

# 19

# Energy Access for Development

## Convening Lead Authors (CLA)

**Shonali Pachauri** (International Institute for Applied Systems Analysis, Austria)

**Abeeku Brew-Hammond** (Kwame Nkrumah University of Science and Technology, Ghana)

## Lead Authors (LA)

**Douglas F. Barnes** (Energy for Development, USA)

**Daniel H. Bouille** (Bariloche Foundation, Argentina)

**Stephen Gitonga** (United Nations Development Programme)

**Vijay Modi** (Columbia University, USA)

**Gisela Prasad** (University of Cape Town, South Africa)

**Amitav Rath** (Policy Research International Inc., Canada)

**Hisham Zerriffi** (University of British Columbia, Canada)

## Contributing Authors (CA)

**Touria Dafrallah** (Environment and Development Action in the Third World, Senegal)

**Conrado Heruela** (United Nations Environment Programme)

**Francis Kemausuor** (Kwame Nkrumah University of Science and Technology, Ghana)

**Reza Kowsari** (University of British Columbia, Canada)

**Yu Nagai** (Vienna University of Technology, Austria)

**Kamal Rijal** (United Nations Development Programme)

**Minoru Takada** (United Nations Development Programme)

**Njeri Wamukonya<sup>†</sup>** (formerly United Nations Environment Programme)

## Review Editor

**Jayant Sathaye** (Lawrence Berkeley National Laboratory, USA)

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# Executive Summary

## Key Challenges

- A quarter of humanity today lives without access to any electricity and almost one-half still depends on solid fuels such as unprocessed biomass, coal, or charcoal for its thermal needs. These people continue to suffer a multitude of impacts detrimental to their welfare. Most live in rural villages and urban slums in developing nations. Access to affordable modern energy carriers is a necessary, but insufficient step toward alleviating poverty and enabling the expansion of local economies.
- Even among populations with physical access to electricity and modern fuels, a lack of affordability and reliable supplies limits the extent to which a transition to using these can occur. Those who can afford the improved energy carriers may still not be able to afford the upfront costs of connections or the conversion technology or equipment that makes that energy useful.
- Beyond the obvious uses of energy for lighting, cooking, heating, and basic home appliances, uses for purposes that might bring economic development to an area are slow to emerge without institutional mechanisms in place that are conducive to fostering entrepreneurial activity and uses of energy for activities that can generate income. Without the expansion of energy uses to activities that generate income, the economic returns to energy providers are likely to remain unattractive in poor and dispersed rural markets.
- Significant success has been achieved with small pilot projects to improve energy access in some rural areas and among poor communities in urban areas. But subsequently, less thought is focused on how to scale-up from these small pilot and demonstration projects to market development and meeting the needs of the larger population.

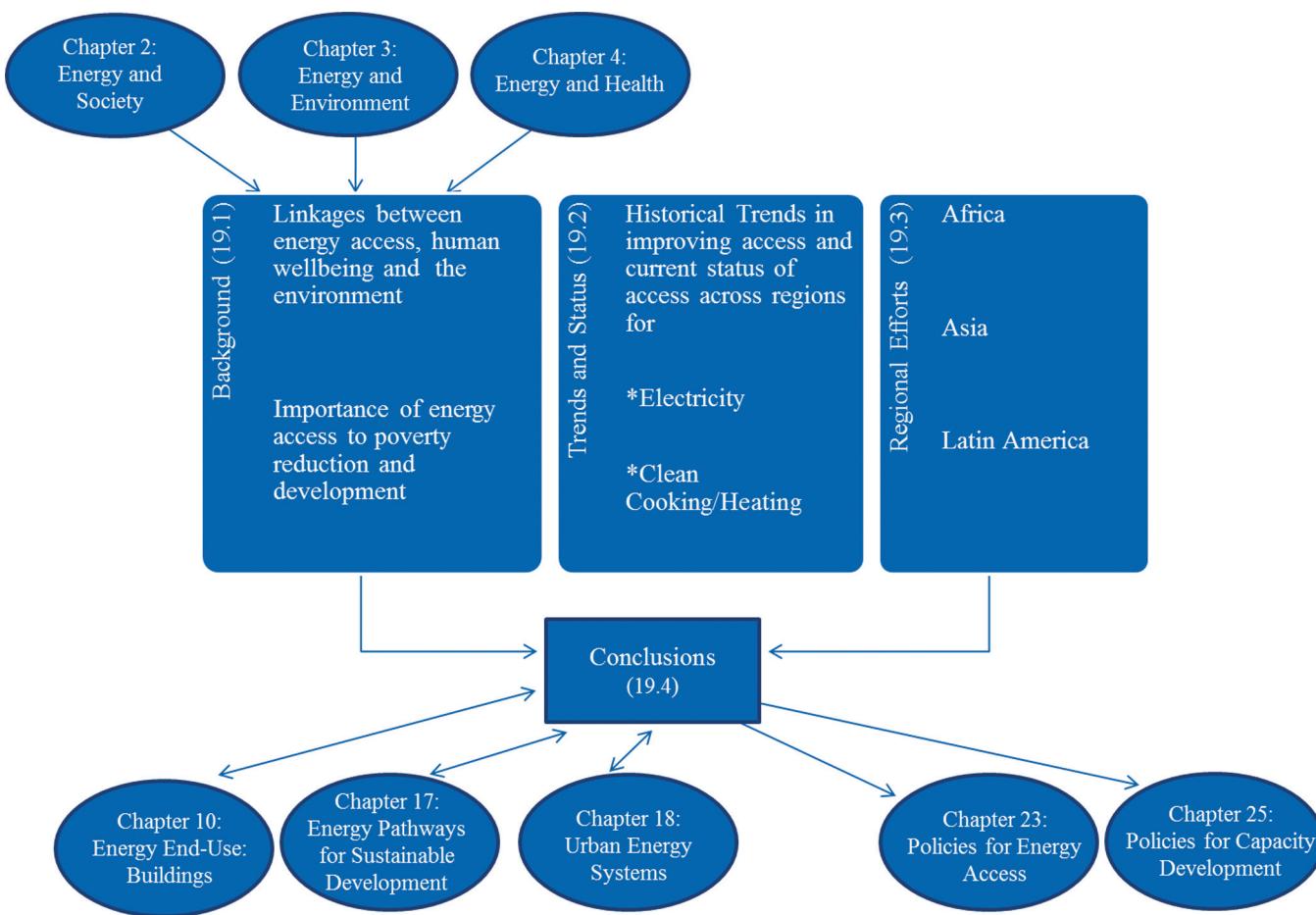
## Key Messages

1. While the scale of the challenge is tremendous, almost universal access to energy, both electricity and clean cooking for all, is achievable by 2030. As estimated in Chapter 17, this will require global investments to the tune of US\$36–41 billion annually, a small fraction of the total energy infrastructural investments required by 2030, and may have a negligible or even negative impact on greenhouse gas (GHG) emissions. Immediate benefits from improved health for millions of people will result and the socioeconomic benefits from improved energy access will extend well beyond those to the current generation.
2. Electrification rates have been more rapid and far in excess of population growth rates in many countries and regions such as East Asia (including China) and Latin America. Between 1990 and 2008, almost two billion people got connected to electricity globally. This provides a basis to believe that electrifying the remaining 1.4 billion people without electricity by 2030 is feasible.
3. The progress with providing clean cooking services globally has been rather dismal over the last decades, with the numbers of people dependent on solid fuels rising in the rural regions of most developing countries and the percentage of rural populations dependent on solid fuels virtually unchanged over the last decade. This suggests that transitioning the global population to clean cooking fuels by 2030 will not be feasible and for some populations, a transition to improved stoves will be necessary to improve their cooking experience. This will require significant advances to be made in rapid diffusion of low-cost, high performing and standardized stoves and more sustainable management and practices along the entire biomass value chain.

4. While the challenge is considerable, the experiences and approaches followed in countries that have been successful in achieving improved access provide important lessons that can be applied elsewhere to achieve universal access by 2030. This will require leveraging funding from public and private sources, both for necessary investments at the macro level, and for meeting costs for low-income households at the micro level. Creative financing mechanisms and transparent cost and price structures will be key to achieving the required scale-up and quick roll-out of solutions to improve access.
5. No single solution fits all in improving access to energy for development. Programs aimed at increasing access must be cognizant of local needs, resources, and existing institutional arrangements and capabilities.
6. Supportive policy and institutional frameworks need to be created that encourage private sector participation, as well as replicability and the scale-up and scale-out of successful programs.
7. Diverse sources of energy supply (fossil and renewable), a wide portfolio of technologies, and a variety of institutional and innovative business and energy service delivery models that are adapted to local circumstances and allow for sustainable replication, deliver social benefits, and generate wealth for the community are required to meet the challenge.
8. An enabling environment shaped by sustained government commitment and enhanced capacity building at all levels is paramount to ensuring access targets are met.
9. Complementary development programs and enhancement of market infrastructure are needed to ensure sustained economic growth and steady employment and income generation for the poor, in order to provide them with a means to pay for improved energy services.

## Structure and Roadmap of Chapter 19

Chapter 19 builds strongly on the concerns raised in Chapter 2 ("Energy and Society"), Chapter 3 ("Energy and Environment"), and Chapter 4 ("Energy and Health"). The Chapter is structured as follows (see Figure 19.1). Section 19.1 presents a brief overview of the linkages between energy access, human wellbeing, and the environment. It also lays the foundation for understanding why energy access is essential for poverty reduction and development. Section 19.2 assesses the historical efforts and trends and the current global status of access to electricity, clean cooking/heating fuels and stoves, and modern energy carriers for income generating activities. The following section, 19.3, provides a more differentiated and nuanced analysis of regional efforts and strategies to improve energy access in households and the status of access in each region. Finally, Section 19.4 concludes with lessons learnt and implications for the way forward. The role of policy and institutional issues is also discussed briefly in this chapter; however, a deeper discussion of this is left to Chapter 23, which focuses specifically on policies and measures for expanding energy access.



**Figure 19.1 | Roadmap of Chapter 19 and its linkages to other chapters.**

### Box 19.1 | Definitions and Dimensions of Access

The simplest definition of universal access to modern energy is the physical availability of electricity and modern energy carriers and improved end-use devices such as cook stoves at affordable prices for all. A target of energy access for all by 2030, set by the United Nations Secretary-General's Advisory Group on Energy and Climate Change (AGECC, 2010), recommends access to be provided in accordance with this basic definition so as to enhance services such as lighting, cooking, heating, and motive power for populations in developing countries. This is no longer only a moral imperative, but also socially prudent and an economic necessity to enable the almost one and a half billion people living without any electricity and over three billion dependent primarily on solid fuels to lift themselves out of poverty and improve their living conditions. Providing access to improved energy carriers is clearly a necessary, but insufficient condition for overall poverty alleviation and socioeconomic growth. Alleviating poverty, in its totality, clearly also requires improving the earnings of the poor by providing them with more sustainable livelihood opportunities through encouraging the use of energy in activities that can generate income. This requires defining access in a much broader sense and would require making available reliable and adequate qualities and quantities of energy and the associated technologies at affordable costs in a manner that is socially acceptable and environmentally sound so as to meet basic human needs and for activities that are income generating and could empower growth and development.

Such a broader definition of access includes several elements and dimensions, including quality, reliability, adequacy, affordability, acceptability, and environmental soundness. Unfortunately, national level indicators and statistics to measure and monitor these various dimensions of access are extremely scarce, particularly for the least developed countries and regions where the issue is the most pressing.

Within GEA, we abstain from defining any global quantitative thresholds for the minimum amount of energy needed to meet basic needs. This is because basic needs are normative and vary significantly between countries and regions depending on climate, social customs and norms, and other region and society-specific factors. We are, however, mindful of the fact that some national governments have defined basic or lifeline energy entitlements for their poorest citizens. In most cases, these fall within the range of 20–50 kWh of final electricity per household per month to meet basic lighting, communication and entertainment needs, and the equivalent of 6–15 kg of LPG per household per month for cooking. Heating requirements, being seasonal, are often approximated as the equivalent of 15–30 kWh useful energy per square meter of living space, annually. Defining lifeline entitlements in final energy units of course also has the limitation that efficiencies of end-use appliances and equipment are not accounted for.

Clearly, such entitlements fall far below what is required for purposes that can generate income to empower growth and development. Ensuring adequate amounts of energy to achieve this end may require defining some average energy equity thresholds and estimating not only direct energy needs, but indirect or embodied energy requirements as well. This is a much more complex endeavor and would require taking account of national economic and energy system structures and characteristics, as the same amount of energy can provide a wide range of energy services. Previous efforts at quantifying such equity thresholds provide estimates in useful energy terms in the range of 1–2 kW per capita to meet basic needs and much more (Goldemberg et al., 1985; Imboden and Voegelin, 2000).

## 19.1 Introduction

### 19.1.1 Background

Energy deeply influences people's lives and is an engine for social development and economic growth. Over the centuries, energy has helped transform societies and has underpinned human development. Energy contributes to fulfilling the most basic human needs, including nutrition, warmth, and light. Furthermore, there is ample evidence that access to reliable, efficient, affordable, and safe energy carriers can directly affect productivity, income, and health, and can enhance gender equity, education, and access to other infrastructure services. However, energy use patterns, in terms of both quality and quantity, are highly inequitably distributed on all sides of the development divide – North and South, rich and poor, men and women, rural and urban. This inequity in energy access and use compromises human welfare and has adverse impacts on the environment. The lack of access to reliable, affordable, and modern energy carriers,<sup>1</sup> particularly in rural areas of developing countries, is a major challenge faced by over one-third of humanity even today. This presents a major impediment to growth and compromises progress toward sustainable development. Providing access to electricity and modern energy carriers and/or devices<sup>2</sup> to all populations is not only a moral obligation, but is also necessary for improving living conditions and may provide economic returns in the long run that far exceed the costs involved.

The world still faces the task of satisfying the demand for energy services of a vast majority of its population to meet basic needs for lighting, cooking, and heating, and for use in activities that can generate income. Recognizing the centrality of improving energy access for the poor, the international community has been increasingly active in discussing the setting of a global energy access target. Several governments and regional bodies have already set national targets to improve access. Building on these, the United Nations Secretary-General's Advisory Group on Energy and Climate Change (AGECC, 2010) recommends ensuring universal energy access by 2030. Meeting such a target requires the provision of affordable<sup>3</sup> electricity and modern fuels and improved end-use devices by 2030 to all who currently lack access. To some, this may appear unattainable, but the technologies and examples of successful policies to achieve this already exist. The challenge to meet such an access target is greater, but can have even more significance

<sup>1</sup> Modern energy carriers in this chapter refer to electricity (grid or off-grid, both renewable and fossil-based) and liquid and gaseous fuels such as liquefied petroleum gas (LPG), biogas, ethanol, and natural gas.

<sup>2</sup> Modern devices refer to improved cook stoves (ICS) that meet a minimum efficiency and emissions standard and have a performance that matches that of LPG stoves. Access to such ICS are assumed to improve cooking energy service for the poor and are included in the universal clean cooking target discussed in Chapter 2 and analyzed in Chapter 17 on future scenarios for improving access.

<sup>3</sup> "Affordable" is evaluated in terms of the current spending on energy services and household purchasing power.

for the rural populations of the world. Before the beginning of 2008, rural areas contained more than half the world's population (UN, 2008), with nearly 90% of the rural population, close to three billion, living in developing countries. However, this half of the population still consumes only a small fraction of total global fossil fuels and electricity, and rural energy issues remain largely overlooked in national energy and developmental plans.

The use of unprocessed solid fuels, both commercial and noncommercial, on the other hand, is predominantly concentrated in rural areas of developing countries, and particularly among the poor. This remains the primary source of fuel for cooking and heating for most of the rural population in the developing world and many urban residents as well. Globally, over three billion people rely on solid fuels, largely biomass (wood and residues), charcoal, and coal for cooking and heating (UNDP and WHO, 2009). The use of biomass is both arduous and time consuming in its harvest, transport, and use and is associated with negative environmental consequences. The majority of biomass harvest is carried out by women and children and its negative impacts on them have been discussed in Chapter 2. Negative health impacts from this traditional use of biomass and other solid fuels, discussed in Chapter 3, include those due to household pollution, which accounts for an estimated almost two million deaths/year, with a higher percentage of these being women and children in developing countries (UNDP and WHO, 2009). Furthermore, the burning of wood fuels contributes to climate change through emissions of GHGs, as discussed in Chapter 4. When the biomass burnt is not sustainably harvested, the use of these fuels has the added disadvantage of no longer being CO<sub>2</sub>-neutral. As mentioned in Chapter 4, recent evidence also shows that the climate impacts of Black Carbon are larger than previous estimates suggested, particularly for the melting of arctic and glacial ice (Ramanathan and Carmichael, 2008). Black Carbon, or soot, is a byproduct of the combustion of fossil fuel, biofuel, or biomass, including wood waste and agricultural green waste (Grieshop et al., 2009).

Access to cleaner and more efficient end-use devices, processed biomass and/or more efficient fuels can alleviate the public health, welfare, and environmental concerns associated with traditional solid fuel use discussed in the preceding paragraph. In addition, such access can address the home heating needs of those who live in colder climates. In many societies, women and girls bear the disproportionate burden of fuel gathering, home care, and cooking, and hence the provision of more efficient and safer fuels and technologies can also contribute to reducing gender inequities in health and time burdens.<sup>4</sup> The performance of improved biomass cook stoves is wide ranging. However, throughout this assessment, when we refer to advanced stoves we imply stoves that have proven efficiency close to that of LPG stoves and the ability to reduce emissions that are health damaging.

<sup>4</sup> Truly enhancing equity for women and children will require significant additional social and cultural change and development. However, a full discussion of these issues is beyond the scope of this assessment.

In addition to lacking access to modern fuels and devices, about a quarter of the world's population also still lacks access to any electricity (UNDP and WHO, 2009). Over 85% of those lacking access live in rural and peri-urban areas (Derdevet and Caubet, 2007). In essence, four out of five people without electricity live in rural areas in developing countries, predominantly in the least developed countries of South Asia and sub-Saharan Africa (UNDP and WHO, 2009). Thus even today, the services that electricity makes possible, from basic lighting and telecommunications with mobile phones to computer-controlled agro-industrial processing, remain outside the reach of many people in the developing world. The communication revolution was first unleashed by radio, television, and computers and has now advanced with mobile telephony and the internet. These tools have become essential for individual empowerment, enterprise development, and the functioning of social infrastructure. Access to such modern media, efficient lighting, and other labor-saving devices are impossible without electricity.

It is widely recognized that improvements in access to more efficient energy carriers, both electricity and fuels, can have huge impacts on the lives of people, particularly the poorest in the developing world (WHO, 2006; Kanagawa and Nakata, 2007; World Bank, 2008a; Hiremath et al., 2009; Khandker et al., 2009). Chapter 2 highlights the multitude of benefits that improvements in energy access can make possible for the poor. In addition to the social benefits, energy is also essential for improving productivity, which is crucial for bringing the rural poor out of subsistence activities. Irrigation pumps, processing capability, storage, and access to markets and market information is not possible without adequate energy services, increasingly enabled through electricity and mechanical power. The growth and facilitation of enterprises is also intimately linked to access to energy. Communal services such as schools and health centers also require energy. In addition, the existing base of technological infrastructure provided by standardized motor fuels is an enabler of lowered transportation costs, which allows the movement of goods and people. Expanding access to better quality energy for the poor and unserved therefore remains a major developmental and environmental challenge for the world, particularly in the case of the Least Developed Countries (LDCs).<sup>5</sup> National energy policies and poverty reduction strategy papers in these countries very often either neglect energy completely or focus solely on electrification. They neither reflect adequately the energy-poverty nexus nor include targets and timelines to meet the energy needs of the poor. Often there is also a misalignment between national priorities and budgetary allocations for rural energy, resulting in a lack of coherence between strategies and plans and program implementation on the ground (UNDP, 2007a).

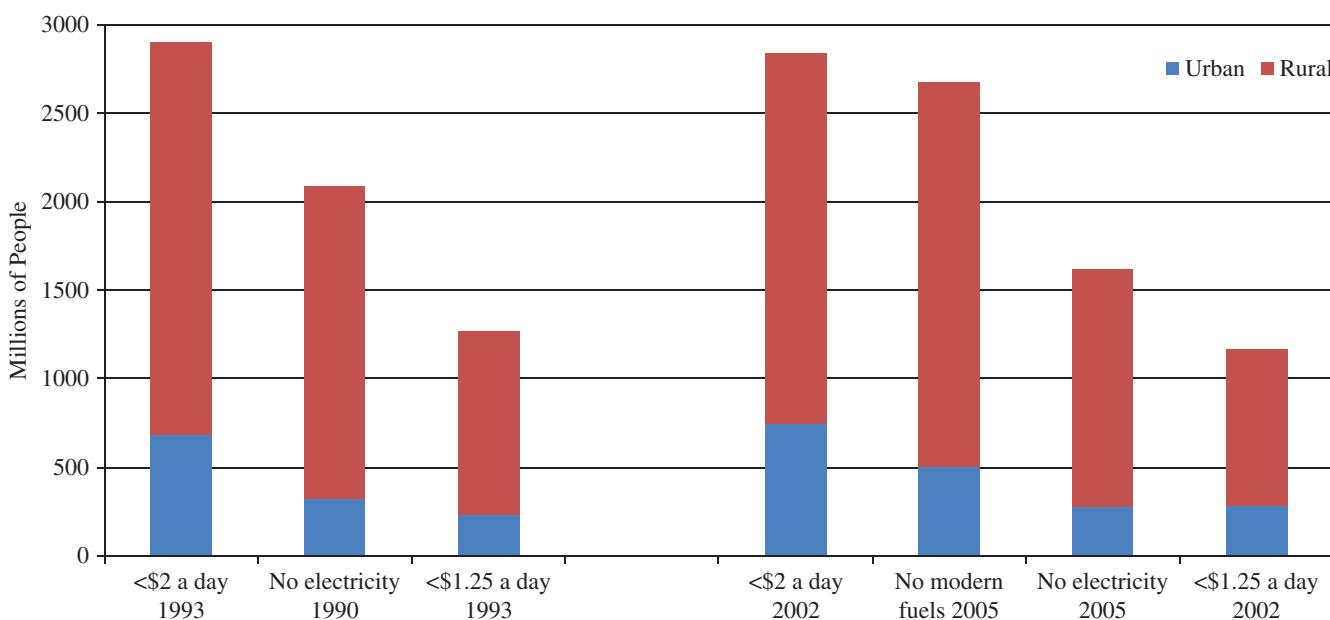
### 19.1.2 The Poverty-Energy Relationship

Access to electricity and modern energy carriers that help fulfill energy service needs is of key importance in future efforts at poverty reduction and development, both in rural and urban areas. Chapter 2 includes a detailed discussion of the role of energy in achieving the Millennium Development Goals (MDG). In addition, Chapter 18 deals with the challenges and issues surrounding the lack of adequate and affordable energy access in urban centers. This chapter focuses more specifically on assessing the nature of the access challenge both globally and regionally, and reviewing the progress made to date in improving access in developing countries and regions.

