohoku University, Sendai.

Karekezi, S. and T. Ranja, 1997: *Renewable energy technologies in Africa*. Zed Books, London.

Karekezi, S., G.B., Khamarunga, and W. Kithyoma, and X. Ochieng, 2002: Improving Energy Services for the Poor in Africa – A Gender Perspectiv. *ENERGIA News* Vol. 5 Nr 4, Energia.

Karekezi, S., and A. Sihag, 2004: *Synthesis/Compilation Report. Energy Access Working Group*. Global Network on Energy for Sustainable Development, Risoe National Laboratory, Roskilde, Denmark.

Karekezi, S., J. Kimani, A. Wambille, P. Balla, F. Magessa, W. Kithyoma, and X. Ochieng, 2005: *The Potential Contribution of Non Electrical Renewable Energy Technologies (RETS) to Poverty Reduction in East Africa*. Energy, Environment and Development Network for Africa, Nairobi.

Karekezi, S., W. Kithyoma, K. Muzee, and J. Wangeci, 2008a: *The Potential for Small and Medium Scale Renewables in Poverty Reduction in Africa*. Energy, Environment and Development Network for Africa, Nairobi.

Karekezi, S., J. Kimani, and O. Onguru, 2008b: *Urban and Peri -Urban Energy Access Working Group – Thematic Study*. Energy, Environment and Development Network for Africa, Nairobi.

Karekezi, S., W. Kithyoma, K. Muzee, and A. Oruta. 2009: *Renewable Energy for Africa: Potential Markets and Strategies*. Energy, Environment and Development Network for Africa, Nairobi.

Khandker, S. R., D. F. Barnes, and H. A. Samad, 2009: *Welfare Impacts of Rural Electrification: A Case Study from Bangladesh*. Policy Research Working Paper No. 4859. World Bank, Washington, DC.

KickStart, 2011: *Our Impact*. www.kickstart.org/what-we-do/impact (accessed 9 June 2011).

Kumarage, A. S., 2007: Impacts of transportation infrastructure and services on urban poverty and land development in Colombo, Sri Lanka. *Global Urban Development Magazine*, 3(1).

Mapako, M., 2010: *Energy, the Millennium Development Goals and the Key Emerging Issues*. Department of Environmental Affairs, South Africa.

Meisen, P., and I. Akin, 2008: *The Case for Meeting the Millennium Development Goals through Access to Clean Electricity*. Global Energy Network Institute, San Diego, CA.

Modi, V., S. McDade, D. Lallement, and J. Saghir, 2006: *Energy and the Millennium Development Goals*. The International Bank for Reconstruction and Development/ The World Bank, Washington, DC, and the United Nations Development Programme, New York, NY.

Morris, E., and G. Kirubi, 2009: *Bringing Small-Scale Finance to the Poor for Modern Energy Services: What is the Role of Government?* United Nations Development Programme, New York, NY.

Nussbaumer, P., M. Bazilian, V. Modi and K. Yumkella, 2011: *Measuring Energy Poverty: Focusing on What Matter*. Oxford Poverty and Human Development Initiative, Oxford.

Njenga, B. K., 2001: *Upesi rural stoves project. In Generating Opportunities: Case Studies on Energy and Women*. United Nations Development Programme, New York, NY.

Population Action International, 2001: *A World of Difference: Sexual and Reproductive Health and Risks*. Washington, DC.

Quansah, S. K., P. Russell, and N-O. Mainoo, 2003: *Ghana LPG Rural Energy Challenge*. Workshop Report. Kumasi Institute of Technology and Environment, Kumasi.

Rosenthal, G., 2010: The financial and economic crisis of 2008 and its repercussions on economic thought. *CEPAL Review* 100:29–39.

Schlag, N. and F. Zuzarte. 2008: *Market Barriers to Clean Cooking Fuels in Sub-Saharan Africa: A Review of Literature. Working Paper*. Stockholm Environment Institute, Stockholm.

Shankar, K. K., 2007: Govt extends kerosene, LPG subsidy till 2010. *Indian Express Limited,* 12 October.

SIL International, 2011: *Women and Literacy*. www.sil.org/literacy/wom_lit.htm (accessed 4 April 2011).

SNV, 2007: *SNV and FMO Provide Bio-Digesters and Micro Loans to Farmers in Cambodia*. Netherlands Development Organisation (SNV). www.snvworld.org/en/aboutus/news/Pages/Bio%20digesters%20for%20Cambodian%20farmers.aspx (accessed 20 November 2011).

SODIS, 2009: *Microbiology*. Solar Water Disinfection (SODIS). www.sodis.ch/methode/forschung/mikrobio/index_en (accessed 17 March 2011).

SODIS, 2010a: *SODIS – Safe Drinking Water in 6 Hours.* www.sodis.ch/index_en (accessed 17 March 2011).

SODIS, 2010b: *Health.* www.sodis.ch/methode/forschung/gesundheit/index_en (accessed 17 March 2011).

Sumner, A., 2010: *Global Poverty and the New Bottom Billion: What if Three-quarters of the World's Poor Live in Middle-income Countries?* IDS Working Paper 349. Institute of Development Studies, University of Sussex, Sussex.

Sumner, A., 2011: *The New Bottom Billion: What If Most of the World's Poor Live in Middle-Income Countries?* Institute of Development studies and Centre for Global Development

Theuambounmy, H. 2007: *Status of Renewable Energy Development in the Lao People's Democratic Republic*. Paper presented at the Greening the Business and Making Environment and Business Opportunity. 5–7 June 2007, Bangkok.