We distinguish between rural and urban areas because the issues related to rural poverty are fundamentally distinct from those of urban poverty and the challenges related to providing access to energy for the rural poor differ from those in urban areas (for further discussion on this topic, see also Chapters 2 and 17). About 75% of the developing world's poor currently live in rural areas, with some marked regional differences (Chen and Ravallion, 2007; Ravallion et al., 2007). Analyses for very different countries, like Brazil, Ecuador, Thailand, Malawi, and Viet Nam, show that poverty rates tend to be higher in remote rural areas than in more accessible areas, and poverty is deeper and more severe in remote areas. While the numbers of rural poor are declining globally, poverty rates in rural areas remain very high, particularly in some regions, and the energy problems of the rural poor persist. The numbers of urban poor, on the other hand, have grown during the last few decades. Indeed, it has been argued that urbanization has helped reduce overall poverty, except that this is shown to be true more for rural poverty than for urban poverty (Ravallion et al., 2007; World Bank, 2008b).

Poverty is linked not only to deprivation of income, but also a lack of access to resources and assets, social networks, voice, and power (UNDP, 2010). Poverty, particularly in rural areas, is often accompanied by both a lack of access to electric power services and an extreme dependence on unprocessed biomass, coal, or charcoal for basic uses such as cooking, water and home heating, as well as a lack of adequate and appropriate energy carriers for use in activities that are income generating. There tends to be a two-way causal relationship between the lack of access to adequate, affordable, and appropriate energy forms and poverty. This has often been termed the "energy-poverty nexus" (UNDP, 2006; Masud et al., 2007) or the "vicious cycle of energy poverty" (WHO, 2006). The cycle is considered vicious because households that lack access to appropriate energy are often trapped in a vortex of deprivation. The lack of energy, in addition to insufficient access to other key services and assets, affects productivity, time budgets, opportunities for income generation, and more generally, the ability to improve living conditions. The low productivity and livelihood opportunities, in turn, result in low earnings and no or little surplus cash for these people. This contributes to the poor remaining poor and consequently, also energy poor, since they cannot afford to pay for improved energy services

<sup>5</sup> We follow the UNDP classification of Least Developed Countries and Developing Countries. Please refer to UNDP and WHO (2009) for further details of the countries included.



**Figure 19.2 |** People living in poverty and with lack of access to electricity and modern fuels. Source: data from IEA, 2002; 2007; Ravallion et al., 2007.

(often neither the fuels nor the equipment). Thus the problem of poverty remains closely intertwined with a lack of energy. This is also evident from looking at the data on the incidence of poverty and lack of access to electricity and more efficient liquid or gaseous fuels, termed “modern fuels” (see Figure 19.2).

Paradoxically, the communities that are the poorest in terms of access to energy are also often the most vulnerable and unable to cope with the threats of climate change. This is because these communities are often those most dependent on their local ecosystems for their livelihoods and energy needs. The Intergovernmental Panel on Climate Change described Africa, the world’s poorest region, as “the continent most vulnerable to the impacts of projected change because widespread poverty limits adaptation capabilities” (IPCC, 2007). As these ecosystems are increasingly affected by climate change, the communities dependent on them will need other energy options and livelihood opportunities (Johnson and Lambe, 2009). Diversifying the energy sources available to these communities could thus also be an important means of enhancing the adaptive capacity of these regions.

### 19.1.3 The Role of Energy Access in Poverty Reduction and Rural Development<sup>6</sup>

Energy can reduce poverty and enable development in direct and indirect ways (Cabraal et al., 2005). Chapter 2 provides a detailed discussion

of the role energy can play in meeting the MDGs, more specifically in reducing poverty and improving literacy, health, gender equity, and community services, as well as how energy contributes to other positive social and environmental outcomes. All of these improvements in welfare constitute an improvement in social and human capital, which in turn can enhance the potential for higher income generation. Energy can also have a more direct influence on income in a variety of ways, such as making possible labor-saving mechanization, freeing up time, and increasing the length of productive hours in a day. The provision of energy itself is necessary, but insufficient to achieve these positive developmental benefits. To reap the largest positive impact, additional efforts and institutional mechanisms conducive to fostering entrepreneurial activity and uses of energy for activities that can generate income are also required.

Mechanical power provides energy services for productive uses and basic processing in many different rural livelihood activities undertaken in enterprises, farms, mines, workshops, forests, wells, and river crossings, to name a few. These energy services are fundamental to rural livelihoods and to the efficient transformation of natural resources into vital products and services, which results in wealth creation for producers and affordable prices for consumers.

Historically, progress in reducing rural poverty in many countries has gone hand in hand with agricultural development (World Bank, 2008b). While economists have struggled to disentangle the multiplicity of factors that enable agricultural growth, studies from Asia show that irrigation has played a prominent role. In particular, groundwater irrigation can be an important means of securing access to water as it allows farmers greater control over the amount and timing of irrigation. However, groundwater

<sup>6</sup> This section draws heavily on Chapter 2 and Chapter 6. Energy access alone is insufficient for development. Several other factors are essential to the development process. A fuller discussion of all these enabling factors is, however, beyond the scope of this assessment.

### Box 19.2 | The Role of Energy in Powering Rural Development in India

Literature providing evidence to support the hypothesis that agricultural growth has a strong impact on poverty reduction is well developed in the context of India, a major player in the Green Revolution (Ahluwalia, 1978). In India, groundwater irrigation was predominantly enabled by motorized pumps, either electric pumps energized through highly subsidized grid power or diesel pumps energized through low cost diesel fuel (the diesel is also subsidized). Barnes et al., (2002) report that irrigation led to income gains from 45–80% for farms of varying sizes.

More recent evidence from Gujarat state in India has also demonstrated the importance of access to electricity to rural businesses. A new scheme called *Jyotigram* was implemented in Gujarat to ensure reliable 24/7 metered supply for any nonagricultural use. Initial evidence suggests that this change from an unreliable 12 to 18 hour supply has increased rural prosperity through increased nonfarm activity as well as access to electricity for social infrastructure and communications (Shah and Varma, 2008).

irrigation requires energy to lift water. For growing cereal crops, this is difficult to achieve without mechanized pumps. Access to mechanized water pumps can increase incomes in multiple ways, such as:

- improving yields due to reduced risk from rainfall variability;
- facilitating a switch from single- to multi-cropping and more remunerative cash crops; and
- increasing the willingness of farmers to invest in fertilizer, improved seeds, and other farming technologies which further increase agricultural productivity, as the risk of crop failures is reduced.

The positive impact of irrigation for agricultural development and its contribution to food security, income generation, and poverty reduction has not been uniform across different regions. In general, unless the cost of irrigation is a small fraction of the value of the food produced, the enabling developmental outcomes are unlikely to materialize. Tube well irrigated agriculture in India uses on average close to 1000 kWh of electricity per hectare of irrigated land (Srivastava, 2004). With electricity supply to Indian farmers being highly subsidized, the costs associated with such mechanized irrigation remain low. While this has resulted in a litany of environmental problems associated with the over-pumping of groundwater in certain regions of India, the improvements in irrigation have been critical in creating the surpluses in food production, which in turn have enabled a transition to a more diversified economy, higher incomes, and now, with an increasing emphasis on female education, may also be helping drive a demographic transition.

In many sub-Saharan African countries with poor existing electricity grid infrastructure and very low rural demand densities, the cost associated with providing electric power for mechanized water pumps tends to be much higher. Moreover, with the exception of a few countries such as South Africa, Nigeria, and Tanzania, which have ample coal and/or natural gas resources, mechanized irrigation in the region

remains dependent upon diesel pumps or grids that rely on heavy fuel oil-fired generators. In either case, the effective cost of generation (at least at the margin) is often much higher than US¢10/kWh. Indeed it is not unusual for costs of power and equipment to add up to as much as US¢30–40/kWh, thus making the cost of energy prohibitively expensive for higher food production in these regions (Modi, 2010). Reliable and reasonably priced energy is an essential ingredient for many aspects of improved or value-added agricultural and post-harvest processes, and is pivotal to enabling development and lifting millions out of poverty. Enhanced productivity in agro/food processing, artisanal activities, and microenterprises has the potential to boost economic development and improve livelihoods. In areas where electricity grids are unable to reach populations, the availability of decentralized mechanical power is particularly important for increasing the social and economic opportunities of the poor. Ironically, despite the importance of this energy service, there exists little data on mechanical power in developing countries.

Access to mechanical power can help increase efficiencies and effectiveness in production, thus raising income levels, which is an important factor for graduating from subsistence production (Box 19.2). A survey carried out in 2005 by the United Nations Development Programme (UNDP) in the villages of Sikasso and Mopti in Mali, showed that women earn additional revenue averaging US\$68/year through access to mechanical power from multifunctional energy platform services. Taking into account their expenses, this translates into an average US\$0.32/day, or US\$44/year of additional income. The cost-benefit ratio is estimated as at least 1:2.5, given that the intervention cost is between US\$80–90 per direct client (i.e., woman user) and that the minimum lifespan of a platform's engine is five years. In a country where the average gap between the dollar-a-day international poverty line and the mean income of the poor is US\$0.37/day, the additional income is a significant step towards poverty reduction (UNDP, 2005).

Improvements in energy access, in addition to having a positive impact on agricultural production, processing and marketing, can also

### Box 19.3 | “Sol de Vida”: Empowering women through Solar Technologies in Costa Rica

Building solar cookers has achieved more than just providing alternative energy sources in the Guanacaste region of Costa Rica. The project has built and emphasized links with women’s empowerment by creating new organizations led by women. Empowering women to take actions on their own, particularly regarding environment and livelihood issues, is a central goal of the program. So far, ten such community organizations have been created.

The solar oven promoted by Sol de Vida has been refined over the years to meet the specific needs of Central American families and continues to evolve to work under local conditions. The stove is basically a wooden box set inside another box, surrounded by insulation. The oven is covered by two panes of glass through which sunlight passes to heat the oven to an average temperature of 150°C. The stove can be built with US\$100–150 worth of locally obtainable materials.

This project illustrates how a new form of energy use can be fully integrated into the lifestyle of a community. Use of the solar cookers is sustained because women build the stoves themselves. Women who learn how to build these stoves can then teach others to duplicate them at the same low cost.

Casa del Sol also creates locally adapted models of solar-powered stoves, water pumps, water heaters, and crop dryers. Educational programs at the Casa del Sol also help improve knowledge about these technologies, some of which can be reproduced locally. In fact, they have designed a parabolic solar stove which they hope to export.

Source: GEF and UNDP, 2003

catalyze a diversification of the rural economy into off-farm activities. Energy access can enable households to engage in a more diverse range of income-generating activities and contribute to the development of home enterprises, rural businesses, and cottage industry. The provision of adequate and affordable thermal, mechanical, and/or electrical energy is crucial for the development of rural entrepreneurship and microenterprises that often provide a significant proportion of off-farm employment opportunities in developing countries. Households are less likely to have a nonfarm enterprise and also have a lower income share from such activities if they live in a location that is more remote, has lower quality roads, lacks access to electricity, and suffers from frequent electricity blackouts. Evidence from rural Indonesia suggests that improvements in village-level infrastructure between 1993 and 2000 were associated with increases in the share of households having nonfarm enterprises (Gibson and Olivia, 2010). Dependable, reasonably priced energy access can contribute to the development and maintenance of small and medium enterprises in several ways. Mechanization and equipment upgrades can transform labor-intensive, low-production enterprises into high value-added operations, increase operating hours, and promote communication. Other benefits of improved access to energy in small enterprises are better efficiency and quality of work, better working environment, and a more attractive and secure environment for customers. In many instances, rural enterprises, especially home-based ones, are run by women. Reaching this segment of the population can serve the dual purpose of improving incomes and gender equity in these communities (Box 19.3). Promoting uses of energy that can enhance income, for

both agricultural and off-farm activities, can work directly and effectively in enabling rural economic development. Recent evidence from South Africa suggests that electrification significantly raised female employment within five years. Several pieces of evidence suggest that household electrification raised employment by releasing women from home production and enabling microenterprises in South Africa (Dinkelmann, 2010).

#### 19.1.4 The Nature of the Access Challenge

Chapter 17 explores a number of interesting future scenarios for the global energy system to the year 2100. Scenarios have also been developed for household access to electricity and clean cooking until 2030 across key regions of the developing world. As a background to developing these access scenarios, this chapter provides an assessment of the historical progress of improving access. The two key indicators of relevance to this chapter, for which scenarios have been developed in GEA, are as follows:

- “People without access to electricity,” which refers to populations that have no access to electricity; and
- “People without access to modern fuels or stoves,” which refers to populations relying on traditional inefficient cooking devices (excluding improved solid fuel and clean-burning kerosene stoves) and solid fuels, including unprocessed biomass, charcoal, and coal.

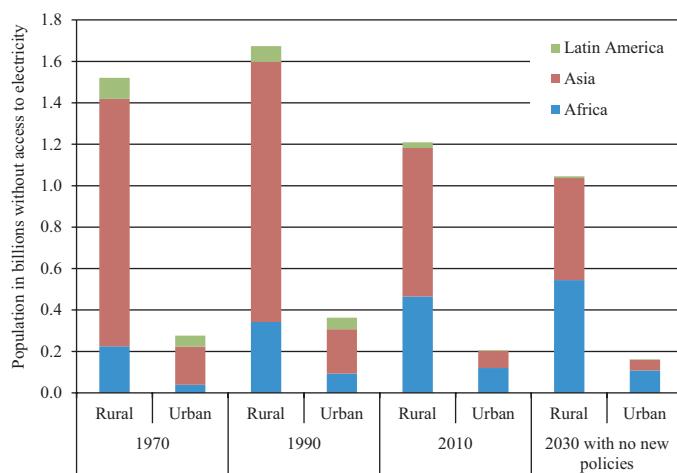
As an input to the GEA scenario development process, a set of projections were generated for the simplest forms of these indicators for which data was available, namely populations with no access to electricity at the household level and populations relying on unprocessed biomass, coal, or charcoal for cooking and heating.

#### 19.1.4.1 Electricity

Globally, less than 68% of the rural population has access to electricity (IEA, 2010b). Two-thirds of the global population lacking electricity access are located in sub-Saharan Africa and South Asia. The region with the lowest electrification level is sub-Saharan Africa, where only 11% of the rural population has access to electricity (UNDP and WHO, 2009). Over 600 million people, more than a third of all those without access to electricity in the world, live in South Asia.

It has been estimated that over 1.2 billion people globally will still lack electricity access in 2030 (IEA, 2010b) without the implementation of any new policies in addition to those already announced in 2010. Electricity for all by 2030 will therefore clearly not be achievable if global events are to unfold in line with current estimated projections (Figure 19.3).

A look at the historical progress with electrification reveals a mixed picture (Figure 19.3). Between 1970 and 1990, the total population without electricity access increased because population growth largely outstripped the pace of electrification in most regions of the world. Between 1990 and 2010, there was a decrease in the global population without electricity as the pace of electrification accelerated in certain countries like China and regions such as Latin America. Scenario analysis carried out in Chapter 17 for the three regions of South and Pacific Asia and sub-Saharan Africa also indicates that between 30–40% of the rural populations in these regions will continue to remain unelectrified in 2030 without additional policies and measures to accelerate access



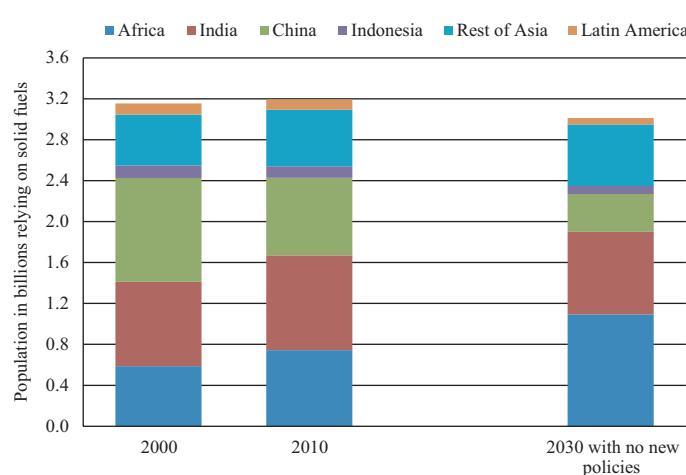
**Figure 19.3 |** Population without access to electricity in households in developing regions. Source: data from World Bank, 1996; IEA, 2002; UN, 2008; UNDP and WHO, 2009; IEA, 2010b.

to electricity. In sub-Saharan Africa over 70% of the rural population will remain unelectrified by 2030 without additional new policies. However, if global events were to unfold differently such that a fast track to providing electricity for all by 2030, or not much later into the future, is targeted, various policy interventions would be needed to accelerate the provision of electricity supply to households through a combination of grid and off-grid options over the next twenty years. This would require a steep acceleration in the rate of connecting new households in South Asia and sub-Saharan Africa, at a pace similar to what occurred in East Asia/China in the 1980s and 1990s. In effect, almost 20 million new households would have to be connected every year between 2010 and 2030 in order to meet the global target.

#### 19.1.4.2 Solid Fuel Dependence

Current projections on the number of people dependent on solid fuels for cooking and heating differ in some ways from those for electricity. First, there are three developing regions of major concern, including East Asia/China in addition to South Asia/India and sub-Saharan Africa. Second, populations with no access to clean cooking fuels have continued to increase over the last decade, except in the case of China. The monotonic increases in people dependent on solid fuels in sub-Saharan Africa and the rest of Asia (excluding China) are very worrying indeed. It is estimated that almost three billion people will not improve their energy situation for cooking and heating by 2030, if current trends continue (Modi et al., 2006; IEA, 2010b). The GEA scenario analysis presented in Chapter 17 also indicates that the numbers of people dependent on solid fuels is projected to remain almost unchanged until 2030 if no new policies beyond those already in place by 2010 are implemented (Figure 19.4).

Given these trends, encouraging the use of improved stoves might be an additional way of increasing the efficiency and sustainability of the use



**Figure 19.4 |** Population dependent on solid fuels in households in developing regions. Sources: IEA, 2002; UN, 2008; UNDP and WHO, 2009; IEA, 2010b.

of biomass. Improved stoves vary widely in terms of performance, efficiency, and emissions. Better quality control and standards are clearly needed to regulate the improved stoves market. However, even relatively simple and inexpensive artisan-produced improved stoves can reduce the amount of fuel needed for cooking by as much as 20–35% (GVEP, 2009). Future scenarios for improving access to the energy services needed for cooking and heating thus consider both shifts and transitions from the use of solid fuels to more efficient liquid or gaseous fuels and the wider dissemination of improved stoves to the poorest households who are likely to continue to depend on biomass fuels in the shorter term.

Given this rather gloomy picture, is there any realistic basis for envisioning a fast track approach to providing universal access by 2030, as far as clean cooking and heating services are concerned? What possible developments at the global, regional, national, and subnational levels, and what possible policy options, could lead to deep cuts in the numbers of people dependent on solid fuels? What would be the constituting elements of such a paradigm shift and what are some of the experiences to date that would point in this direction? The following sections will review the experiences to date and provide answers to some of these key questions. Specific policies needed to achieve such desirable future scenarios will be discussed in Chapter 23, which deals specifically with policies and measures for energy access.

## 19.2 Past Efforts and Current Status

### 19.2.1 Access to Electricity

#### 19.2.1.1 Historical Experience and Current Status

Electricity was first commercially supplied to the public in the mid-19th century in the United Kingdom, and thereafter spread quickly throughout Europe and the United States (Smil, 2005). As many nations attained independence in the 20th century, providing electricity access to their population was considered a prerequisite to modernization and progress and therefore accorded priority by the governments of these countries early on in their development. The political and social pressure to expand electrification was high in these nations, but the financial resources for doing so were often limited. As a consequence, electrification was pursued with uneven ambition and success. The historical model of pursuing electrification through a centralized energy system made it possible to benefit from economies of scale and to supply electricity to a mass market in many industrialized nations. However, this very paradigm, emphasizing the extension of a centralized grid network, also hampered a more rapid spread of electricity infrastructure to remote rural and low population density regions in many developing countries where it was not economical. In most countries, industrial and urban customers were the first to be supplied and the electrification of rural areas lagged behind.

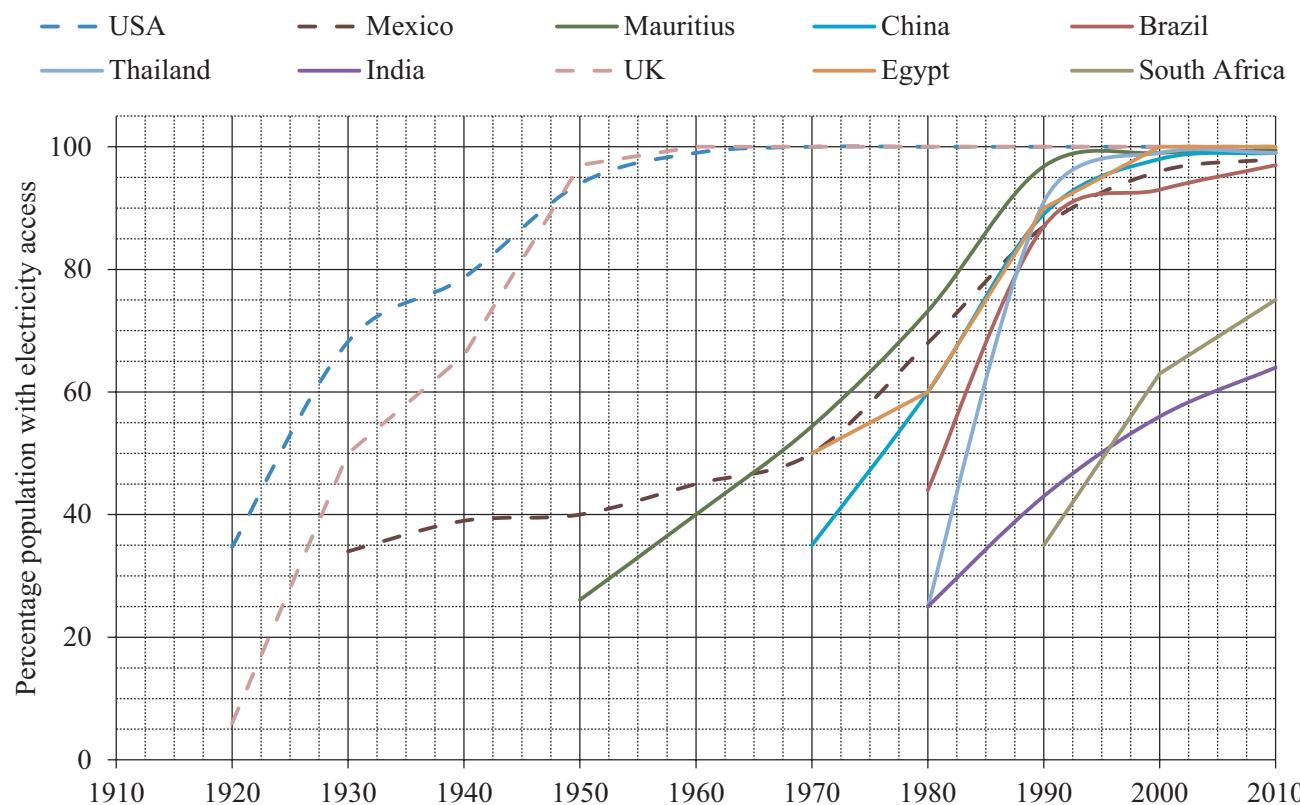
The pace at which electrification occurred historically has been very different across nations (Figure 19.5). While Mexico took almost 90 years to electrify most of its population, Thailand achieved this in essentially a period of 20 years. While a number of factors are responsible for the uneven rate at which electrification occurred across different nations, the historical evidence supports the view that, given the commitment, an appropriate level of investments and appropriate institutional mechanisms, fast tracking the provision of electricity access is possible.

The more recent experience with electrification improvements across regions continues to remain very uneven, but provides a basis for hope. Between 1970 and 1990, over a billion people gained access to electricity, more than half of these in China alone. Between 1990 and 2008, almost two billion people gained access to electricity (Figure 19.6). In Latin America, North Africa, the Middle East, and East Asia, the pace of electrification outstripped the rate of growth of the population by a large margin, so that access significantly improved. In South Asia, the progress has been more uneven. However, in the period since 1990, the pace has increased. In sub-Saharan Africa, the rate at which new electricity connections have been provided over the last four decades has been consistently lower than the rate of population growth. This has been particularly true in rural areas.

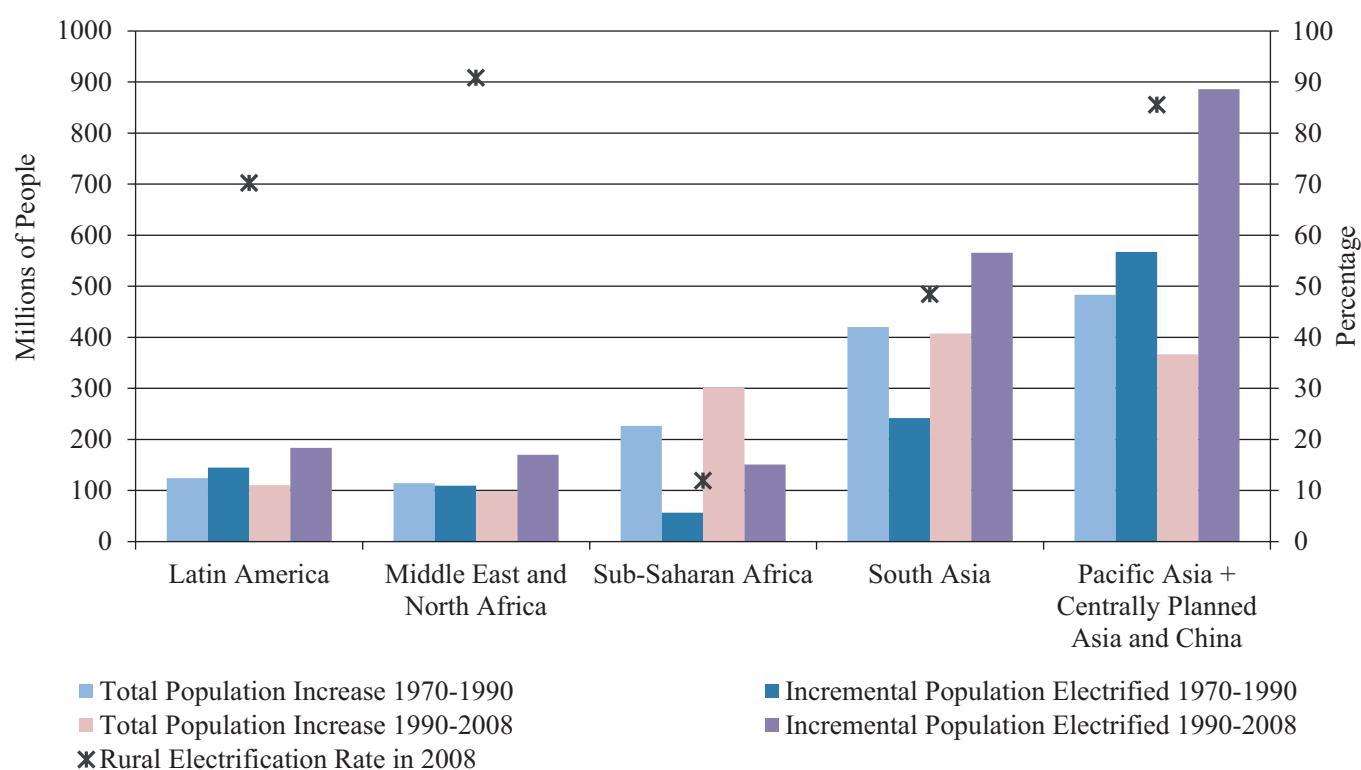
Unfortunately, the region that faces the lowest rate of electrification today and the greatest challenge in increasing access, particularly among its rural population – sub-Saharan Africa – is also the region where the rural population density in areas without light is among the lowest in the world (Figure 19.7). This has implications for future options for expanding electricity access to these areas. Clearly, a diversity of electrification solutions is needed to increase access and centralized grid electrification alone may not be the optimal choice in all cases.

While access to electricity has been successfully extended to almost two billion people in the past 20 years, the overall picture is more complex. There is a dynamic associated with getting connected, staying connected, and increasing consumption in a situation of constrained supply. Many poor households that are connected face challenges in staying connected and increasing consumption beyond minimum levels due to poor quality, inadequate supply, and unaffordable connection costs and tariffs (PRAYAS, 2010). Per capita levels of consumption in rural areas in developing countries remain extremely low and in the case of some countries, have even declined because the growth in electricity supply to these regions has not been able to keep pace with rate of population increase and growth in demand.

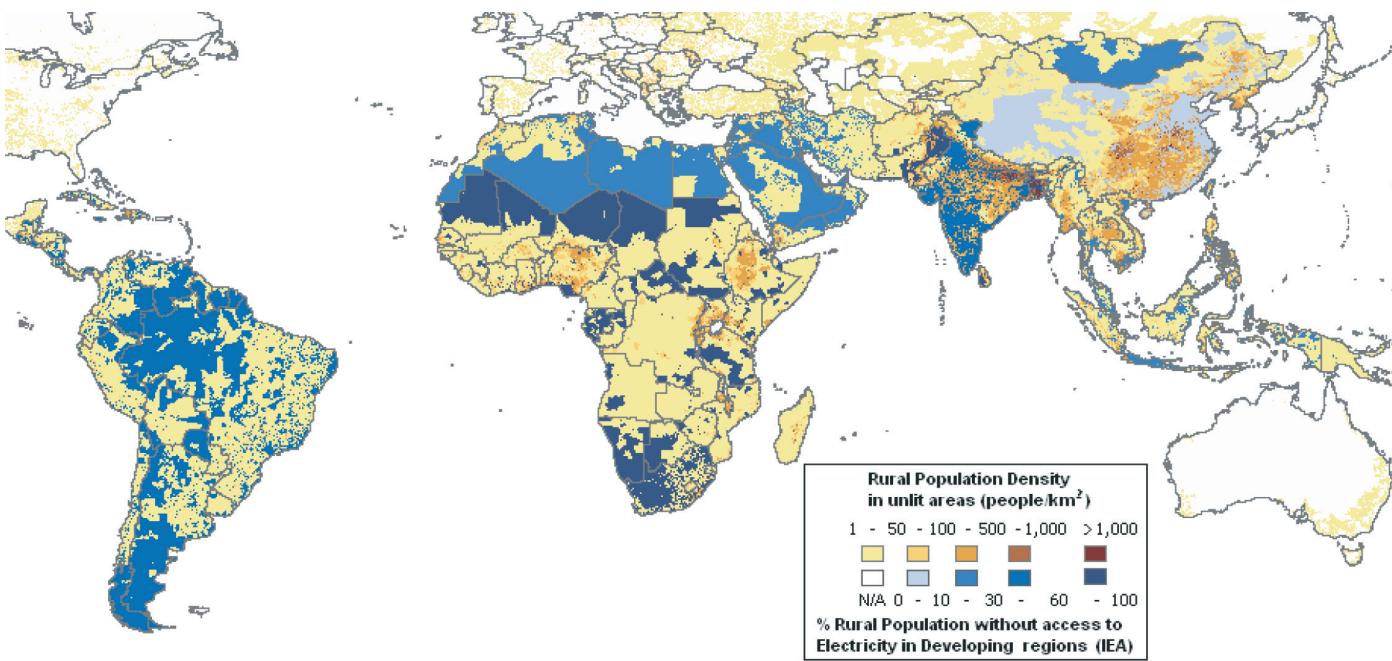
Variations in the level of electricity consumption across nations, across rural and urban residents, and within rural and urban areas across income levels and different segments of the population, are very large. Just providing electricity connections does not ensure adequate access if the reliability and quality of supply remains exceedingly irregular or households just cannot afford sufficient amounts because of their exceedingly



**Figure 19.5 |** Historical experience with household electrification in select countries. Source: Byatt, 1979; Goldemberg et al., 2004; Shrestha et al., 2004; UNDESA, 2004; Karekezi et al., 2005; Pan et al., 2006; Pachauri, 2007; UNDESA, 2007; Bekker et al., 2008; Collins, 2009.



**Figure 19.6 |** Change in population and electrified population by region between 1970 and 2008. Source: data from World Bank, 1996; IEA, 2002; UNDP and WHO, 2009; IEA, 2010b.

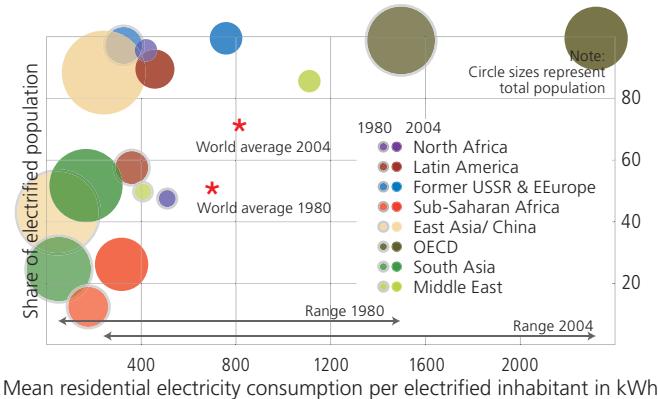


**Figure 19.7 |** Rural population density in unlit areas overlaid with regional estimates of population without access to electricity. Source: Doll and Pachauri, 2010.

low incomes and purchasing power. Figure 19.8 depicts changes in the mean residential electricity consumption per electrified inhabitant for major regions of the world. The average residential sector electricity consumption per electrified inhabitant is lowest in South Asia, even though a much larger proportion of the population has access to electricity in South Asia than in sub-Saharan Africa. The higher mean residential electricity consumption in sub-Saharan Africa is a consequence of the relatively high electricity consumption in South Africa. Excluding South Africa from sub-Saharan Africa would result in a lower average consumption for that region as a whole. South Africa has been relatively successful in improving access and increasing consumption of electricity even in low-income households through innovative financing and tariff schemes for providing lifeline electricity entitlements to the poorest consumers. However, issues relating to adequate metering and monitoring need to be resolved before such schemes can be implemented on a wider scale (see Box 19.8 for a fuller discussion of South Africa's lifeline electricity entitlement policy).

#### 19.2.1.2 Social and Efficiency Benefits from Improved Energy Service through Electrification

Immediate applications of electricity in newly electrified households are for lighting and appliances, communications, and entertainment. Among community needs, public/street lighting, refrigeration, health centers and schools, piped water, communication, and the like are often cited. As already mentioned above in Section 19.1.3, electrification also benefits productive enterprises and agricultural activities. Electrification has the potential to be particularly beneficial to women, as their daily



**Figure 19.8 |** Changes in residential electricity consumption and access. Source: Pachauri, 2007.

drudgery is reduced, their safety is enhanced, and the availability of lighting allows them to spend more time on leisure or productive activities. Electrification can also influence social capital and civil society. Well-lit streets, illuminated buildings, and systems of mass transit all increase mobility, giving citizens the ability to participate in community activities. These and other multiple benefits that are made possible through access to electricity have also already been described in Chapter 2.

Households also benefit from the use of many types of appliances that use electricity. There is a clear progression in terms of the energy services enjoyed by those connected to electricity. The first use is for lighting and entertainment. Thereafter, a wide array of benefits are potentially available – from security, comfort, and convenience to education, health, and

home productivity –made possible by appliances such as electric lamps, radios, televisions, computers, refrigerators, fans, stoves, and electric pumps. In 2008, the Independent Evaluation Group of the World Bank (World Bank, 2008a) confirmed the findings of earlier World Bank work that valued the benefits of household lighting at US\$5–16/month and the added benefits of entertainment, time savings, education, and home productivity at US\$20–30/month (World Bank, 2002). These amounts are much higher than the US\$2–5/month that a household typically pays for electricity service. However, even these low payments are often beyond the reach of cash-stripped, poor households and cannot be afforded despite the large potential benefits and high value attached to these services.

Access to electric lighting can even save households money through efficiency gains. Estimates of the effective cost of electricity for home lighting, computed on the basis of the cost of an equivalent amount of electricity needed to deliver the same amount of lighting as that provided by kerosene, are as high as US\$3–4/kWh. Similar high costs are involved when one computes the cost of electricity obtained from batteries that are poorly charged and discharged. Surveys for Millennium Villages in Africa show that nearly half of households surveyed spend about US\$5/month on such poor substitutes for electric lighting (Figure 19.9). This is because the substitutes to electricity used for lighting, such as kerosene or candles, are extremely inefficient (Figure 19.10). In addition to being highly inefficient, the use of kerosene and candles for lighting are associated with fire and poisoning hazards. These have been quantified for the case of South Africa in Spalding-Fecher (2005).

#### 19.2.1.3 A Multitrack Approach for Future Electrification

Traditionally, the centralized model for electrification has been followed in most nations. To improve the status of access in the future, multiple tracks should be explored. Development strategies should consider innovations in the development and deployment of economically accessible distributed energy sources. Many renewable energy strategies look for land and natural resource conditions available in less developed landscapes where rural communities reside. The potential for providing meaningful livelihood options related to distributed energy supply and usage may provide a broader set of development pathways than those currently envisioned. Development of strategies along a more holistic framework that takes account of the socioecological system and incorporates development goals is needed.

While the reasons for continued lack of access to electricity are complex, there are two main reasons why many poor and rural households are still not connected to a source of electricity supply. The first is that a connection is not possible due to distance from a source of supply. The second is that even though the grid may pass through the community, some households cannot afford the cost of electricity installation. If the connection of low-income households is to be made financially

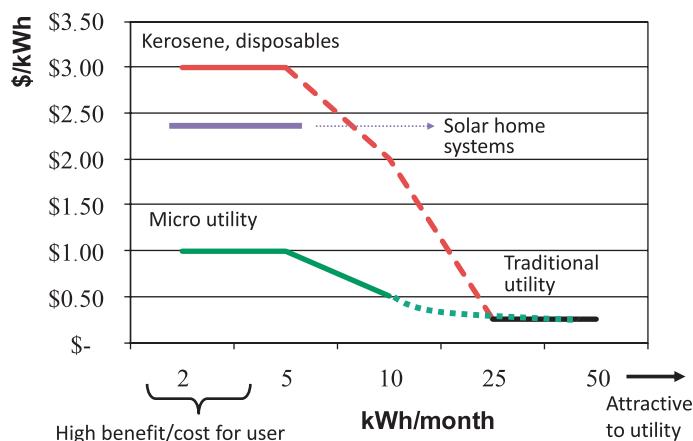


Figure 19.9 | Effective costs for lighting services. Source: Modi, 2010.

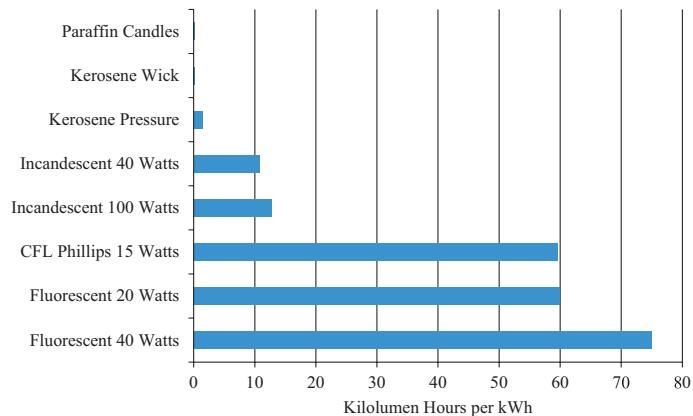


Figure 19.10 | Relative efficiency of different sources of lighting. Source: World Bank, 2010b.

viable to utilities, then special approaches are required to address the problem of low revenue caused by very low levels of consumption, and the highly dispersed and low density of consumers, particularly in rural areas. In addition, the connection and supply costs of providing electricity to low-income households need to be reduced by adopting least-cost options.

Success in the continued expansion of electricity access means adapting programs to local contexts and country environments. The past has witnessed strong advocates for centralized grid approaches to rural electrification, as well as more decentralized off-grid approaches. More recently, countries have adopted strategies that include both grid and off-grid approaches executed by various types of institutions, including public and private companies and large and small nongovernmental or microfinance organizations. Such a multitrack approach is based on the costs of supply, expected electricity demand, and development impacts of the project. The rationale is based on the difference in the cost of supply in areas with different socioeconomic and geographic profiles. Studies have shown how the cost-effectiveness boundary between grid

electricity service and off-grid solar photovoltaic (PV) service changes as load density and village distance from the grid change (Cabraal et al., 1996). The implications of this are that the approach to electricity expansion must match the demand characteristics of population types. In addition, from an equity perspective, people in remote areas for which the cost of grid supply is high should not have to wait to gain access to grid electricity service when less costly alternatives could be made available with appropriate incentive policies.

### Main Grid Electrification

The costs of conventional grid-based rural electrification vary greatly, both among and within countries. Local material and labor costs, terrain, and materials and construction standards can all have a major effect on the overall construction and maintenance costs. Typical figures quoted for marginal cost of grid electrification, including generation, transmission, and distribution, are in the range of US\$0.10–0.20/kWh (Malik and Al-Zubeidi, 2006; Eberhard et al., 2008), with costs in rural areas typically higher than in urban ones. In many cases, the high initial costs of grid electrification can be held down by using design standards suitable for areas with less demand. Most rural consumers use about 0.5 kWh/day, much less than the minimum electricity connections typical of developing country utilities (Barnes et al., 1997). The high cost of wiring installation by utilities can be lowered by simplifying wiring codes to encourage lower electricity consumption levels. Other cost-cutting strategies include using cheaper utility poles and involving local people in construction and maintenance.

Although their institutional forms vary, as a general rule successful grid-extension programs require financially and technically strong utilities (Barnes, 2007). To ensure sustainability, distribution companies must address the issue of increased technical losses and low revenues in creative ways. The Tunisian Electricity and Gas Company (STEG), for example, reduced the capital costs of rural grid extension by shifting engineering standards and using capital subsidies provided by the government (Cecelski et al., 2007). By adopting a MALT (*mise à la terre*) design, a blend of three-phase backbone and single-phase network distribution, financing costs were reduced 20–30%. Making this technical design decision was not easy for STEG, which faced opposition from many of its own engineers accustomed to serving high-demand urban areas. This case demonstrates how careful and critical analysis of design assumptions and implementation practices reveals the potential for significant cost savings and thus more attractive financing (Cecelski et al., 2007; STEG, 2010).

Extending the grid to rural industries or commercial consumers can also promote economic growth while increasing revenue that can be used to maintain lower prices for residential and other rural consumers (Cabraal et al., 2005). Giving priority to major load centers and productive facilities can also help improve financial viability.

### Microgrid Electrification

Off-grid electricity is necessary in some instances because the expansion of grid electricity will require decades to reach remote populations. In the short and medium term, the only way to reach many remote households without electricity may be through single household systems and small electricity providers using both renewable and conventional energy sources. Although these approaches to electricity provision may sound straightforward, in practice they have been difficult to implement. Decentralized, isolated distribution systems have been common in remote population centers for many decades. In most developing countries, they predate the establishment of main grid systems. The marginal costs of such systems are about US¢20–60/kWh. But diesel generators in remote locations can be hard to maintain and expensive to operate because of the high cost of spare parts and fuel. Micro hydropower systems have lower operating costs but involve higher capital costs for the systems and civil works to channel the water. Most other types of microgrids have similar cost levels.

Successful service delivery in remote locations via microgrids often involves specialized government agencies that perform an enabling role in support of private and community-based operators. For example, five years ago the Cambodian government created the Rural Electrification Fund to support small, private-sector operators of grid systems in rural areas. These indigenous operators had developed in rural and market towns, but faced significant investment constraints to expansion. To date, some 140 minigrid operators have been licensed under the new program. The Fund board, which provides overall guidance and policy oversight, comprises both public- and private-sector nominees. The Fund secretariat, which is responsible for operations, includes technical, finance, and administrative units. To ensure safety, quality, and service standards, Fund support is available only to qualified operators that are licensed by the Electricity Authority of Cambodia, the country's regulatory agency, for a minimum five-year period. The Fund has been fully operational since April 2007, and projects involving approximately 23,000 connections have been approved.

### Renewable Energy and Household Systems

For countries endowed with the necessary natural resources, solar, wind, and pico and micro hydropower systems offer attractive options. The marginal costs of electricity generated by such systems are about US\$0.50–1.00/kWh. Off-grid projects in such countries have taken advantage of private-sector institutions, nongovernmental organizations, and microfinance institutions that operate in rural areas. These programs can provide electricity to people in remote areas where main grid electrification is prohibitively expensive owing to the high capital cost of extending electricity lines.

The best off-grid models typically combine private-sector organizations (e.g., private entrepreneurs in Kenya have sold more than

200,000 PV systems to households that lack access to grid electricity), donor agencies, local communities, and national utilities supported by a strong energy agency whose role is to promote off-grid electrification. For example, Bangladesh's Rural Electrification and Renewable Energy Project combines main grid financing for rural electric cooperatives administered by the Rural Electrification Board and an off-grid component administered by the Infrastructure Development Company Limited, a public financial institution. The project offers participating organizations – nongovernmental and microfinance institutions, including the Grameen Bank, municipalities, and private-sector institutions – both credit and grants with which to cover about 20% of the purchase cost of solar home systems. Each participating organization signs an agreement with the Infrastructure Development Company for this blend of loans and grants, which lowers the cost for customers (Asaduzzaman et al., 2010; IDCOL, 2010). Under this program, more than 150,000 rural off-grid consumers are receiving electricity. Similar programs supported by the World Bank are functioning in more than 30 countries, including China, Sri Lanka, and Bolivia. Under these programs, funds have been committed to support services to 1.3 million consumers (seven million people). Currently, about half of these households receive electricity.