TWP, 2010: *Water Scarcity and Its Effects*. The Water Project (TWP), thewaterproject.org/water_stats.asp (accessed 10 October 2011).

UN, 2010a: *The Millennium Development Goals Report*. United Nations (UN), New York, NY.

UN, 2010b: *Energy for a sustainable future: summary report and recommendations of the Secretary-General's Advisory Group on Energy and Climate Change (AGECC)*. United Nations (UN), New York, NY.

UN, 2011a: *Water for life Meeting Global Targets for Water and Sanitation*. United Nations (UN), New York, NY.

UNDP, 2004: *Reducing Rural Poverty Through Increased Access to Energy Services: A Review of Multifunctional Platform Project in Mali*. United Nations Development Programme (UNDP), New York, NY.

UNDP, 2005: *Energizing the MDGs: A Guide to Energy's Role in Reducing Poverty*. United Nations Development Programme (UNDP), New York, NY.

UNDP, 2006: *Energizing Poverty Reduction. A Review of Energy-Poverty Nexus in Poverty Reduction Strategy Paper*. United Nations Development Programme (UNDP), New York, NY.

UNDP, 2007a: *A Review of Energy in National MDG Reports by Minoru Takada and Silvia Fracchia*. United Nations Development Programme (UNDP), New York, NY.

UNDP, 2007b: *Delivering Energy Services for Poverty Reduction: Success Stories from Asia and the Pacific*. UNDP Regional Centre, Bangkok.

UNDP, 2009: *UNDP Human Development Indicators Report 2009*. United Nations Development Programme (UNDP), New York, NY.

UNDP, 2010: *UNDP Human Development Indicators Report 2010*. United Nations Development Programme (UNDP), New York, NY.

UNDP, 2011: *Human Development Report 2011. Sustainability and Equity: A better future for all*. United Nations Development Programme (UNDP), New York, NY. http://hdr.undp.org/en/media/HDR_2011_en_Complete.pdf

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

UNECA, 2010: *Economic Report on Africa Promoting High-Level Sustainable Growth to Reduce Unemployment in Africa*. United Nations Economic Commission for Africa (UNECA), Addis Ababa.

UNEP, undated: *Empowering Rural Communities by Planting Energy: Roundtable on Bioenergy Enterprise in Developing Regions*. United Nations Environment Programme (UNEP), Nairobi.

UNIDO, 2009: *Industrial Development Report 2009*. United Nations Industrial Development Organization (UNIDO), Vienna.

UNFPA, 2005: *State of World Population 2005: Journalists Press Kit*. United Nations Population Fund (UNFPA), New York, NY. www.unfpa.org/swp/2005/presskit/factsheets/facts_rh.htm (accessed 18 June 2011).

UNFPA, 2008: *Linking Population, Poverty and Development – Reducing Poverty and Achieving Sustainable Development*. United Nations Population Fund (UNFPA), New York, NY. www.unfpa.org/pds/poverty.html (accessed 18 June 2011).

UNFPA, 2009: *A Review of Maternal Health in Eastern Europe and Central Asia*. United Nations Population Fund (UNFPA), New York, NY.

UN Energy, 2005: *The Energy Challenge for Achieving the Millennium Development Goals*. United Nations, New York, NY.

UN Women, 2011: *Facts and Figures on Gender and Climate Change.* www.unifem.org/partnerships/climate_change/facts_figures.php (accessed 25 May 2011).

Vivien, F. and C. Briceno-Garmendia, (eds.), 2010: *Africa's Infrastructure – A Time for Transformation*. The International Bank for Reconstruction and Development and The World Bank, Washington, DC.

Ward, S., 2002: *The Energy Book for Urban Development in South Africa*. Sustainable Energy Africa, Noordhoek.

WaterAid, 2009: *Women's issues*. Issue Sheet, November 2009.

Wegelin, M. and B. Sommer, 1997: SODIS at the turning point – A technology ready for use. *SANDEC News* No. 3, EAWAG/SANDEC, October 1997, Ueberlandstrasse.

WFP, 2010: *WFP Activities: Tanzania*. World Food Programme (WFP), Rome. www.wfp.org/countries/Tanzania – United-Republic-Of/Operations (accessed 15 July 2011).

WHO, 2006: *Fuel for Life, Household Energy and Health*. World Health Organization (WHO), Geneva.

WHO, 2008: *Maternal Health – Fact Sheet*. World Health Organization (WHO), Geneva.

WHO, 2011a: Indoor Air Pollution: Multiple Links between Household Energy and the Millennium Development Goals. www.who.int/indoorair/mdg/energymdg/en (accessed on 18 May, 2011).

WHO, 2011b: *Global Tuberculosis Control: WHO Report 2011*. World Health Organization (WHO), Geneva.

World Bank, 2007: *World Development Indicators*. Washington, DC. data.worldbank.org/products/data-books/WDI-2007 (accessed 7 March 2011).

World Bank, 2008a: *Climate Change and the World Bank Group, Phase 1: An Evaluation of World Bank Win-Win Energy Policy Reforms*. Washington, DC, pp.114–119.

World Bank, 2008b: *Designing Sustainable Off-Grid Rural Electrification Projects: Principles*

World Bank, 2010a: *The Millennium Development Goals and the Road to 2015. Building on Progress and Responding to Crisis*. Washington, DC.

World Bank, 2010b: *World Development Report 2010*. Washington, DC.

World Bank, 2011a: *World Development Indicators*. Washington, DC.

World Bank & IBRD, 2008: *Africa development Indicators 2007*. The World Bank and International Bank for Reconstruction and Development (IBRD),Washington, DC.3 A ropeway is a form of lifting device used to transport light goods across rivers or ravines.