Off-grid household programs in Bangladesh and Sri Lanka demonstrate that it is possible to implement large-scale, off-grid projects that complement strong grid electrification programs. Off-grid projects in both countries have taken advantage of private-sector institutions, non-governmental organizations, and microfinance institutions that operate in rural areas. However, this has also been backed by strong centralized institutional support.

#### 19.2.1.4 Principles for Success

Countries must discover solutions consistent with their geography and natural resources; demographics; and socioeconomic, cultural, and political realities. Rural electrification is a dynamic, problem-solving process. Problems change as programs evolve, but certain underlying principles guide successful programs (Barnes, 2007). Governments' sustained commitment must be reflected in effective institutional structures that exhibit a high degree of operating autonomy and accountability, strong management, and dynamic leadership with the capacity to motivate and train staff. Successful programs also require effective prioritization and planning. Clear criteria based on market research are required for prioritizing areas to supply. Key factors include capital investment costs, level of local contributions, numbers and density of consumers, institutional capacities, and likely demand. For off-grid systems, reducing construction and operating costs as well as sustained financing is also vital. Sustained financing will require increased and more effective use of both domestic and external funding sources. When cost recovery is pursued, most other program elements fall into place.

Summarizing some of the key lessons and principles for successful electrification as discussed in Krupp (2007) and Barnes (2007), the following are key:

- sustained financing;
- metering and payment for cost recovery;
- local buy-in and training;
- flexible and adequate institutional arrangements;
- independent regulation; and
- lower-cost options for supplying power.

In spite of the many challenges to rural electrification, many countries have been successful in providing electricity to their rural areas. In Thailand, well over 90% of the rural population has electricity access. In Costa Rica, cooperatives and the government power utility provide electricity to nearly 100% of the rural population. In Tunisia, over 90% of rural households are already supplied. Studying countries like these and others there appear to be certain factors critical to the successful implementation of rural electrification. Strong and sustained political commitment, intensive financial support and clear earmarking of funds by the government, along with the establishment of clear planning criteria for rural electrification, are paramount to success (Barnes, 2007).

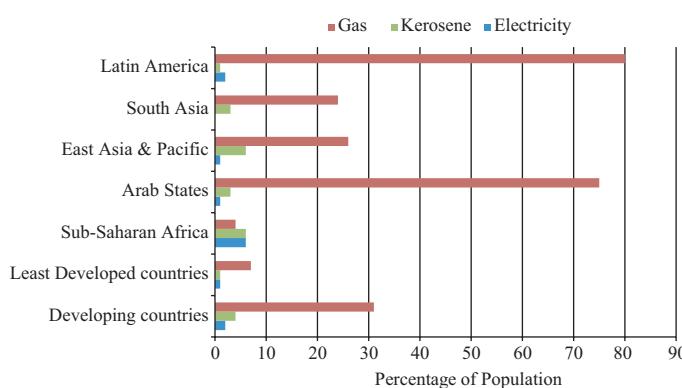
### 19.2.2 Access to Modern Fuels and Technologies for Cooking and Heating

Households in developing countries, particularly those in rural areas, largely rely on a range of fuels rather than electricity to meet their cooking and heating needs. Electricity use for cooking remains rare in most developing-country households because of high service and appliance costs associated with the use of electricity, limited availability, and relatively low incomes levels. Hierarchies in household energy services are quite common. Almost always, cooking and heating are the first functions fulfilled, followed by lighting and then entertainment. For the poorest people in developing countries, cooking (and space heating in particularly cold climates) can account for up to 90% of the total volume of energy used (WEC and FAO, 1999). Cooking is an energy service that is often associated with strong and highly specific fuel and appliance preferences. In addition, cooking is often only one of a range of services that are delivered from a stove or a fire. For example, coal and wood stoves serve multiple functions, including cooking, space heating, water heating, lighting, and social focus (van Horen et al., 1993). The multi-functionality of some stoves is one of the key reasons why households are at times averse to substituting their old stoves for newer more efficient and cleaner technologies.

Households use a variety of fuels for cooking and heating purposes, such as wood, dung, crop wastes, charcoal, kerosene, LPG, coal, and electricity, to name the most common. Households use the different

fuels in different combinations, depending on the needs they satisfy, their availabilities, and the socioeconomic circumstances of the households. Fuels are chosen for their cost effectiveness, ease of access, and perceived efficacy in performing specific tasks. Fuel use patterns may differ at different times of the year. Tastes and cultural preferences also play an important role in decisions concerning which fuels are used, particularly in rural households.

The use of more efficient liquid or gaseous fuels and efficient appliances for heating homes and cooking food has significant social and environmental benefits and yet access to these among most of the developing world remains extremely limited (Figure 19.11 and 19.12). In sub-Saharan Africa only 16% of people use modern fuels as their primary cooking fuel. The level of reliance on modern fuels is lower than in

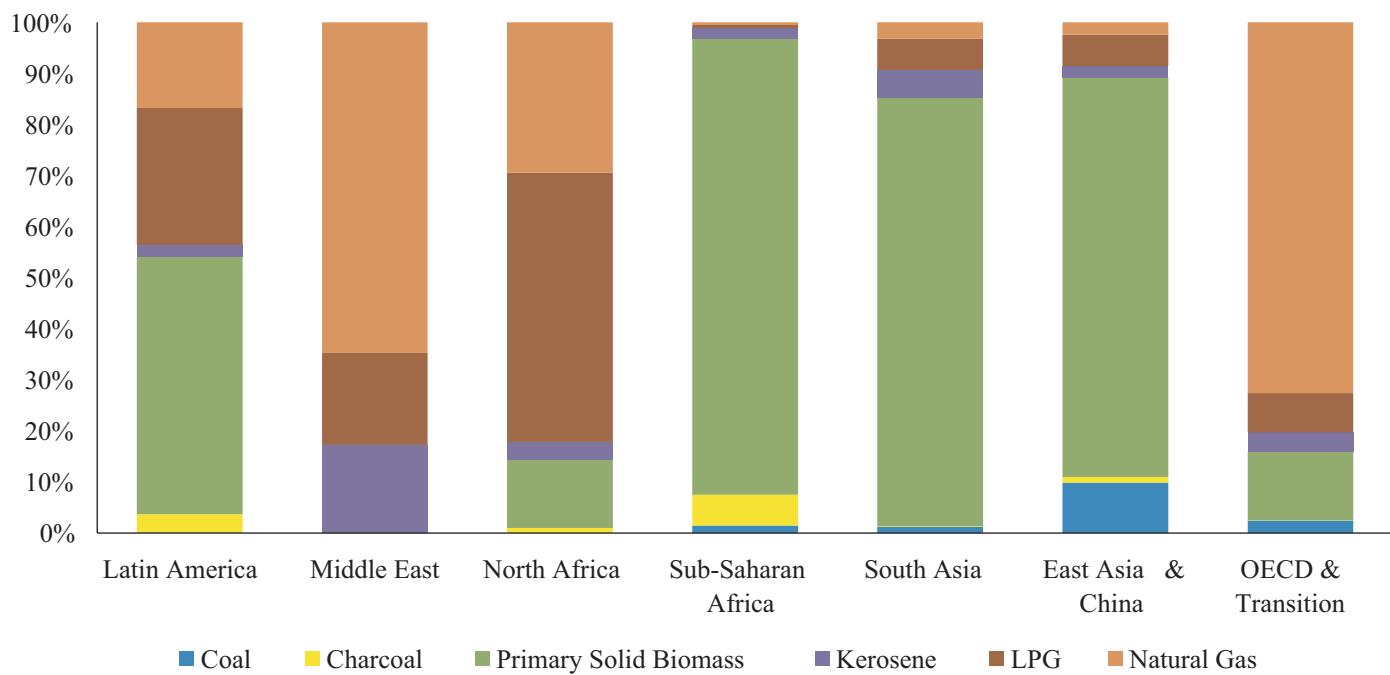


**Figure 19.11 | Share of population using non-solid fuels.** Source: UNDP and WHO, 2009.

any other geographic region, and is comparable to that in the average for all LDCs (10%). Overall, some 41% of people in developing countries have access to different types of modern fuels for cooking. Across all developing countries, almost one-third of people (33%) use gaseous fuels (including natural gas, LPG, and biogas) as their primary cooking fuel (Figure 19.11). Use of gas is much less common in the LDCs and sub-Saharan Africa, where only 7% and 4%, respectively, of the population rely on gas as their main cooking fuel.

About 75% of people living in rural areas use traditional biomass for cooking, primarily wood, while 65% of those living in urban areas rely on modern fuels, especially gas (UNDP and WHO, 2009). Of those who rely on solid fuels, roughly 800 million people (only 27%) are estimated to use improved cooking stoves, most of which belong to households situated in China and Brazil. There has recently been an increased effort to bridge the gap between the inefficient use of traditional fuels such as wood, straw, and dung by promoting the use of improved stoves. Stove programs around the world have had an uneven history, but there are some recent developments involving more durable efficient biomass stoves that are encouraging for the future.

The environmental consequences of unprocessed biomass, charcoal, and coal use – first put before the international community several decades ago as the “other energy crisis” (Eckholm, 1975) – involve household air pollution and degradation of local and global commons. Cooking and heating with biomass fuels on open fires or traditional stoves results in high levels of health-damaging pollutants and has been associated with numerous respiratory problems, thus contributing to global mortality and morbidity. Fuel collection can lead to a deterioration of the local

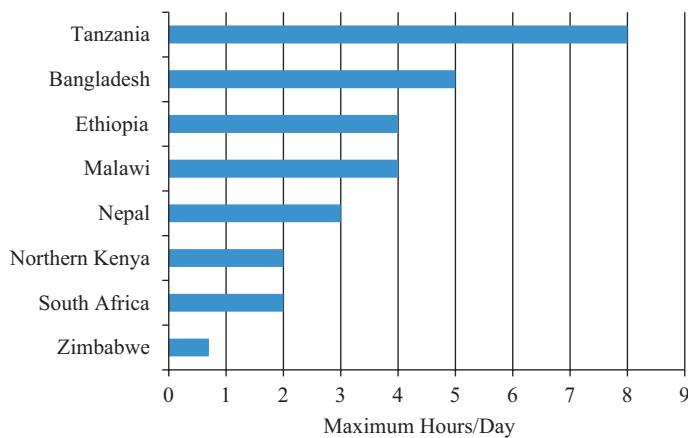


**Figure 19.12 | Structure of final residential fuels use across regions in 2006.** Source: Based on IEA, 2008a; b.

environment and depletion of biomass, meaning ever-longer walks to collect fuel. In Haiti, for example, the overall decline in forested areas resulting from charcoal production for urban use is well documented (Stevenson, 1989). The production and use of energy for cooking and heating in developing countries contributes to threats to human health and quality of life, affects the local ecological balance and biodiversity as demand for traditional fuels outstrips supply, and alters the climate that we live in through pollutant emissions, such as those of black carbon (Bice et al., 2008).

High dependence on traditional biomass and coal leaves many people in developing countries with few options for improving their lives. In the recent past, the health costs of the continued dependence on traditional solid fuels have been very high, particularly for many developing countries. Current estimates indicate that annually, almost two million worldwide deaths from pneumonia, chronic lung disease, and lung cancer are associated with exposure to household air pollution resulting from cooking with biomass and coal, and 99% of these deaths occur in developing countries (UNDP and WHO, 2009). The poor devote a large portion of another important asset – their time – to cooking and heating energy-related activities; women and young girls can spend in excess of six hours per day (see Figure 19.13) gathering fuelwood and water, cooking, and agro-processing (UNDP, 2007b).

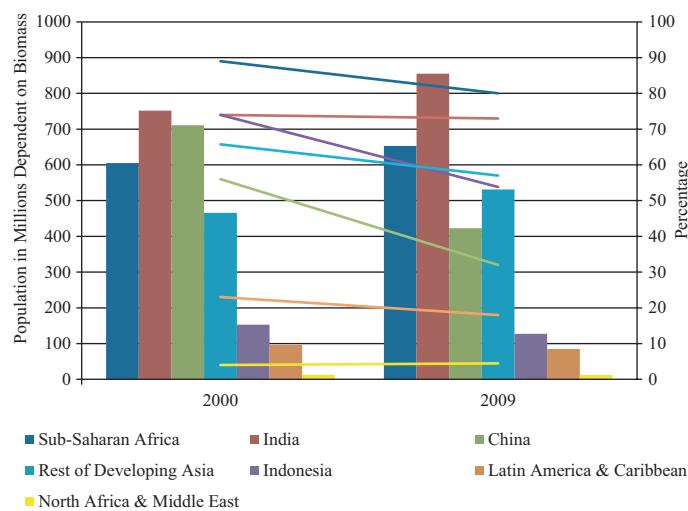
Studies on understanding the factors determining fuel choices and drivers of fuels usage in developing countries are limited (e.g., Heltberg, 2004; Ouedraogo, 2006; Pachauri and Jiang, 2008; Ekholm et al., 2010). Data on fuel choices and consumption and how these factors have changed over time also remains very sparse, particularly for rural areas and in the poorest countries. Progress with expanding access to modern fuels and technologies for cooking and heating in developing countries over the past 25 years has been rather dismal. A recent review of World Bank lending for improving energy access over the period 2000–2008 also shockingly concludes that only about 1% of the total lending was dedicated to promoting a transition to more modern cooking fuels or



**Figure 19.13 |** Selected data on time spent in wood collection. Source: Practical Action, 2010.

clean cooking devices (World Bank, 2010a). More efficient and cleaner fuels and improved stoves to meet people's most basic cooking needs are still out of the reach for the majority of populations living in developing countries, especially those in rural areas. The widespread diffusion of improved and clean cooking stoves has also yet to happen even though new designs of clean stoves are being piloted around the world. Much remains to be done on the fuel-stove package to make it available as a clean cooking option. An astounding three billion people in developing countries primarily rely on coal and traditional biomass such as wood, charcoal, and dung for their cooking and heating needs, with little or no access to more efficient, modern forms of energy (UNDP and WHO, 2009). In other words, almost half of humanity still uses traditional biomass or coal, with about 2.7 billion relying on traditional biomass alone (IEA, 2010b). Access to improved cooking stoves is also very limited. The IEA estimates that people will continue to rely on these solid fuels for the next few decades, and those relying on traditional biomass alone will increase to 2.8 billion by 2030 (IEA, 2010b) in the absence of any new policies beyond those already in place in 2010. The majority of these people will remain concentrated in rural areas of the LDCs in sub-Saharan Africa and South Asia. This places a huge burden on the economies of these countries and stifles efforts toward achieving the MDGs and poverty reduction for these populations (Modi et al., 2006).

Data on the use of biomass and other solid fuels, both in terms of the percentage of population dependent on these fuels and the actual consumption levels, remains exceedingly scarce, particularly for those countries that remain the most dependent on these fuels. Internationally comparable statistics over time are hard to find. However, over the last decade, there has been a slight decline in the number of people dependent on biomass alone, largely on account of a significant reduction in the number of people using biomass in China (Figure 19.14). Overall, little change is observed in the dependence on solid fuels, particularly among households in rural areas.



**Figure 19.14 |** Changes in the number of people relying on biomass. Source: IEA, 2002; 2007; UNDP and WHO, 2009.

Cooking is the major energy end-use among poor families in developing countries. Because most staple foods must be processed, conserved, and/or cooked, and thus require some form of heating before consumption, access to affordable, clean cooking fuels and equipment are among the most basic energy needs of the world's poor.

The importance of gender issues in understanding transitions in the use of cooking fuels and/or stoves cannot be overemphasized. Women tend to have limited control over and access to productive assets and income in many developing countries, especially in the poorest households. They often have little say in how much can be spent on fuels or new stoves. While not all women would embrace new fuels and stoves if given the choice, often a proposed change has to benefit the man of the house to have a chance of being adopted (Lambrou and Piana, 2006). In addition, women are disproportionately burdened by the drudgery and poor health impacts associated with the use of solid fuels. Gender issues related to energy have often been overlooked due to a lack of gender-specific data in the energy sector (Parikh, 1995; ENERGIA, 2010). However, it is well recognized that greater attention to the energy needs and concerns of women in developing countries can improve the effectiveness of energy policies and projects (Clancy, 2000).

The estimates of the numbers of people using improved cook stoves (UNDP and WHO, 2009) suggest that programs to disseminate such stoves have not had much of an impact. This is despite the fact that examples of improved cook stoves abound (see Table A19.1 in the appendix and Chapter 10 for more on improved biomass cook stoves). However, the characteristics of the stoves, the level of efficiency gains, and the level of sophistication and mode of manufacturing all vary enormously. Developing programs aimed at the sustainable dissemination of improved cooking stoves must overcome a number of barriers, including issues that relate to the maintenance and replacement of free-of-charge or self-produced stoves. Recently, there has been a surge of social entrepreneurs entering the energy field and a drive toward market models by implementing institutions and social investors, which may result in larger scale-up (GVEP, 2009). Product developers (e.g., ENVIROFIT), donors, and social investors are shifting the focus for design and diffusion of clean burning, off-the-shelf cook stoves toward a market-based approach. How successful these market approaches will be in reaching the poorest consumers remains to be seen.

Heating and cooking often go hand in hand in developing countries, particularly in cold mountainous areas where household energy is primarily used for space heating. Space heating is also common in tropical countries that have very warm weather during the day and cold temperatures at night. The need for space heating is often higher among the poor because their houses are not necessarily constructed well enough to preserve heat. Space heating is extremely important for improving health and livelihoods, especially for the young and the elderly.

### 19.2.2.1 Expanding Access to Modern Fuels and Technologies: Status and Implications

*Energy for Cooking:* There are a number of ways in which those dependent upon biomass can benefit from switching to cleaner burning cooking fuels or stoves. Practical solutions also include smokeless biomass cooking devices fitted with chimneys or hoods and switching fuels from biomass to biogas, kerosene, LPG, ethanol, or electricity. It is important to consider all of these options when evaluating suitable intervention for a specific target population. The availability and access to fuels, ease of handling, and affordability are all important determinants in the selection of a particular intervention in a given context. Contexts may be defined by factors such as urban/rural settings, domestic situation, institutional setting (schools, hospitals, prisons, etc.), poor/rich clients, and biomass-rich or -degraded areas.

*Energy for Heating:* Charcoal is the most popular biomass fuel for space heating in biomass stoves in peri-urban households because it emits less smoke and the thermal efficiency of charcoal stoves is relatively high. Firewood is widely used in rural homes where cooking and heating are the two major uses of fuel. Coal is widely used in China. Other fuels and energy sources such as electricity, kerosene, and LPG are not widely used in most developing country households because of limitations in affordability, availability, and accessibility.

In colder rural areas of the world (including high altitude areas within the tropics), space heating is often required during the winter months. Vast quantities of energy are used to achieve this. Not all buildings in rural areas of developing countries are designed to conserve heat. Firewood is the main fuel used for space heating in rural areas, followed by charcoal, which is the primary heating fuel for relatively few people. Providing affordable warmth to the peri-urban poor is among the main challenges facing many developing countries. The peri-urban poor often use a mix of fuels depending on availability, accessibility, and affordability. Charcoal is an important fuel for space heating in peri-urban areas; carbon monoxide poisoning is occasionally reported in peri-urban areas during the cold seasons because of use of charcoal in unventilated houses. Firewood is also used in biomass stoves with chimneys but is not a popular source of energy for space heating in peri-urban areas. Where electricity is available, small space electric heaters are used, albeit sparingly and only when extremely necessary, such as when there is a newborn baby or an elderly person in need. One option in addressing the space heating problem is housing policies – including housing finance – that take energy efficiency and improved stoves into account.

### 19.2.3 Access to Energy for Income-Generating Activities

The poor, especially those living in rural and remote areas of developing countries, face limited or total lack of access to reliable modern

energy for activities that can generate income, commonly referred to as productive end-uses. It should be noted that the distinction between "productive uses" and "consumptive uses" is by no means clear cut. However, we refer to "productive uses" of energy as those that involve the utilization of energy, both electric and non-electric, in the forms of heat or mechanical energy, for activities that enhance income and welfare. The problem of access to energy services for productive end-uses in developing countries is far greater in rural areas than in peri-urban and urban areas (Bates et al., 2009).

To spur sustainable development in rural areas and indeed, nationally, improved rural productivity is needed. Productive end-uses can be enhanced by reducing the problems associated with dependence on solid fuels (traditional biomass and coal) in rural households and expanding access to electricity and other modern energy carriers and technologies and mechanical power. It can be accelerated by scaling up distribution of cleaner energy-conversion devices (e.g., improved stoves, gasifiers, and kilns); cleaner fuels (e.g., biogas, ethanol, and LPG); and decentralized energy options (e.g., wind, biomass micro distilleries, micro hydropower, and solar energy) that have shown some level of success (UNDP, 2006). For it to succeed, massive mainstreaming of energy issues into development planning, mobilization of finance for scaling up of energy for productive end-uses, and extensive building of national and local capacity to deliver modern energy for specific productive end-uses is needed.

To reflect the full extent of the energy access for productive end-uses in developing countries, it is important to highlight the role of mechanical power<sup>7</sup> in improving the lives of the poor in developing countries. Energy for mechanical power is obtained from electricity and nonelectric sources and is used for daily livelihood activities including agroprocessing, artisanal activities, and small and micro enterprises. Over the past century, technological advances have helped reduce the drudgery of human labor through the widespread use of mechanical power. Mechanical power is perhaps second only to cooking when it comes to the sorts of energy services poor people need most. Mechanical power is critical to enhancing the productive end-uses of labor and poverty alleviation.

*Challenge one:* With respect to access to mechanical power for productive uses, a desk survey by UNDP indicates that mechanical power is not included in most policy debates at the country level. Despite its importance in expanding access to energy services, little data exists on productive end-uses of energy or mechanical power in developing countries. Governments lack vision, time-bound targets, or data concerning the contribution of mechanical power to general human development. Even where there are targets, programs to upscale initiatives are lacking. National decision makers often fail to recognize the significance

**Table 19.1 |** Mechanical power is least documented by LDC countries that provide data on access to modern energy (baseline and target).

		National	Rural	Urban
Fuels for cooking/heating	Baseline	48 (96%)	17 (34%)	15 (30%)
	Target	5 (10%)	2 (4%)	2 (4%)
Mechanical Power	Baseline	0 (0%)	2 (4%)	0 (0%)
	Target	0 (0%)	2 (4%)	3 (6%)
Electricity	Baseline	48 (96%)	38 (76%)	35 (70%)
	Target	22 (44%)	16 (32%)	9 (18%)

\* The 50 LDCs are used in the calculation. (%) indicates the percentage of LDCs that provides data on access to modern energy.

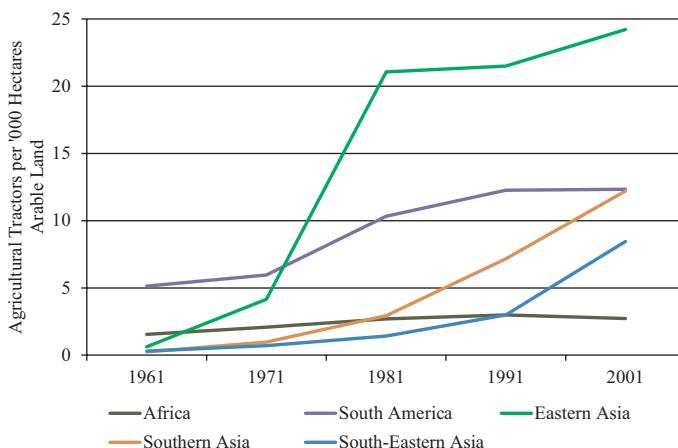
\* Source: UNDP and WHO 2009.

of productive end-uses through the provision of energy especially by motive power. For example, Table 19.1 shows that although five out of the 50 LDCs have a national target on access to modern fuels, and 22 have targets on access to electricity, none of them has a specific national target on access to motive power.

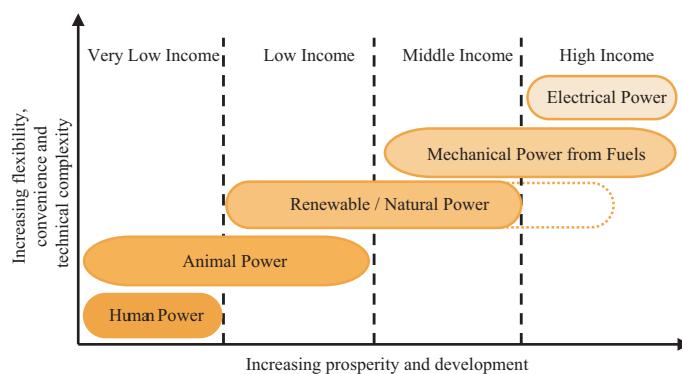
The lack of data is a challenge, particularly considering that the majority of developing countries' rural and peri-urban populations depend on mechanical power for activities in households, agriculture, or small and micro enterprises. For instance, small commercial enterprises and agriculture depend on motorized and nonmotorized mechanical power. Devices such as treadle pumps, ram pumps, floating pumps, wind-powered water pumping, hydro-powered carpentry, or agricultural processing enterprises such as corn threshers, are all important mechanical power devices that are commonly used in developing countries. Diesel or electric motors for mechanical power are becoming increasingly important for providing mechanical power in most developing countries. Mechanical power is one of the quickest ways that energy is used for productive end-uses, mainly in agriculture and forestry and at the small enterprise level. In terms of targets for access, national plans are lacking in all areas of energy access, with cooking fuels much more poorly represented than electricity, and mechanical power not even registering. The lack of data in this regard is a serious barrier to setting such targets. What is needed is detailed data on ownership and use of machinery and power availability at the farm level, as well as studies that link this with yields and productivity improvements (Figure 19.15).

Small and microenterprises (SMEs), many belonging to the informal sector, have become integral in many developing country economies. Studies in India have shown that SMEs enable rural households to generate nonfarm income, which can largely contribute to poverty reduction (Lanjouw and Shariff, 2002). In general, SMEs purchase (rather than harvest or collect) their energy, including electricity, LPG, kerosene, firewood, charcoal, etc. This is true even in rural areas. Moreover, despite energy being one of the significant factors for most microenterprises, there is a knowledge gap on how much energy is being used; neither is it systematically documented what role energy

<sup>7</sup> Mechanical Power is defined here as the effective outcome of transforming different forms of energy sources (e.g., wind, hydro, fossil fuels, etc.) to kinetic energy (to cause motion).



**Figure 19.15 |** Growth in agricultural mechanization. Source: FAOSTAT, 2010



**Figure 19.16 |** Mechanical power ladder. Source: adapted from WHO, 2006; UNDP, 2009a.

plays in diversifying production and expanding employment opportunities by microenterprises, both in urban and rural areas (Clancy and Dutta, 2005).

**Challenge two:** The second challenge is the lack of improvement in technology or form of use in impoverished regions of the world today. Since the industrial revolution, access to advanced forms of mechanical power has defined the pace of human development and advancement, and shaped development in various ways in different parts of the world. However, the gap between technologies used for mechanical power in developed countries and in the rural areas of developing countries is increasing. Despite technological improvements, those without access to modern energy still depend on less efficient and effective versions of mechanical power that use human, animal, or unimproved motorized equipments to meet their energy needs, resulting in low efficiencies and limited productivity. The implications for the poor include lower incomes, increased drudgery, and a continued dependence on subsistence production practices. Access to motive power has remained an important driver of livelihood activities in impoverished regions of the world. Figure 19.16 depicts this challenge (UNDP, 2009a).

#### 19.2.4 Institutional Development and Financing Mechanisms for Scale-up of Access

In order to meet the ambitious energy access targets discussed in Chapter 2 and highlighted in Section 19.1.1, new ways to generate additional sources of funding will be needed and funds made available will have to be allocated effectively and efficiently. In the following sections we discuss the need for innovative institutional approaches and financial mechanisms for scale-up of access initiatives and activities.

##### 19.2.4.1 Need for Innovative Institutional Approaches

Massive diffusion of new technologies for meeting thermal energy (e.g., cooking), motive power, and electricity needs is necessary to meet the grand challenges of improving access laid out in previous sections. While electricity grids have expanded and programs have been put in place to spread distributed generation technologies and cleaner cook stoves and fuels, these efforts have often been plagued by numerous problems and the scale of expansion is barely sufficient to keep pace with increasing demand and even population growth, as in the case of many sub-Saharan countries. In many cases, the barrier is in the policies and institutional arrangements. While it may not always be clear what is needed for a given region, what is clear is the need for change to meet these grand challenges. It is also clear that some key lessons can be learned from mistakes of the past.

The circumstances in developing countries militate that energy pathways, especially for rural and peri-urban areas, be dissimilar to those followed by developed countries. This requires innovation and experimentation on both technological and institutional levels. In Ethiopia, for example, the use of inappropriate institutional structures was found to be one of the key factors hindering wide dissemination of modern energy services to rural areas (Habtetsion and Tsighe, 2002). Lack of appreciation of such approaches at a policy level is curtailing progress, as many policymakers tend to follow conventional approaches without taking into account contextual differences. It is critical that policy makers realize that the markets in developing countries are quite different from those that have emerged in the industrialized world. For example, the impetus to rationalize prices and engage in reforms of the electricity sector may actually be stronger in developing countries due to the poor state of utility finances in many of these countries, the lack of easy access to capital for system expansion, and the resulting inability to maintain existing systems or meet latent demand (e.g., the Indian utilities). However, at the same time, electricity reforms<sup>8</sup> could have negative impacts on low-income households that are already facing hardships quite different from those in the industrialized countries.

<sup>8</sup> The role and impact of electricity and wider energy sector reforms on the poor is dealt with in greater detail in Chapter 2.

### Box 19.4 | Issues with Measuring and Monitoring Access

Identifying progress in providing access and the extent of electrification depends heavily on the official definitions adopted and the measurement units used. Foley, in his 1990 paper, states that the definition of rural electrification, in particular, varies considerably across countries. In one country "rural" may include provincial towns with a population up to 50,000 while in another it may refer to small farming villages and surrounding areas. The unit of measurement also matters. The initial focus of Indian rural electrification was on "village electrification," rather than household electrification, with this being very loosely defined. As a consequence, villages were often deemed "electrified" without a single household having been connected. Changes in the definition of "electrified village" also impacted the measurement of electrification over time (Pachauri and Mueller, 2008).

The source of electricity supply can also matter. In many countries, official electrification rates refer to connections to grid electricity alone. Thus in Cambodia, where the government has not had a strong involvement in rural electrification, official electrification rates (defined only in terms of connections to a central power grid) remain very low (15%). However, according to Zerriffi (2007), the number of households with access to at least a minimal amount of electricity (e.g., enough to power a light bulb and maybe a small television) is extremely high (50% of the households have a television and an estimated 85–90% have a light bulb). Their electricity comes primarily from rural electricity entrepreneurs that run diesel-based microgrids, battery charging stations, or a combination of the two.

Measuring electricity access can also be complicated by the issue of unauthorized or illegal connections and consumption. In some countries, such as in India, transmission and distribution losses in the electricity sector can be as high as 20–30%. A large part of these losses are attributable to electricity thefts or pilferage by poor households who illegally tap electricity lines (Tongia, 2003). Official access numbers often do not account for these people.

Ideally, the quality and reliability of supply should also be a part of any access measure, but often, well-documented data and indicators measuring quality remain lacking. However, in many developing countries, particularly the least developed, the duration, reliability, and quality (measured in variability of voltage) of electricity supply remain highly irregular.

The importance of institutional factors for the implementation and sustainability of access efforts for poor and rural communities has most recently been reiterated in a World Bank review of its own rural electrification projects (World Bank, 2008a). The review of different country experiences supports the view that there is no superior institutional model. Public, private, and cooperative approaches have led to both success and failure. These models are also not necessarily mutually exclusive. What is important is the choice and strengthening of a framework that takes advantage of the country's strengths and considers the nature of their specific challenges (World Bank, 2010b). Learning these lessons has not been easy. Field surveys undertaken in Thailand show that despite flaws in the implementation of heavily subsidized solar home systems (SHS) and PV battery charging systems in rural areas, the inefficient policy continued over a 15-year period at a cost of over US\$11 million (1984–2001), and by the time of the analysis, 60% of the systems were no longer operational (Green, 2004). In Viet Nam, a survey undertaken in 2006 found that 80% of SHS in a project in Vientiane Province were not working properly due to technical hitches, in some cases reducing the power available to the households to about 30 minutes a day (World Bank, 2008a). This implies the need for continuous monitoring and strategic corrections to programmatic activities (Box 19.4). However, funding is not always allocated for the necessary monitoring and evaluation activities. Furthermore, path dependencies and institutional inertia can make mid-course corrections difficult to implement (Annecke, 2008).

The lack of infrastructure and access to energy creates further economic problems at both the micro and macro level for countries. In the recent past, many sub-Saharan countries have faced sporadic and critical power shortages forcing them to resort to emergency power access methods. Over 23 countries have experienced crises, including an electricity crisis in the largest power system in the region: South Africa. This obviously undermined the well-publicized success story of rural and peri-urban electrification in South Africa. The general response to the crises has been largely dominated by the installation of high-cost diesel generators that have eroded savings made by governments or imposed additional financial burdens on those forced to install their own private generators. The consequences have included extremely high tariffs and crippled economies. In general, the low quality and reliability of centralized power, as well as issues of accessing centralized power systems, have created significant opportunities for the use of decentralized generation to meet local energy needs. However, significant financial and institutional barriers exist to the effective use of decentralized technologies, particularly for rural electrification (Zerriffi, 2010).

The provision of energy services accessible to all is often considered to be part of the social contract between governments and their people. For example, in the electricity industry, the social contract was an exchange in which the government regulates the industry and guarantees its financial viability while ensuring protection of the poor and the

environment (Heller et al., 2003; Chaurey et al., 2004). However, there have been some fundamental problems with this model. It has generally relied on a combination of centralized organizations, particularly ministries, and heavy subsidies to reduce the costs to the end users. This has not always been financially viable and can exclude options that might better meet social needs. Therefore, new and innovative institutional frameworks are necessary. This may involve a greater role for the private sector, community groups, consumer organizations, and other alternatives to the centralized model of energy service delivery. However, this puts a greater emphasis on the need to rationalize the financing of rural energy efforts. The result will be an increasingly decentralized and heterogeneous approach to rural energy delivery and an emphasis on rationalizing the finances of rural energy efforts (Zerriffi, 2010).

#### 19.2.4.2 New Financing Mechanisms

New financing mechanisms are needed for every scale of energy intervention, from large-scale infrastructure investments by both the public and private sectors to local entrepreneurs and right down to the individual household level. Mobilizing local finance is crucial for sustainability, especially taking into account that Official Development Assistance is decreasing and, in addition, it is mainly driven by donor interests (Hansen and Rand, 2006). For example, in 2006 the Kenyan utility, KenGen, offered 659 million shares to the public at 11.90 K. Shillings (~ US\$0.15) with additional shares offered to KenGen employees at the same price. The goal was to raise around US\$110 million. By the end of the public offering, it was over-subscribed by US\$200 million (UPDEA, 2009). Notably, the investors originated from all walks of life and areas of the country, demonstrating the availability of local money and confidence in the local market.

There are a number of ways to overcome the problems of cost, affordability, and access to financial resources that do not rely entirely upon subsidies. In the case of standalone technologies, the first is to reduce the total amount of capital required by reducing the size of systems (e.g., lower wattage PV systems or smaller LPG canisters) (Cabraal et al., 1998; Barnes and Halpern, 2000; Martinot et al., 2002). Another solution to the capital cost problem for the consumers are rental models or fee-for-service models. This saves the household from having to raise enough capital to purchase the technology outright, and dealers can presumably improve their buying power and access different credit facilities (Barnes and Floor, 1996; Cabraal et al., 1998; Barnes and Halpern, 2000). A third option is to use a fee-for-service model in which the consumer only buys energy and not a technology. In the case of electricity, this would include microgrid systems or battery charging stations. These can be run by a local entrepreneur, the local government, a cooperative, or an NGO. The capital cost problem still remains for the provider of the service, however. This is an area of active institutional experimentation with various approaches for incentivizing existing financial institutions to enter into this market as well as setting up new financial

arrangements. This can include revolving capital funds and dedicated loan programs.

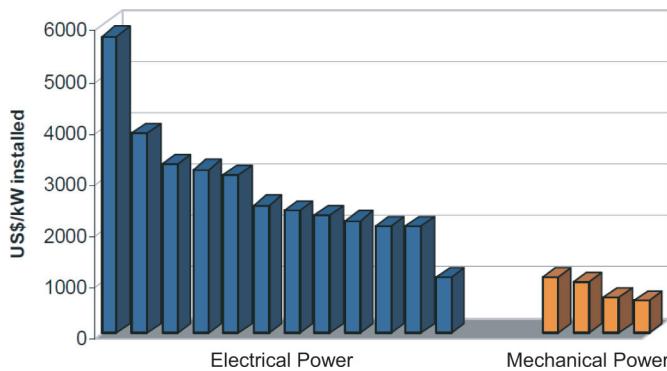
For the private sector at the local level, one way to address this deficiency is through what are called Market Facilitation Organizations. These are “public-private entities that support the growth of particular markets through a variety of means” (Martinot et al., 2002), ranging from more intangible benefits – such as access to information and networking – to technical support and financing.

One solution to the rural finance problem that has proven successful in a number of nonenergy areas and is now being applied to energy is the presence of microcredit lending agencies (Martinot et al., 2002; Armendáriz and Morduch, 2005). For example, Grameen Shakti has been successfully providing credit for the purchase of solar home systems in Bangladesh (Biswas et al., 2004; Uddin et al., 2006). The challenge with microcredit is that the sums may be too small for some energy purposes and at the household level, energy purchases may not lead directly to increased income, often a requirement for microlending.

Reforming the way in which energy access activities are financed and sustainably operated has potentially serious social consequences. For example, the implications of subsidy reform are that rural and peri-urban electricity consumers may be served with lower levels of energy service than their urban counterparts and by local actors rather than large government or private utilities. However, this does not absolve centralized governments of their responsibilities nor does it call for a complete removal of the international donor community from solving the problem. Some form of lifeline subsidy is needed at a minimum for low-income households.

There are conditions under which cross-subsidies could be implemented while minimizing the economic damage. Such cross-subsidies, if kept to a modest level, can be effective. Many institutional innovations may be implemented through local-scale actors, making traditional cross-subsidies for energy supply more difficult. If energy subsidies are desired, then new mechanisms may be needed. One option would be to provide subsidies directly to the end-users as an energy subsidy rather than being tied to a particular end-use or technology (Howells et al., 2006). Consumers can then make decisions based upon their energy needs and the availability of different options for meeting those needs. This would remove what is essentially a societal and political decision from affecting the functioning of the energy sector. A second option would be to create transfers among the electricity service providers either directly or via the government. This would depend on the particular institutional arrangements in each country. It could include partnerships between small actors such as NGOs, cooperatives, and small entrepreneurs and the utilities within a regulated concession model.

These new institutional arrangements may require a different role for both higher level government agencies and international donors (both official donor aid and NGO aid). This is necessary in order to maintain



**Figure 19.17** | Various costs per kW installed for rural hydro schemes in Africa, Asia, and Latin America. Source: based on UNDP, 2009a.

the social contract that previously existed, though perhaps in a different form. The key is to find a role for nonlocal actors to meet certain societal goals without destroying the market segmentation, local needs-based decision-making and possible contributions to greater rural development that comes with smaller scale solutions. Some principles, such as supporting energy planning, making investment capital available, creating incentives for commercial lending, promotional campaigns, and technical assistance have already been identified for certain markets. Centralized agencies can also aid in coordination, reduce their conflicting mandates and programs, and help create sorely lacking local institutional and organizational capacity (Bird, 1994; Cabraal et al., 1998; Radulovic, 2005; Srivastava and Rehman, 2006).

A number of development agencies are helping to facilitate microcredit schemes or small scale financing options by assisting the private sector and providing the interface between poor communities, energy providers, and private capital (UNDP, 2009b). The financial commitment of communities and entrepreneurs, together with a commercial approach, offers more guarantees for sustainability and poverty alleviation. Cost reduction, though not specific to productive end-uses of energy or mechanical power, is achieved mainly by addressing nonenergy barriers that hinder access to financing (e.g., policies, institutions), community participation, and enabling costs to be reduced by employing a local labor force and/or utilizing other community-owned assets, such as land, as collateral to secure loans. Cost reduction is also achieved by advocating for the incorporation of productive end-uses into national and international energy programs, budget allocations, strategies, and declarations, and finally, by implementing financing initiatives to scale up productive end-uses alongside other energy options in new and existing financing windows.

Financing prospects are linked to the productive end-uses ranging from financing for provision of social services, to income generation activities (commercial), to motive power for value-addition activities in rural areas (Bates et al., 2009).

For *social services*, it is likely that subsidies and grants from governments and international donors, in collaboration with relevant government

ministries and NGOs, will remain a key mechanism for funding productive end-uses and mechanical power installations for basic services. For this category of services (e.g., water pumping for drinking water or sanitation), substantial incentives (government grants, support from projects/programs) remain necessary to reach the poorest. Indeed, income generated from social services is generally extremely low and is not sufficient to pay back the up-front investment. Nevertheless, tariffs in line with the beneficiaries' willingness or ability to pay should be set in order to ensure that the maintenance costs (labor force, spare parts) are covered and costs are shared between public funding, community contributions, and, where possible, private finance.

For *income-generating activities* (for instance, grain milling or manufacturing), soft and/or commercial loans, coupled in some instances with small subsidies, are instrumental in creating thriving businesses. The success story of microhydro in Nepal is mainly based on an implicit strategy aimed at prioritizing microhydro for productive end-uses through mechanical power and income-generating activities. Experiences highlighted in Khennas and Barnett (2000), based on case studies from five countries in Latin America, Africa, and Asia, illustrate the relatively low financial barriers to enter the microhydro business aimed at end-uses supplied by mechanical power. Despite interest rates of up to 17%, hundreds of schemes were developed on a sustainable basis in Nepal by small entrepreneurs.

For *enterprise-based productive end-uses* and mechanical power initiatives, there is a range of sources of funding already in existence that are potentially appropriate, based on commercial or semi-commercial loans, including AREED (African Rural Energy Enterprise Development)<sup>9</sup> in Africa. The Government of Senegal, for example, has used the AREED approach to develop its national program delivery in rural areas. For stand-alone productive end-uses and mechanical power systems at the farm or household level, financing and microlending models have been developed, such as that of the Grameen Bank of Bangladesh. This microlending agency has over 1000 branches and two million members and disseminates energy systems through a nonprofit rural energy company, Grameen Shakti. Loans are made after a small down payment and, while the model was initially developed for solar PV systems, it is extending into other sectors that include productive end-uses such as treadle pumps.

A survey of UNDP projects that expands access to modern energy at the local level indicates that the average cost per beneficiary for providing mechanical power by use of multifunctional platforms/equipment attached to stationary engines is US\$24. Despite the relatively low cost (see Figure 19.17), there are inherent bottlenecks related to financing access to mechanical power (Bates et al., 2009).

<sup>9</sup> AREED offers rural energy entrepreneurs in sub-Saharan Africa a combination of enterprise development services and start-up financing. The program allows entrepreneurs to structure their companies for growth and, by mainstreaming local financial partners, makes eventual investments possible through loans.

For *decentralized productive end-uses* and mechanical power systems, such as community water supply or shared milling resources, additional financing options are considered, drawing from existing experience in revolving funds for microhydro. Loans are given to institutions involving local government and the community, often with the management and operation of schemes headed by trained local enterprises.

The promotion of productive uses of energy with the objective to stimulate economic development should go hand in hand with other activities and instruments to support the establishment and/or development of enterprises. This requires cooperation with many actors and provision of other conditions for entrepreneurship and business (e.g., the availability of easy credit). Energy per se will not lead to the establishment of new enterprises and the alleviation of poverty. It is linked with factors of rural development, market demand and access, infrastructure, and entrepreneurship. Productive-use development must be based on demand-pull rather than technology-push.

### 19.3 Improvements in Household Access to Modern Energy: Regional Efforts and Status

In the following sections, the issue of household access to electricity and modern cooking/heating is assessed from a regional perspective. The focus is on the regions where the lack of access is most acute, including Africa, Asia, and Latin America. Data and information available for these three regions varies widely. For this reason the three regions are dealt with differently, although the discussion adheres to a common framework as much as possible. The objectives in discussing the following regions in more detail are to understand past trends and efforts, assess the current situation regarding access, and draw lessons from each region that might be applicable for other regions or individual nations. We do not include a deeper discussion of policies for access here, as Chapter 23 provides in-depth coverage of that issue.

#### 19.3.1 Africa

Africa is home to about 15% of the world's population and 22% of its land. It also hosts an adequate share of energy reserves, but these remain largely unused. From 1997 to 2007 African economies grew at a steady average rate of 5.4% (World Bank, 2007) and the percentage of Africans living on US\$1.25 a day decreased from 58% in 1996 to 50% in the first quarter of 2009 (World Bank, 2009). Nevertheless, Africa remains the continent with the lowest electrification level, and a third of all people in the world without access to electricity live in this region. Even today, only 11% of the rural population in sub-Saharan Africa has access to electricity and the majority of households cook with wood and charcoal over open fires or on inefficient stoves (UNDP and WHO, 2009). The use of traditional cooking fuels is highest in rural areas

(93%), but it is still very significant (about 70%) in urban households (Banerjee et al., 2009).

A detailed account of the energy access situation and efforts in North Africa, West and Central Africa, and Eastern and Southern Africa is presented in the following sections. Compared to Latin America and Asia, there are fewer studies and summaries on energy access in Africa. For this reason, data and case studies from individual countries have been widely used.

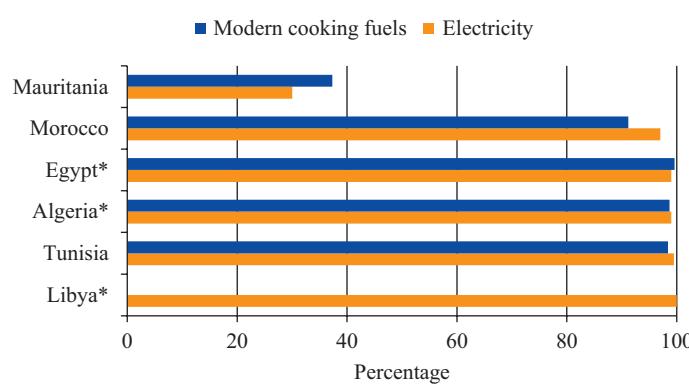
#### 19.3.1.1 North Africa

North Africa, unlike sub-Saharan Africa, has made relatively good progress with respect to the provision of modern energy for the majority of people in the subregion.

##### Access to Electricity

The disparities in access to electricity between North and sub-Saharan Africa cover urban and rural populations. The rural electrification rate is around 98% in North Africa (IEA, 2010b). In urban areas of North Africa, electricity access is almost universal.

Algeria, Libya, and Egypt, the three oil and gas producing countries in North Africa, accelerated their electrification efforts over the last 30 to 40 years and achieved universal electricity access (Figure 19.18). Tunisia and Morocco, the two oil importing countries, pursued ambitious electrification drives that led to universal access in Tunisia and to 97% electricity access in Morocco. Mauritania is the exception in this region with national electrification levels as low as 30% and rural access levels at 2%. Mauritania is more similar to sub-Saharan Africa than other North African countries. Morocco's Global Rural Electrification Programme (PERG) (Box 19.5 and Fig 19.19) shows how political will, supported by technical and financial plans and capacity, lead to a steady increase in rural electrification levels from 18% in 1995 to 95% in 2008.



**Figure 19.18 |** Access to electricity and modern cooking fuels in North Africa. Source: UNDP and WHO, 2009. Note: Countries indicated with \* are oil exporting.

### Box 19.5 | Rural Electrification in Morocco, PERG Program

The Global Rural Electrification Program (PERG) was launched in 1996 with the aim to achieve complete rural electrification by 2010. This target date was reviewed to achieve the electrification objective in 2007, through the expansion of the electrification pace from 1000 to more than 1500 villages/year. Starting from 18% in 1995, a rural electrification level of 95% was achieved by the end of September 2008 (Figure 19.20), as a consequence of the ambitious PERG and its associated budgetary provision.

The PERG is based on the following three “global” principles:

- Territorial: it aims to provide electricity to all rural households, in all communities;
- Technical: it aims to integrate all the available electrification techniques (grid extension and decentralized power generation) to meet the electricity needs of each household and within feasible technoeconomic conditions;
- Financial: it integrates all financial resources that can be used for the rural electrification nationwide, under the PERG global financial mechanism. This financial mechanism involves three contributing partners, namely the Electricity Utility (ONE), the local authorities, and the end users/beneficiaries. The PERG budget amounted to about 20 billion Moroccan Dirham (US\$2 billion).

The ONE contributes 55% of the financial cost through a fund raised from a 2% levy on grid electricity sales (35% of the electrification cost) and its own contribution of 20%. Local authorities co-finance 20% of the program costs: either 2085 MAD (~US\$200) per household or 500 MAD (~US\$48) per household/year over five years. Households contribute 25% of the electrification cost: either 2500 MAD (~US\$240) per household or 40 MAD (~US\$ 4) per month over seven years.

Decentralized electrification is being implemented mainly through solar PV installations, targeting 150,000 remote households.

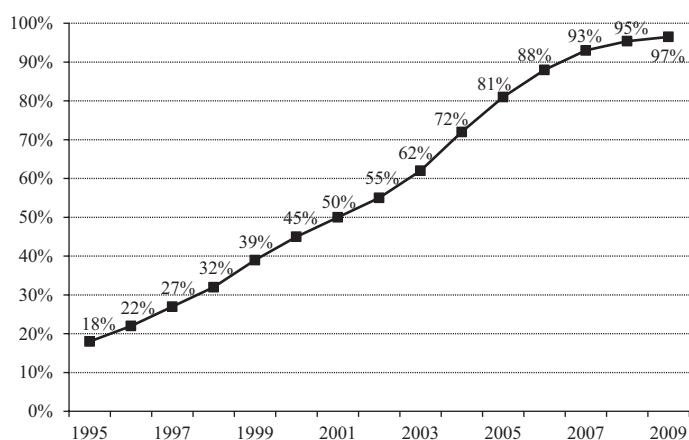


Figure 19.19 | Evolution of the rural electrification rate in Morocco 1995–2009.  
Source: ONE, 2009.

#### Access to Modern Cooking and Heating Fuels in North Africa

North Africa, including the Saharan desert, is generally a region with low rainfall. Access to traditional biomass and sustainably harvested wood resources for household cooking and heating needs has been a major challenge in the region, particularly in rural areas. North African governments have addressed the problem and successfully replaced traditional biomass with modern fuels by making access to LPG and

natural gas a policy priority. Access levels in Egypt, Algeria, and Tunisia range from 98% to almost 100%. Morocco is slightly below that and Mauritania lags behind with only 37% of households having access to LPG (Figure 19.18).

The three oil and gas producing countries – Algeria, Egypt, and Libya – used their own local resources. Morocco and Tunisia import gas from their neighbors. Most of the gas used in households is LPG, but access to natural gas for household uses is also quite well developed in the North African gas-producing countries and is progressing or emerging in the countries where gas pipelines are passing through to feed the European gas markets (Morocco and Tunisia).

In Egypt, natural gas consumption reached 25.39 Mtoe in 2003/2004. 1.7% of the total consumption is used in the residential and commercial sectors. The country has been trying to improve the availability of natural gas for residential customers by allocating service areas to several private companies since the beginning of 1998 (Drück et al., 2007).

In Tunisia, gas pipes pass through the country from the Algerian border to Italy, over an onshore length of more than 320 km. The Electricity and Gas Utility has a natural gas network that presently covers the coastal cities from Gabes to Tunis. There are plans to extend the gas network to include the Djerba and Bizerte areas (MEDREC and GNESD, 2009).

In Morocco, a natural gas market is emerging after the implementation of the Algeria-EU gas pipeline crossing the country. The first applications are for power generation, with the prospect of opening this market to improve household access to modern energy. However, about 30% of the population is still dependent on biomass (Mchirgui and Kanzari, 2006). To improve household access to LPG, some governments, such as Morocco, have been subsidizing gas bottled in small (e.g., 3 kg and 12 kg) canisters.

#### Access to Domestic Hot Water

Tunisia and Morocco showcase successful experiences of solar thermal applications, especially for solar water heating.

The Tunisian program, PROSOL, is supported by the electricity and gas utility (Box 19.6) and shows the importance of implementing appropriate financial mechanisms to sustain a quality dissemination of solar water heaters (SWH).

In Morocco, the SWH program (PROMASOL), supported by the Global Environment Facility, targets the installation of a capacity of 400,000 m<sup>2</sup> of solar collectors by 2010. According to the Renewable Energy Centre, the objective of one million m<sup>2</sup> of collectors is set for the year 2020.

The program is based on awareness-raising and communication, quality equipment, and after sale maintenance, as well as adequate financial mechanisms for households (leasing approach) and the tertiary/services sector.

In Egypt, the introduction of SWH technology to the national market started in 1980 with the import of 1000 home solar water heaters. In the same year, the first private local manufacturing company started and since then, SWH systems are manufactured in the country. In the mid-eighties a law was passed to promote the technology, which made the installation of solar water heaters compulsory for residential buildings in new satellite towns. Unfortunately this law did not have a lasting effect. Major obstacles included a lack of execution by the local authorities and the often poor quality of the SWH heaters, which gave the technology a bad reputation (Drück et al., 2007). More than 500,000 m<sup>2</sup> of solar collectors have been installed (end 2004), particularly in the new cities and tourist villages resorts. About 200,000 families are using SWH systems in Egypt. Tourist resorts and hotels are considered to be the main customers in this market. The distribution of the installed SWH systems shows that 40% of the total capacity is installed in new cities while 14%, 24%, and 14%, respectively, are installed in old cities, tourist villages, and government and public enterprises (Drück et al., 2007).

#### Box 19.6 | Large-scale Dissemination of Solar Water Heaters in Tunisia: PROSOL Program

Within the framework of its strategy to develop renewable energy, the Tunisian government decided to implement a program of massive dissemination of SWHs in the residential sector. This program, called "PROSOL TUNISIA" (Solar promotion for Tunisia), was launched in February 2005 and targets three types of SWH: 200-, 300-, and 500-liter capacity.

This program benefits from institutional and financial backups to promote the SWH market development. The financial support covers the following main incentives under the PROSOL:

- 20% subsidy of the SWH cost, provided by the government through the National Fund of Energy with a maximum of 100 Tunisian Dinar/m<sup>2</sup> (TD/m<sup>2</sup>);
- A complementary subsidy of about 80 TD of the 300 liters SWH cost, supported by the Italian government through MEDREC Funds;
- A loan mechanism to finance the remaining cost of a SWH, granted over a period of five years, and paid through the electricity bill of the utility (STEG);
- The reduction of the interest rate, using UNEP funds during 2005 (MEDREP Program).

Therefore, the end user needs to provide only 10% cash contribution toward the SWH cost.

The installed capacity of SWH decreased to about 8000 m<sup>2</sup> in 2003 from around 18,000 m<sup>2</sup> in 2001. The PROSOL Tunisia Program aimed at reaching 225,000 m<sup>2</sup> SWH over the period 2005–2008; 500,000 m<sup>2</sup> SWH in 2009; and finally, 540,000 m<sup>2</sup> to achieve an installed capacity of 740,000 m<sup>2</sup> in 2011.

Source: MEDREC and GNESD, 2009

### Lessons Learnt from North Africa

North African countries have succeeded in providing electricity access ranging from 97% to 100% of their populations. Access to modern cooking fuels is also very high and varies from 91% in Morocco to almost 100% in Egypt. The following lessons from the success of the programs in this region may be useful to other regions, particularly sub-Saharan Africa:

- The political will to implement rural electrification programs is a key driver to improve access to electricity in rural areas.
- The availability of fossil fuels resources in some countries helped in implementing early strategies for improving access to electricity and natural gas.
- The adoption of adequate financial mechanisms, involving cross subsidy, fee-for-service, stimulates large-scale access to electricity.
- Mobilization of decentralized access to electricity through renewable energy resources helps speed up access to electricity in remote villages.
- Subsidies stimulate LPG penetration and improve access to modern cooking fuels, especially when combined with the reinforcement of the LPG filling units and distribution network.
- Household access to natural gas is secured in gas-producing countries and facilitated by the gas pipelines passing through nonproducing countries.
- There is significant potential for South-South cooperation around energy access, between North African and sub-Saharan countries. Morocco and Senegal are cooperating in rural electrification through the implementation of the electrification concession in North Senegal, based on successful experiences in Morocco.

#### 19.3.1.2 West and Central Africa

The energy access situation in West and Central Africa<sup>10</sup> compares poorly to North Africa and is similar to Eastern and Southern Africa (minus South Africa). Biomass energy forms the bulk of energy supply in the two regions, contributing more than 81% of final energy (GNESD, 2007) with related environmental consequences. At a national level, in countries such as Liberia, Chad, and Togo, more than 95% of the population

relies on traditional biomass for cooking and heating. Access to modern energy for cooking is very low in most countries. Access to LPG remains low, but there has been encouraging progress made in Senegal and to a lesser extent in Ghana, where a range of government policy and fiscal interventions have helped scale-up access to LPG.

### Access to Electricity

According to the West African Power Pool (Diallo, 2009), only 30% of the population in West Africa has access to electricity, with 53% having access in urban areas and 7.5% in rural areas. The recent unprecedented escalation of oil prices has had a devastating effect on the economies in the region. Some countries, such as Ghana, Nigeria, Cameroon, Cote d'Ivoire, and Senegal, have household electricity access levels above 35% (IEA, 2009), with Ghana often regarded as a role model in these two regions with an access level of about 54%. At the bottom end of the scale are countries like Burundi, Chad, and Rwanda, which have access levels of 5% or below. In most rural areas, where the poor are mostly found, household access to electricity is lower than 1%. The low access levels of the poor are due in part to the high level of poverty of local communities and the under-development of the electricity supply infrastructure (Sokona et al., 2004). There is insufficient grid coverage in most of the major load centers. Where available, national electricity grids are bedeviled with intermittent power supply, with frequent blackouts and sometimes power rationing as generating capacities fail to match growing populations and consumption levels (Brew-Hammond and Kemausuor, 2007). Also, the deterioration of distribution infrastructure has led to supply bottlenecks and higher technical losses comparable to other parts of sub-Saharan Africa, where inefficiencies in collection of revenues and distribution losses amount to 1.9% of GDP (Foster and Briceño-Garmendia, 2010). In Ghana, for instance, technical and commercial losses account for about 25% of supplied electricity (Energy Commission Ghana, 2008).

Several plans have been outlined in a number of countries to increase access to electricity. About 54% of the total population of Ghana has access to electricity, achieved largely through the National Electrification Scheme described in Box 19.7. The government is hoping to achieve universal access by 2020. In 2008, only 47% of the Nigerian population had access to electricity, mainly in urban areas (UNDP and WHO, 2009). The Government of Nigeria has committed resources to improve the access situation. There is an increased drive toward regional approaches in addressing the region's developmental challenges. The energy sector is spearheading this initiative, as demonstrated by the ongoing regional projects such as the West African Power Pool (WAPP) and the West African Gas Pipeline (WAGP).

In Central Africa, only 3.5% of Chad's population has access to electricity and only 30% of households in Cameroon have access to electricity (UNDP and WHO, 2009). In 2007, the Cameroon government signed an accord with the European Union worth about US\$16.2 million to facilitate access to electricity in some rural areas in the country. The

<sup>10</sup> The United Nations' definition of West Africa comprises all countries forming the ECOWAS, namely, Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. For the purpose of this review, Central Africa comprises all countries forming CEMAC: Cameroon, Central African Republic, Congo, Gabon, Equatorial Guinea and Chad.

### Box 19.7 | Electricity Access Scale-up in Ghana

Ghana increased its electrification levels from 23% in 1985 to 54% in 2005. In 1985, only 250 out of about 4202 towns and cities in Ghana, in five of the then nine regions, had access to the national electricity grid. The national electrification drive in Ghana started in 1985 with the preparation of a project by the Volta River Authority to extend the 161 kV National Grid northward to reach all the administrative regions of Ghana under a project captioned the Northern Electrification and System Reinforcement Project (NESRP). The total project cost was estimated at US\$150 million.

The Volta River Authority completed the definition of the project and obtained financial support for the first phase from the African Development Bank in 1987. Thereafter, several other multilateral agencies joined in quick succession to provide support for the entire scope of the project.

Implementation of the NESRP project was successful in every respect: financial, technical, and social. Within three years of project commencement, the national grid supplied electricity to all the regional capitals except the Upper West regional capital. The construction, commissioning, and testing of the 600 kilometers of high voltage (161 kV) lines and associated substations had been completed within budget and ahead of schedule.

The impact of the achievement of the NESRP objective by the Volta River Authority spurred the preparation of a plan called the National Electrification Scheme (NES) which was issued in 1990. The goal of the NES was to provide within a 30-year timeframe, electricity access to about 4200 settlements with populations of 500 or more. The NES was pursued through various discrete projects. Prominent among these were the Northern Electrification Project and the Self-Help Electrification Project (SHEP).

The SHEP was a nationwide scheme that was introduced as a policy framework under which communities could advance their electrification projects ahead of the dates indicated in the NES by meeting agreed criteria for community contributions to the project implementation. The SHEP aimed to connect to the national grid ahead of their respective scheduled dates any communities that:

- were within 20 km of an existing 33 kV or 11 kV network;
- had procured low-voltage poles for the network within the community; and
- had a certain minimum number of premises wired and ready to receive power.

The Government's obligation was to provide the conductors, transformers, pole-top, and other materials and assume responsibility for the construction work required to make the connection.

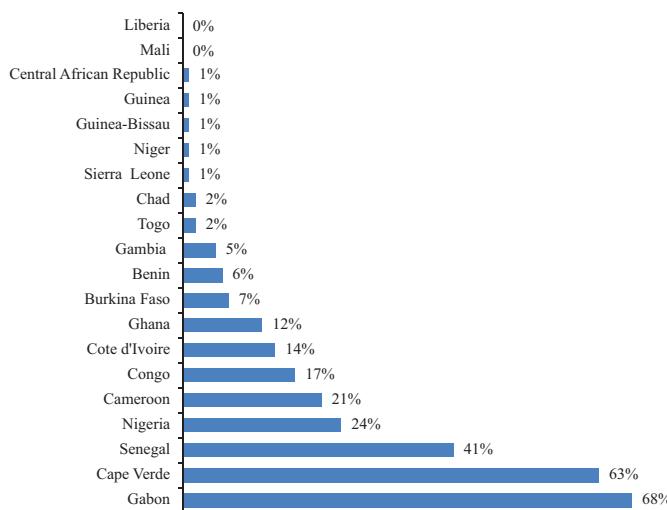
The achievements of the electrification drive (i.e., connecting 2350 communities in just ten years after the launch of the NES plan, reaching 40% of all communities with population exceeding 500 in 2000, and achieving an electrification rate of 54% by the end of 2005) were impressive. The NES was reviewed in 2010. It was estimated that the level of electrification stood at close to 70% at that time and the government has recommitted itself to building on the successes of the last two decades to achieve universal electrification by 2020.

Cameroonian government co-financed 50% of the projects and some 128 villages are expected to benefit.

#### Access to Fuels

Millions of households in West and Central Africa lack access to modern cooking fuels. For most of these households, energy from biomass (mainly fuelwood, charcoal, bagasse, and animal and agricultural waste)

is the main fuel source for cooking, even with its attendant environmental and health hazards. In many countries in these regions, including Liberia, Guinea, Mali, Sierra Leone, Niger, Togo, and Chad, more than 95% of the population relies on traditional biomass for cooking and heating (Figure 19.20). Only in Gabon, Cape Verde, and Senegal does more than 40% of the population have access to modern cooking fuels. In most of these countries, biomass energy accounts for over 80% of



**Figure 19.20 | Share of population with access to modern fuels in West and Central Africa.** Source: data from UNDP and WHO, 2009.

total energy used (Hagan, 2006). The bulk of modern energy fuels used in these two regions comes from LPG.

The numbers of people relying on traditional biomass for cooking in these regions is projected to increase consistently over the next 20 years (Modi et al., 2006; IEA, 2010b). Bearing in mind the negative effects of these projections, several countries are making efforts to reverse this trend for the better. But while many countries have tried, only Gabon, Cape Verde, Senegal, have succeeded in implementing far-reaching programs to substitute woodfuels for cooking with LPG. Nigeria and Cameroon follow in that order, but the access levels are very low compared to the LPG potentials from the oil and gas industries in these two countries. Interestingly, the same countries that have somewhat higher access to electricity also have higher access to modern fuels for cooking. Ghana, and to a lesser extent Côte d'Ivoire, seem to deviate slightly from this trend. For example, Ghana's electricity access rate of over 54% compares poorly with its 12% access to modern fuels. There has been a recent drive in Ghana to focus attention on modern fuels and an ambitious target of increasing the population using LPG to 50% by 2015 has been set but it remains to be seen how this will materialize given the frequent LPG shortages in the country.

### Participation of Regional Economic Communities in Energy

#### Access Scale-up and Lessons Learnt

Following recommendations from the New Partnership for Africa's Development (NEPAD) in 2002 to the Regional Economic Communities, the Economic Community for West African States (ECOWAS) and Communauté Economique et Monétaire de l'Afrique Centrale (CEMAC) proposed some very ambitious targets. The regional organizations have developed strategies or action plans, such as the ECOWAS/UEMOA

**Table 19.2 | Specific Energy Access Targets by ECOWAS and CEMAC for 2015.**

	ECOWAS	CEMAC
Modern energy for cooking	100%	80%
Modern energy / electricity for basic needs in urban and peri-urban areas	100%	50%
Electricity for rural households	36%	35%
Electricity for schools, clinics and community centers	60%	56%
Mechanical power for productive uses in rural areas	60%	-

**Table 19.3 | Barriers for LPG access for households and LPG suppliers.**

	Demand Side	Supply side
Accessibility	Rural Household Access to LPG – Local LP Gas supply to households – Smaller cylinders – Full local sales and services – Fast and convenient refills – Plenty of cylinders frequently refilled	LP Gas Supplier Access to Rural Households – Dispersed customers – Long supply chains – Lack of rural supply infrastructure – Need for local agents and sub agents – Higher investment, risk and maintenance cost
Affordability	Low LP Gas Appliance Prices – Ability to pay – Need for credit – Small quantities – Low cost of appliance to switch to LP Gas – Access to credit – Below poverty line households	Higher Margins to Support Higher Rural Supply Cost – Low LP Gas prices – Small margins – Economic viability – Need for subsidies for market entry appliances – Need to reduce overheads – Special third party financial support
Acceptability	Rural Household View of LP Gas – Low or zero cost fuel alternatives such as wood – Higher fuel cost – Safety and proper usage – Cooking major usage – Government friendly household energy policy – Zero rated taxes – Many competing suppliers	Attractiveness of Rural Markets to Suppliers – Added cost of competitive marketing – Low margins – Costly user education – Small volumes of LP Gas – Government policy favoring other fuels such as paraffin/natural gas – VAT on LP Gas sales – Exclusive supply territories

Source: WLPGA, 2005.

White Paper on Energy Access (ECOWAS, 2006) and the CEMAC Action Plan for Promotion of Energy Access (CEMAC, 2006) with assistance from UNDP and the EU Energy Initiative Partnership Dialogue Facility. Whereas CEMAC is aiming for 80% access to modern fuels for cooking by 2015, ECOWAS is hoping to achieve 100% access to modern fuels by 2015, with between 50% and 70% being provided through LPG and the rest through improved fuelwood cook stoves (Table 19.2). Judging from progress made so far, it is going to be very difficult to achieve these

targets and they may need to be revised with greater emphasis placed on developing capacity.

The penetration of LPG, particularly in rural areas, has been very slow and access levels remain very low. The World LPG Association identified several key barriers to the accessibility, affordability, and acceptability of LPG, in particular for rural households and suppliers (Table 19.3). The World LPG Association believes that increasing access to LPG would require a concerted effort by industry and government to address all aspects of the energy puzzle, including developing local resources, financing, building capacity in local energy entrepreneurs, developing joint marketing campaigns, and increasing public awareness, with the right mix of policy changes, dissolution of market barriers, and responsible investment (WLPGA, 2005). Senegal is one country that managed to address all the barriers successfully and LPG access levels are 41% overall, with 74% in urban areas and 12% in rural areas (UNDP and WHO, 2009).<sup>11</sup>

Efforts that succeed in integrating productive uses and income generation activities into energy access initiatives may well turn out to be the deciding factor in improving access to households in this region. So far, private sector participation in energy access scale-up has been abysmal, as policies and tariffs have not been favorable for encouraging the private sector to venture into power production. Countries in the two regions should be learning from the experiences of Senegal – and countries outside the regions, such as Botswana and Brazil – to explore sustainable ways of increasing access to LPG, emerging biofuels, and improved cook stoves. Ultimately, a major shift is needed in the current access trajectory if realistic increases in energy access are to be achieved by 2030, which is the reference date for most forecasts by the Regional Economic Communities, the IEA, and the World Bank.

#### 19.3.1.3 Eastern and Southern Africa

In most countries in Eastern and Southern Africa<sup>12</sup> energy use overall has risen and governments and utilities have made efforts to increase generation, transmission, and distribution capacities, but the progress made has been too slow to keep pace with population growth. The energy supply and use situation is generally similar to West and Central Africa (see above), but national rates of deforestation are much heavier in Eastern Africa, and in many regions, adequate supplies of wood and charcoal fuels are an issue. The cost of these fuels, when purchased, has been rising steadily. In most countries, traditional biomass still plays the major role (up to 80%) in energy supply. Some governments have implemented projects and policies to make modern cooking fuels (LPG and kerosene) more easily

available in rural and peri-urban areas (e.g., Botswana, Lesotho, and South Africa) and private companies sell them more widely now. In other countries, deregulation of LPG and kerosene made them more expensive for the end-user, leading to a decline in kerosene use. Many African countries grow sugarcane and there is a rising interest in producing ethanol for the transport sector and as a household cooking fuel. In Eastern and Southern Africa, ethanol gelfuel – ethanol with a gelling agent – was introduced, starting with the Millennium Gelfuel Project, but wider dissemination did not follow. The efficiency of technology using ethanol gelfuel compared with LPG and kerosene was also found to be significantly lower. The retail price of ethanol gel fuel would have to be well below that of kerosene and LPG to make ethanol gelfuel competitive.

Improved cook stoves have received much attention and the Kenyan Ceramic Jiko, an improved charcoal stove, is distributed to over eight million customers across Africa, from Senegal to Ethiopia and South Africa, and has become an African success story (AFREPREN/FWD, 2009). Biogas plants have been introduced on a project basis in the region. The biogas scheme in Rwanda that integrates agriculture and energy appears to be one of the more successful ones.

#### Access to Electricity

Levels of household access to electricity in Eastern and Southern Africa range from a low of about 6% in Rwanda to 100% in Mauritius. The countries with the highest access are Mauritius (100%) and South Africa (73%). The two countries are the two middle-income economies in the regions. Electricity supply is not always the largest limiting factor to improved access, and barriers sometimes lie in the lack of national infrastructure. The Democratic Republic of Congo (DRC), Lesotho, and Mozambique are exporting electricity through the Southern African Power Pool to other countries in the region, while their national electrification levels are less than 15%.

In Southern Africa, four countries – Botswana, Mauritius, South Africa, and Zimbabwe – have successfully extended electrification to rural areas using different approaches. In Botswana, the utility connects households on a cost-recovery basis and customers can apply for loans for their electricity connection. Monitoring the implementation and impact of the rural electrification policy, the Energy, Environment, Computer and Geophysical Applications Group (EECG, 2004) found that if the upfront payment and monthly repayments are small and extended over longer periods, the uptake of connections increases significantly. South Africa highly subsidises electricity to low-income households. Under the National Electrification Programme, access to electricity is very affordable even for the urban and rural poor. In addition, the Free Basic Electricity allocates 50kWh/month free of charge to poor households (Box 19.8). In Zimbabwe, the Rural Electrification Agency targets rural growth centres where local government infrastructure such as agricultural extension, health services, schools, and police stations are concentrated. Local councils facilitate enterprise development and lease stands to medium and small enterprises that provide services including automotive, electrical, electronic and

<sup>11</sup> See Chapter 23 for further discussion on the success of transitioning to LPG as a cooking fuel in Senegal.

<sup>12</sup> For this study, Eastern Africa includes Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Tanzania, Somalia, Sudan, and Uganda. Southern Africa includes the 15 countries of the Southern African Development Community (SADC): Angola, Botswana, Democratic Republic of Congo (DRC), Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe.

### Box 19.8 | South African National Electrification Programme and the Free Basic Electricity

Through the government's National Electrification Programme, electricity connections in South Africa grew from 36 % of households in 1995 to over 70% in 2008. Electricity to low-income households is subsidised, making access affordable for the poor. The blanket roll out, in which whole areas are provided with electricity supply so all potential customers are served, not only customers applying and paying, significantly reduces cost. Technological innovations such as prepayment meters further reduce costs.

While the National Electrification Programme facilitated access to electricity, the poor did not automatically benefit from being connected. Often they could not afford to use the electricity and consumption levels among the newly connected households remained low. In 2003, the government introduced the Free Basic Electricity so the poor could benefit from the huge investments in national electrification.

The example of Cape Town illustrates how the subsidised connection works. The municipality of Cape Town charges ZAR 225 (approximately US\$29) for a subsidised connection of 40 ampere to recognised areas of informal housing. If the new customer cannot pay the connection fee upfront, the amount is charged to their prepayment account and deducted gradually each time an electricity purchase is made, at the rate of 20% of the purchase. No interest is charged on the advanced connection fee. If customers use less than 450 kWh/month they are eligible for a lifeline tariff divided into three blocks. The first block up to 50 kWh/month is free, the second block from 51–150 kWh at ZAR cents 58.11/kWh, and the third block from 151–450 kWh is charged at ZAR cents 70.47/kWh. This compares to the domestic consumption tariff without subsidy of ZAR cents 93.32/kWh.

#### Why are some excluded from subsidised access?

Informal houses built on land not approved for electrification (flood plains, road reserves, power-line servitudes, private land, etc) cannot get a metered electricity connection and have to rely on extension cords to neighbouring houses that are metered. This generally costs twice as much as electricity from metered access.

general repairs, welding and spray painting, milling, carpentry, secretarial, and general retail services. In Mauritius, the rural electrification program started well before the country gained its independence in 1968 from the British. Since that time, the Central Electricity Board has been the only electric utility responsible for generating, transmitting, and distributing electricity in Mauritius and it had connected all households by the year 2000.

Over half a million households in Africa use PV systems for lighting and communication (AFREPREN/FWD, 2009). In Kenya, about 150,000 solar systems have been distributed through the market. Other countries, such as South Africa, started subsidised programs in the late 1990s. The number of systems distributed was far below the target figure. Financial and technical barriers and the expectation of the recipients, particularly those who live near the national grid and hoped to get a grid connection, seem to have been the major problems. In Botswana, the distribution of solar systems has been stepped up and is bringing light and communication to remote villages and dispersed cattle posts.

#### Access to Fuels

Fuelwood is still very widely used in Eastern and Southern Africa and 80% of the population in 13 of the 24 countries use fuelwood for

cooking. In six countries, households are almost entirely dependent on woodfuels: Burundi (99.3), Madagascar (99.1%), Malawi (98.6%), Rwanda (98.6%), Somalia (99.1%), and Tanzania (96.6%). Out of these, Burundi, Malawi, and Rwanda are land-locked countries without any fossil fuel resources. In contrast, 80% of the population in four countries have access to modern fuels (electricity, gas, and kerosene). These are Djibouti (86.1%), Mauritius (95.8%), Seychelles (>95%), and South Africa (83.2%). The first three countries in the latter set have small populations below 1.3 million and make up only a small proportion of the sub-Saharan African population. Gas is a major cooking fuel in only three countries: Angola (51.9%), Botswana (45.8%), and Mauritius (91%) (Figure 19.21).

Not only a high proportion of households, but also a significant number of industries in Eastern and Southern Africa depend on fuelwood and charcoal for their energy needs. The poorest use fuelwood and as incomes rise charcoal is the preferred fuel. Charcoal is also the preferred fuel in urban areas. In densely populated areas and particularly around major cities, fuelwood and charcoal are becoming scarce and overharvesting contributes to forest and soil degradation. Woodfuels (fuelwood and charcoal) have become a lucrative trade and are a major source of income for many households. The poor are employed along the entire value chain, from the rural woodcutters and charcoal

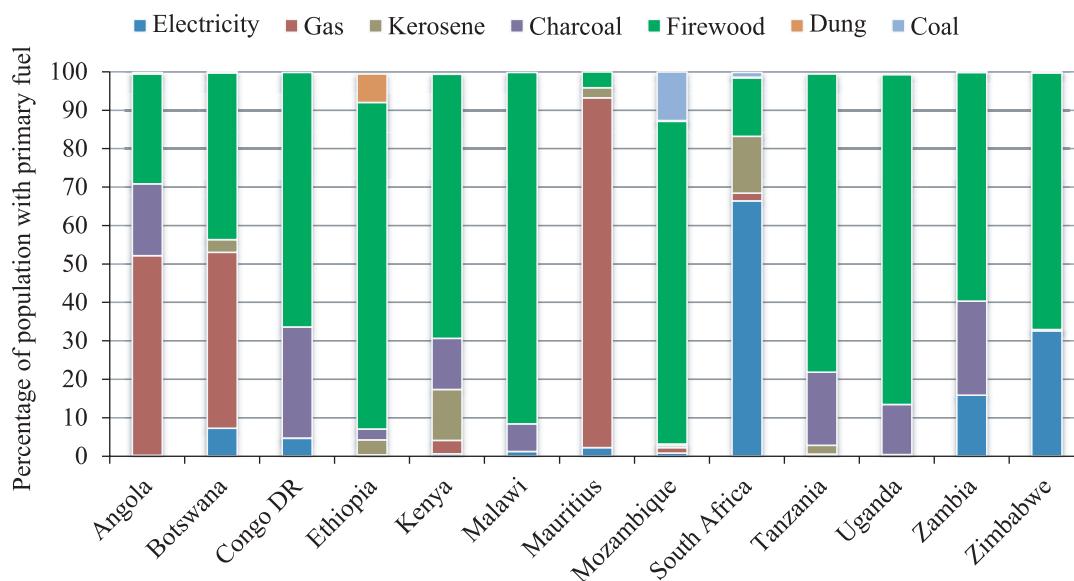


Figure 19.21 | Fuels used for cooking by country in Eastern and Southern Africa. Source: UNDP and WHO, 2009.

producers to the transporters and the urban distributors. The growing wood and charcoal markets are in many cases seen as a threat to forest and woodland resources, but if they are regarded as an opportunity to create employment for the rural poor and provide affordable energy they could provide an important contribution to poverty alleviation. This would require that forest management and the charcoal trade are well and transparently regulated and the implementation of the regulation is in the interest of all stakeholders. It is estimated that the woodfuel trade in Malawi and Rwanda is about 2% of GDP and governments could collect substantial revenues from a regulated woodfuel industry. This income could contribute to making the markets sustainable.

Generally, woodfuel policies and strategies need to be better integrated and address the following objectives: to provide a sustainable woodfuel supply for the majority of sub-Saharan Africans, to protect the environment, and to approach the fuelwood chain as an opportunity for poverty alleviation and job creation.

The traditional three-stone cook stove is still used in many parts of Eastern and Southern Africa. At the same time, improved cook stoves are locally designed and manufactured to reduce heat loss, decrease indoor air pollution, increase combustion efficiency, and improve heat transfer (AFREPREN/FWD, 2009). The best known example is the Kenya Ceramic Jiko, which is disseminated in Kenya and other African countries. The dissemination level for improved woodfuel stoves (Table 19.4) is low in relation to the number of people using woodfuels for cooking. The barriers may be limited local production levels, acceptance, and affordability of the improved cook stoves.

Table 19.4 | Dissemination of improved woodfuel cook stoves in Eastern and Southern Africa.

Country	Number disseminated
Botswana	1500
Eritrea	50,000
Ethiopia	3,010,000
Kenya	3,136,739
Malawi	3700
South Africa	1,250,000
Sudan	100,000
Tanzania	54,000
Uganda	170 000
Zambia	4082
Zimbabwe	20,880

Source: AFREPREN/FWD, 2009.

### 19.3.2 Asia and Pacific

With about 60% of the world's population, the Asia and Pacific region comprises the largest of the global regions. A very high level of the population in the region still lives in poverty. Although economic development has resulted in rapid urbanization and changed the composition of the population, about two-thirds of the region's population still lives in rural areas. Furthermore, these rural areas are home to more than three-quarters of the poor in the region, who are distinguished by some of the lowest levels of per capita energy use in the world. Huge variations within Asia are evident in the levels of access to both electricity and modern fuels and more efficient devices. Progress with

**Table 19.5 |** Per capita energy use and percentage users by energy sources for China.

		Urban 1992	Urban 1996	Urban 1999	Urban 2001	Rural 1999
Coal	MJ	3245	2313	2085	2356	1843
	%	47.5	32.3	27	28.8	38
LPG	MJ	541	734	845	805	40
	%	45.1	53.6	56.7	56	28
Piped natural gas (urban only)/ Biomass (rural only)	MJ	892	1400	1421	1464	6214*
	%	21.3	30.8	33	34.7	62
Electricity	MJ	1445	2357	3182	3774	84
	%	93.8	92.5	94.8	96.2	97
Total	MJ	6122	6805	7544	8398	8181

\* In rural areas this represents biomass use as no piped natural gas is used in rural households.

Source: Pachauri and Jiang, 2008.

electrification has also been extremely uneven across the region in the past. The problem of provision of modern fuels and/or devices for thermal energy needs, however, remains a larger challenge for Asia. For most countries in the region, the majority of the rural population relies on unprocessed biomass or coal for most of their cooking and heating needs. Over half of the total global population relying on biomass lives in China and India alone.

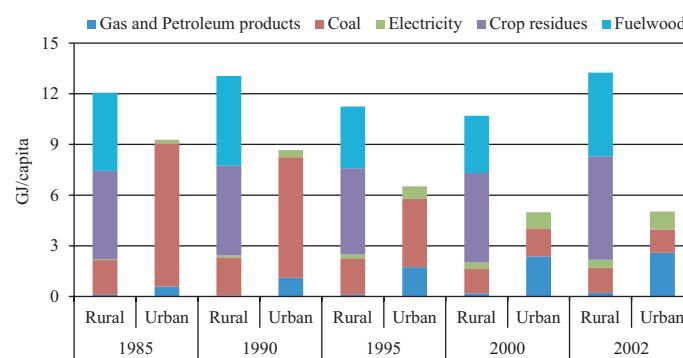
A detailed account of the energy access situation and efforts in the two largest Asian nations, China and India, and that for the other developing Asian countries is presented in the following sections.

### 19.3.2.1 China

China is an example of a country that has achieved significant success in improving the access to electricity for its rural population and in the dissemination of clean cook stoves. In overall terms, total residential energy demand increased little in China over the last couple of decades, because of a transition from inefficient to efficient fuels. However, significant changes in the pattern of residential energy occurred, largely on account of shifts in the choices of energy used in urban households. Within the rural sector, relatively little change in the patterns of household energy use took place (Figure 19.22 and Table 19.5). What has been significant is the access to modern energy among rural households in the country. However, actual consumption amounts of the modern energy sources remain very low in rural households.

### Access to Electricity

China has achieved enormous success in electrifying its population.<sup>13</sup> During the 1980s and 1990s, almost the entire population was electrified, with over 900 million rural inhabitants gaining access to electricity (Peng and Pan, 2006). Currently, it is estimated that only about 1% of the total population remains without access to electricity. Strong government commitment was important to achieving the current status of



**Figure 19.22 |** Average household energy demand by energy type in China 1985–2002. Source: Pachauri and Jiang, 2008.

electrification in China. The latest statistics from the National Energy Administration suggest that in 2008, two million rural households still lacked electricity in China, which represents some nine to 10 million people (IEA, 2010a). Through the deployment of decentralized power systems, the government aims to supply about 10 million people with electricity by the end of 2020. The government expects, however, that by 2020 universal access will still not be achieved (the last customer will not be connected). At present, most areas without electricity are located in western regions and islands in the eastern coastal areas, far away from the grid. Most of these areas are rich in renewable energy resources (hydropower, solar, and wind energy), which can practically and economically provide electrification to remote regions. Lessons from the electrification programs in China point to certain key factors that were responsible for its success. These include strong government commitment, technological flexibility, a sense of ownership for the electrification solutions among remote communities not served by the grid, and the inclusion of the private sector in the implementation of electrification programs (IEA, 2010b).

### Access to Modern Fuels and Stoves

Biomass and coal continue to be key sources of cooking and heating energy among rural households in China. Today, over 700 million

<sup>13</sup> For a more detailed assessment of the policies that led to the success of the electrification efforts in China, refer to Chapter 23.

**Table 19.6 | Shifts in the percentage of population using different sources of household energy in India.**

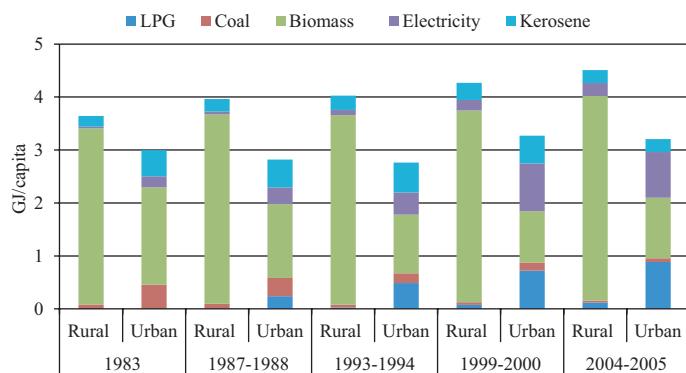
	1983		1987–1988		1993–1994		1999–2000		2004–2005	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
LPG	0	9	1	20	2	33	6	47	12	61
Coal/coke	3	21	3	14	2	8	2	5	2	5
Electricity	15	58	24	67	36	77	47	84	54	91
Kerosene	95	92	96	88	95	83	96	75	91	55
Fuelwood	86	61	89	50	88	42	88	35	88	35
Dung	53	27	56	24	53	18	52	12	46	10

Source: Pachauri and Jiang, 2008.

inhabitants of China continue to rely on solid fuels. Although gas, oil, and electricity consumption in rural areas has increased over the last 25 years, it still remains very low, and much lower than in urban households in aggregate and per capita terms. The total consumption of biomass has remained high in rural areas because of population growth and the relatively slow transition away from the use of this fuel. Urban households in China use a larger share of modern energy. Looking at changes over time among rural households, although per capita biomass use gradually declined during most of the 1990s and coal use was moderately substituted by modern energy, no significant transition in energy use patterns occurred. In urban households, in contrast, a significant shift away from biomass and coal has taken place over the last twenty years. Without any new policies, it is projected that about a quarter of the total population will still rely on solid fuels in 2030.

The Chinese have also made significant efforts in improved dissemination of cook stoves. Between 1982 and 1999, the Chinese National Improved Stoves Program disseminated 180 million improved biomass stoves (Zhang and Smith, 2007). While it is difficult to know how many of these stoves are still in use, the recent UNDP and WHO study (2009) suggests that many still are. The Chinese ICS program, the largest and arguably most successful in the world, relied on rural private stove companies for its success. Main features of the program included:

- stove adopters paying the full cost of material and labor (about US\$10);
- government-provided support to producers through designs for stove construction, training, administration, and promotion support; basically there was an indirect subsidy to pay for the costs of stove-making enterprises;
- establishment of local energy offices to provide training, service, installation support, and program monitoring;
- fostering the development of self-sustaining rural energy enterprises that manufactured, installed, and serviced the stoves; and
- an unprecedented scale of rural energy intervention.

**Figure 19.23 | Average household energy use by energy type in India, 1983–2005.**  
Source: Pachauri and Jiang, 2008.

### 19.3.2.2 India

Even today about 40% of India's rural population lacks access to electricity and almost 80% rely on unprocessed biomass for their cooking and heating needs (Pachauri and Jiang, 2008). Several programs were implemented in the past to improve access; however, the focus was largely on improving access in urban centers and in fertile agricultural belts in rural areas.

Rural households did not witness any striking changes in their patterns of energy use. Biomass use per capita increased in absolute terms, but only slightly between 1983 and 2005. The total amounts and the proportions of commercial energy used in rural households continue to remain very low. In urban households, a much more rapid substitution of biomass by commercial fuels and electricity is evident. Biomass consumption per capita declined, and this decline resulted in a decrease in total per capita household energy demand in urban households between 1983 and 1993–1994 and between 1999–2000 and 2004–2005. However, during the mid-1990s, rise in LPG and electricity consumption among urban households drove up per capita energy use (Table 19.6 and Figure 19.23).

#### Access to Electricity

India today hosts the world's largest population without access to electricity. Traditionally, village electrification was used as an indicator of the

### Box 19.9 | Achievements of the Rajiv Gandhi Grameen Vidyutikaran Yojana

The Rajiv Gandhi Grameen Vidyutikaran Yojana program, with a total estimated budget of over US\$5 billion, is one of the most ambitious to date in India. It aims at electrifying all unelectrified villages, electrifying all households in electrified villages, and providing free electricity connections to all below-the-poverty line (BPL) households. In all, the program aims to electrify about 115 thousand unelectrified villages and connect 23.4 million BPL households. Close to 90% of the funds committed have been disbursed and the table below provides an overview of the programs achievements to date.

	Electrification of Unelectrified Villages	Intensive Electrification of Electrified Villages	Connection to BPL Households
Total Numbers (%)	103,402 (87.8%)	248,553 (69.7%)	18,912,729 (76.5%)

Source: India Ministry of Power, 2011

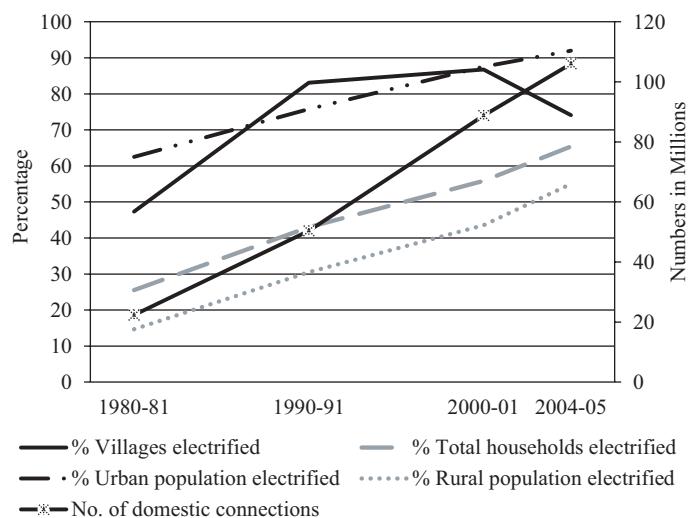


Figure 19.24 | Progress with electrification in India according to different indicators.  
Source: Pachauri and Mueller, 2008.

extent of rural electrification, but this did not provide an accurate picture of the actual use of electricity among households and also changed over time as a consequence of changes in the definition of "electrified village" (see Figure 19.24). Historical progress on electrification in India when measured in terms of household access has been rather poor, but the status varies significantly across states and regions.

The Indian government has recently redoubled its efforts at initiating policy reforms and new programs for accelerating electrification. The Rural Electrification Policy 2006 aimed at the provision of electricity access to all households by 2009 and a minimum lifeline consumption of one unit per household/day as a merit good by the year 2012. The National Electrification Policy 2005, which preceded this by a year, targeted total village electrification by 2010 and total household electrification by 2012 (India Ministry of Power, 2005). The main program through which universal access objectives of the Electricity Policy are being implemented is the Rajiv Gandhi Grameen Vidyutikaran

Yojana, launched in April 2005. A large effort towards grid extension and strengthening of the rural electricity infrastructure has been initiated through the Rajiv Gandhi Grameen Vidyutikaran Yojana. The government's Rural Electrification Policy 2006 also specifies, among other things, guidelines for decentralized distributed generation. The Ministry of New and Renewable Energy has also initiated a new remote village electrification program. Significant progress in providing access has been achieved in certain regions and states of the country. However, in other states, particularly among rural households, large fractions of the population are still in the dark. The ambitious targets for 2009, 2010 have not been met and future target for 2012 will also likely not be met given current trends (Pachauri and Mueller, 2008).

#### Access to Modern Fuels and Stoves

In 1980–1981, over 90% of energy used by households in India was from biomass sources. While this share declined to just over 80% in 2000–2001, the actual quantity of biomass consumed increased continuously over the entire period (Pachauri and Jiang, 2008). As observed in Table 19.6, major changes are evident in the percentage of persons using different energy types across rural and urban households over this period. The percentage of population using LPG increased from 9% to 61% in urban areas. However, in rural households the uptake of LPG was much slower and even in 2004–2005, only 12% of the rural population used this fuel. Thus, for the majority of the rural population even today, biomass remains the main source of cooking and heating fuel. Over 800 million people – 75% of the rural households and 22% of the urban households – rely on solid fuels in India today. Without any additional new policies, the number of people relying on solid fuels is projected to increase or at best remain unchanged by 2030.

In order to improve the access to improved end-use devices, especially among rural households who are likely to depend on biomass for the foreseeable future, the Ministry of New and Renewable Energy of the Government of India has launched a new initiative on biomass cook stoves, with the primary aim of enhancing the availability of clean and efficient energy for the energy deficient and poorer sections of society.

The new initiative is based on the recognition that cook stove technology has improved considerably in the past few years. But further advances are still possible and, indeed essential. The aim is to achieve the quality of energy services from cook stoves comparable to that from other clean energy sources such as LPG. Under this initiative, a series of pilot-scale projects are envisaged using several existing commercially-available and better cook stoves and different grades of processed biomass fuels. The goal of the program is to sell 150 million stoves in 10 years.

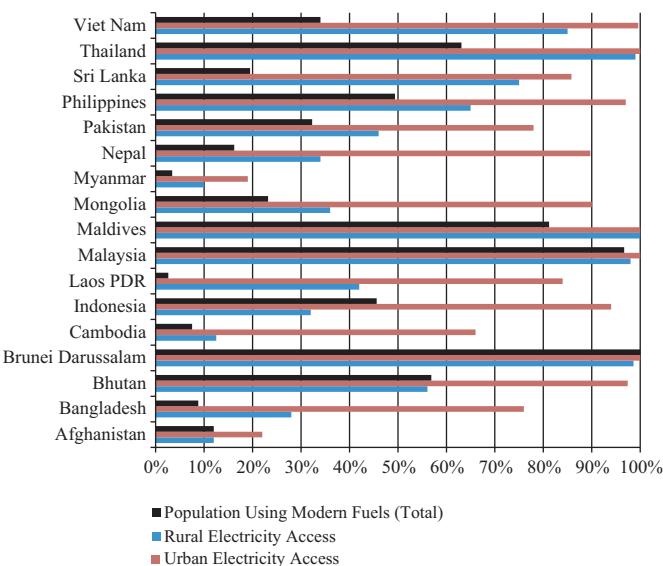
The Indian government is not alone in its effort to expand Indians' access to cleaner biomass cook stoves. International donors such as the Shell Foundation are increasing their support of cook stove programs that show potential for economic sustainability and scalability. Corporations such as Royal Philips Electronics, First Energy (formerly a BP company), and Bosch-Siemens, are developing cleaner cook stoves that can be customized for cooking needs around the world. Companies that can manufacture stoves include Envirofit, StoveTec, First Energy, WorldStove, and HELPS International. The Shell Foundation has invested US\$3.5 million in Envirofit to support its program to sell 5–7 million stoves in seven states in India in the next five years and is investing several million dollars in a public awareness campaign. So far most companies are marketing only to consumers who can afford to pay about US\$20 for a stove, which excludes the very poor. But Envirofit plans to launch a new model that customers can purchase through monthly payments to a microfinance company. The users will be required to pay about US\$1 a month for around a year. Another payment option that stove companies, including Philips, may pursue is to seek carbon credits for cleaner stoves (Adler, 2010).

### 19.3.2.3 Other Developing Asian Countries

As mentioned above, Asia is a very diverse region. In this section we discuss the state of access in developing nations of Asia other than India and China. It is also one of the world's most dynamic regions, and as such, the region has made relatively rapid progress towards socioeconomic development. Even so, a very high level of the region's population lives in poverty, the highest in the world. As early as the 1970s, countries in the region had already adopted energy development programs that aimed to alleviate poverty. These energy development programs focused mostly on rural electrification because the majority of the poor people in these countries reside in rural areas. The view that rural electrification would be enough to generate rural development and lead to poverty alleviation was widely held when these programs were initiated.

#### Access to Electricity

About 14% of the total population without electricity globally is living in other developing nations in Asia. In the 1970s, nationwide electrification programs, which were generally based on grid-extension systems, were implemented with uneven success in several developing countries in the region, such as Bangladesh, Indonesia, Malaysia, Philippines, and Thailand. While some of these countries have been fairly successful in providing access to electricity to their rural populations, most of the rural population



**Figure 19.25 | Status of electrification and dependence on solid fuels in the Rest of Developing Asia.** Source: UNDP and WHO, 2009.

in South Asia, other than in Sri Lanka and about 70 million Indonesians, are estimated to be unconnected to electricity (Figure 19.25).

More recently, Viet Nam and Laos have been extremely successful in improving the access to electricity for their populations. The World Bank and the Asian Development Bank have been particularly instrumental in improving access in these two countries.

Recent initiatives in the region have also focused on off-grid solutions to electrification and promoting renewable energy technologies. For instance, The Grameen Shakti Solar Home Systems Program in Bangladesh sells SHSs on credit. It is implemented in several districts of the country and initially targeted the installation of 8000 systems in three years. Since the systems are expensive, Grameen Shakti, part of the microfinancing institution Grameen Bank, has introduced soft-financing systems for the customer. Grameen Shakti encourages PV users to venture into income generating activities using their PV systems such as charging cellular phones; provision of light to post-harvest processing facilities, small enterprises, household-based livelihood activities and clinics so these can extend operations to early evening hours (thus increasing daily income); and power for radio/television repair shops (Shakti, 2010).

#### Access to Modern Fuels and Stoves

The problem of provision of modern energy for thermal energy needs remains a larger challenge for Asia. For most countries in the region, the majority of the rural population relies on unprocessed biomass or coal for most of its cooking and heating needs. Bringing about shifts in the energy-related behaviors of millions of households requires strong policies and large investments. Though complex, the problem of solid fuel use is not insoluble. Programs to reduce solid fuel use have been successful, most visibly the Chinese National Improved Stove Program mentioned above. Within other countries in the region, relatively little change in the dependence of rural populations on traditional solid fuels has taken place.

### Box 19.10 | Enterprise Approach to Improved Cook Stove Programs in Asia

The Sri Lankan Anagi stove was promoted by encouraging artisans to enter business as mass producers of stoves that they market through normal market mechanisms. Village potters were trained to manufacture the models made of clay within strict standards. General distributors (wholesale buyers) visit the production centers to buy the stoves in bulk. Producers thus have their regular buyers. Stoves purchased are distributed to retail shops spread over a radius of about 200 km. Small producers living in isolated areas sell their products directly in the village. Today, about 300,000 stoves are annually produced by 120 rural potters trained by an NGO (IDEA) scattered in 14 districts of the country. The Anagi ICS has become one of the most widespread pottery items in village grocery stores.

In Cambodia, the Cambodia Fuelwood Saving Project provides technical and business development training to stove entrepreneurs to produce improved cook stoves. For each ICS, the producers invest an average of US\$0.50 more than for a traditional stove. The Cambodia Fuelwood Saving Project has also created the Improved Cook Stove Producers and Distributors Association of Cambodia, which facilitates sectoral development, quality assurance, and the long-term sustainability of ICS dissemination.

In the Nepal program, capacity building inputs are provided by the government agency Alternative Energy Promotion Centre, which supported the participation of the informal private sector in cooperation with the Center for Rural Technology and other NGOs. Stove artisans (many of them women) have been trained and are now paid for their services constructing and maintaining stoves in their villages. The constructions of the improved stoves are exclusively carried out by these trained, predominantly women, masons. In 2005, there were about 1700 such trained technicians.

A UNDP survey of poor communities in the Asia Pacific region clearly indicates that rising oil prices left the poor with few choices other than to cut back on their consumption of oil products or, for uses that cannot be avoided, to bear the higher prices and look elsewhere in their household budgets to find the additional money (UNDP, 2007c). Since the urban poor rely more on oil products like kerosene and LPG, they are worse off than their rural counterparts, who are either biomass users or have the biomass option to fall back upon. The rural poor, however, are more vulnerable to higher lighting fuel prices, especially in unelectrified villages but also in electrified villages subject to frequent supply disruptions. Improved cook stove initiatives have been seen to be an important complement to improve cooking energy services for the poor and militate against rising oil prices.

#### 19.3.3 Latin America and the Caribbean

The levels of access to electricity and clean cooking services in Latin America and the Caribbean (LAC), as shown in Section 1 of this chapter, are much higher than those in the other developing regions. Close to 90% of the region's population have access to electricity, compared to 62% for South Asia and around 28.5% for sub-Saharan Africa. (World Bank, 2010a). Access levels for clean cooking (and heating) services follow a similar pattern, with Latin America leading the way followed by Asia and then sub-Saharan Africa. Nevertheless, in Latin America and the Caribbean, approximately 200 million people currently live under the poverty line, and approximately 133 million live in urban areas and 67 million in rural areas. Seventy-two million are in absolute poverty (50% in urban areas and 50% in rural areas).

Table 19.7 shows that approximately 21.5 million people are estimated to have no access to electricity in the sample of the 14 most populated countries in the region (excluding Mexico). The largest numbers of people without access to electricity are concentrated in Peru and Brazil (over 7 million each); Bolivia, Guatemala, and Honduras (over two million each); and Nicaragua (over 1.5 million). Table 19.7 also highlights that in most countries, over 70% of the people without access to electric service are poor.

##### 19.3.3.1 South America

The lowest energy use rates for modern energies are invariably in nations with the lowest Human Development Index (HDI) rankings. The correlation between access to modern energies, per capita energy demand, and HDI rankings are not exclusive to this region and similar correlations are observed worldwide (Fig 19.26).

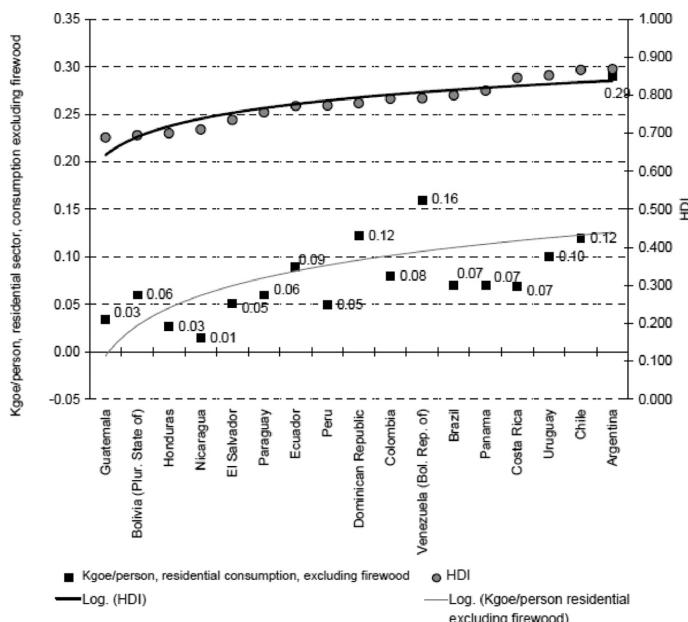
In general, in all LAC countries the poor use less energy than the other social strata but they spend a higher proportion of their income on energy than the non-poor. Additionally, lower energy use by the poor is reflected in the differences in the level of access to equipment between income quintiles.

However, illegal connections, especially to electricity, could reflect very high consumption levels for services like cooking or heating. Energy access policies should be combined with efficient use of energy programs in closer coordination with public utilities.

**Table 19.7** | Estimates of population without access to electricity in a sample of Latin American countries.

Country	Poor population without electric service (thousand)	Non poor population without electric service (thousand)	Total population without electric service (thousand)	% poor in total population without electric service	Country share % in total population without electric service
Argentina	57	91	148	38%	0.5%
Bolivia	2904	708	3611	80%	12.2%
Brazil	5123	2753	7875	65%	26.7%
Chile	62	168	231	27%	0.8%
Colombia	420	956	1376	31%	4.7%
Costa Rica	34	18	52	66%	0.2%
Ecuador	51	15	66	77%	0.2%
El Salvador	751	191	942	80%	3.2%
Guatemala	2569	687	3256	79%	11.0%
Honduras	2272	210	2482	92%	8.4%
Nicaragua	1377	219	1596	86%	5.4%
Paraguay	510	75	585	87%	2.0%
Peru	5264	1982	7245	73%	24.6%
Venezuela	16	19	35	46%	0.1%
<b>Total estimate</b>	<b>21,410</b>	<b>8092</b>	<b>29,501</b>	<b>73%</b>	<b>100.0%</b>

Source: ECLAC et al., 2010.

**Figure 19.26** | Relationship between residential energy use and HDI in LAC nations.  
Source: ECLAC et al., 2010.

### Access to Electricity

The process of rapid urbanization in South America and domestic migration from rural to urban areas has been accompanied by an increasing need for energy, but has also made it easier to provide electricity access. In effect, a high density concentration of potential consumers has meant lower costs to expand distribution systems. Greater access to employment

for the new inhabitants of the cities has been accompanied by higher payment capacity from an important share of urban consumers. The combination of these different issues has provided an important opportunity for cross subsidies to facilitate access for the poor population.

The information at the national-average level conceals large differences between urban and rural areas (Figure 19.27). For instance, countries with a relatively higher development level have problems of extreme poverty more serious than those of relatively lower development.

Even in countries with significant electricity access, poor households generally lack basic electrical equipment to benefit from energy services and have very limited access to communication and information technologies in comparison with the upper income groups within the same country. As shown in Figure 19.28 below, the percentage of upper income population (q5) with access to electric and communication equipment, relative to the percentage of lower income (q1) with access to the same type of equipment, can be 10 to 40 times as large in countries like Brazil, Uruguay, and Paraguay, which already have more than 90% electrical coverage. These data highlight the fundamental role of providing equipment in order to achieve effective access to energy services as coverage is extended to the poor sectors of the population.

### Access to Fuels

The consumption of firewood in households drastically reduced from the 1970s to mid-1990s. Since then, firewood consumption has remained stable or even grown in some cases as shown in Figure 19.29. This

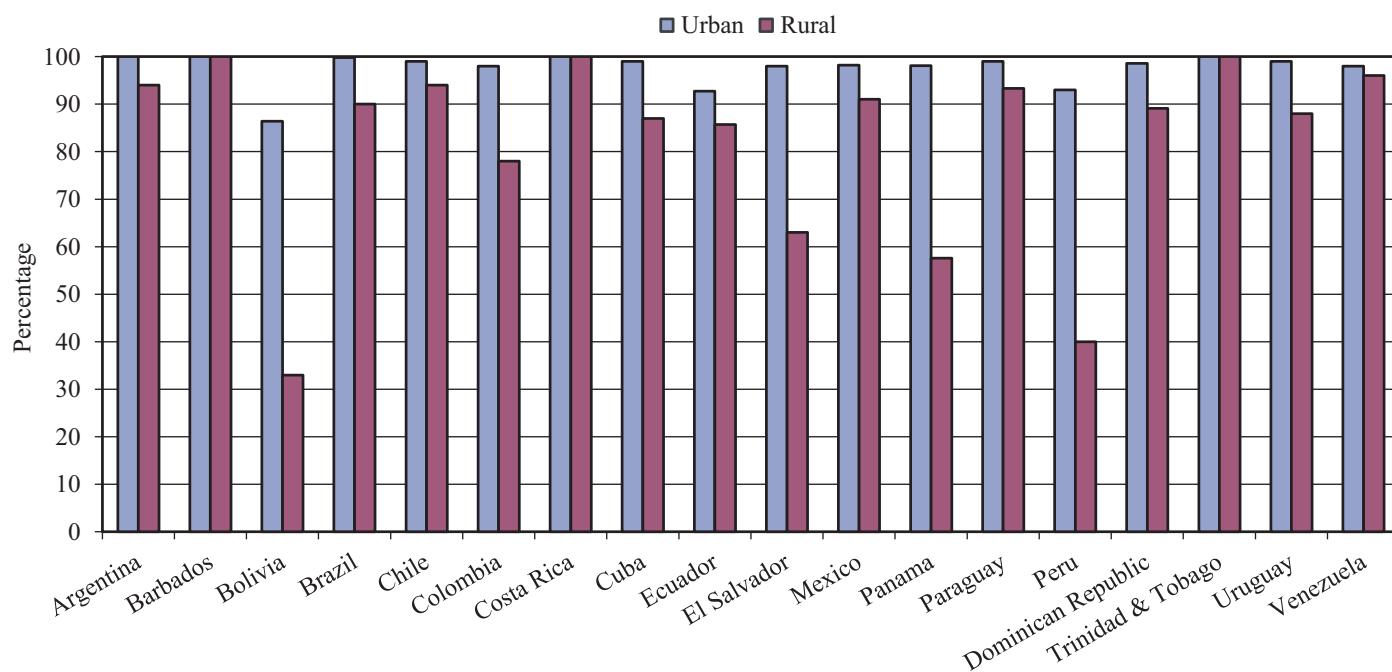


Figure 19.27 | Access to electricity in urban and rural areas of Latin America. Source: OLADE, 2008.

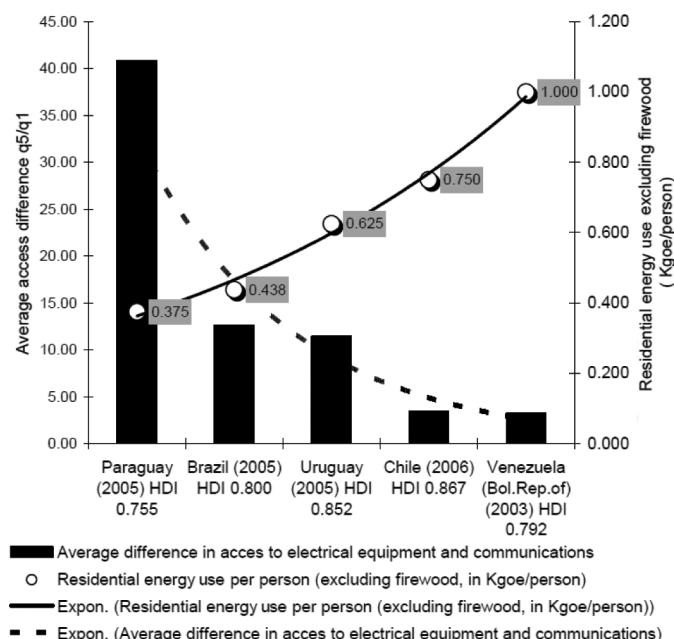


Figure 19.28 | Differences in access and use across income quintiles in select countries of Latin America. Source: ECLAC et al., 2010.

phenomenon has been the result of rural-urban migration processes more than the introduction of end-use technologies for firewood savings. For instance, the diffusion of improved fuelwood stoves in South America is low compared to other developing regions like China and India.

In some countries, like Brazil, Chile, and Uruguay, the daily consumption of firewood per inhabitant has been growing systematically. Therefore,

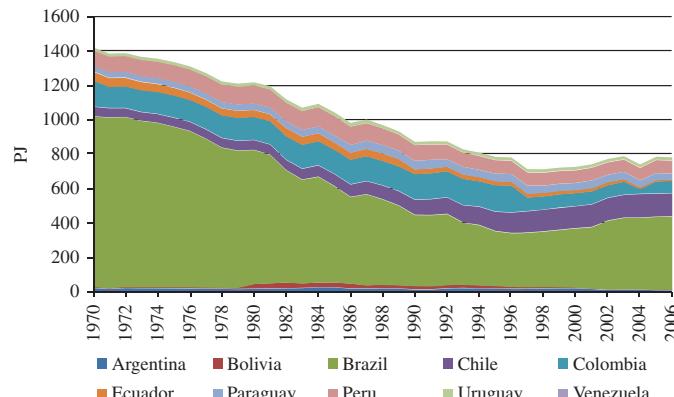


Figure 19.29 | Evolution of firewood consumption in the South American household sector. Source: based on estimates with data from OLADE, 2008.

despite the rural-urban migration processes and the resulting reduction of the rural population, the total consumption per inhabitant has increased. This situation represents many simultaneous realities, as in the case of Brazil where, in spite of a decreasing trend in the per capita consumption, the energy balances have shown a significant growth in firewood consumption since 1996. In the case of Chile, the consumption of firewood per rural inhabitant has also grown systematically. This may be the result of both the introduction of sustainable-use firewood programs and the impact of better living conditions of the rural population vis-à-vis the lack of commercial energy products that compete with firewood.

Use of LPG or natural gas is a clear indicator of increasing income levels and appears to be most preferred fuel among the rich, as shown for

**Table 19.8 | Energy sources used for cooking according to income quintiles.**

<b>Argentina</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>Q4</b>	<b>Q5</b>
Natural Gas	56.6%	57.8%	66.9%	76.4%	89.7%
LPG	40.2%	40.0%	32.3%	23.4%	10.3%
<b>Brazil</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>Q4</b>	<b>Q5</b>
LPG	43.5%	52.4%	58.9%	62.9%	72.2%
Firewood	47.5%	40.3%	37.6%	33.3%	26.2%
Charcoal	8.7%	7.0%	3.0%	3.3%	1.2%

Source: based on ECLAC et al., 2010 and OLADE, 2008.

### Box 19.11 | The Brazilian Experience with LPG

In Brazil, 98% of households (including 93% of rural households) have access to LPG – a situation attributable to a government policy that has promoted the development of an LPG delivery infrastructure in all regions, including rural area, and subsidies to LPG users (Jannuzzi and Sanga, 2004; Lucon et al., 2004). Until the late 1990s, the rise in LPG use was accompanied by a sharp decline in residential wood consumption.

During the period 1973–2001, retail LPG prices were set at the same level in all regions and the average level of the subsidy amounted to 18% of the retail price. In May 2001, end-user prices were liberalized, as part of a process of deregulating the petroleum sector. At the same time, the government introduced an Auxílio-Gás ("gas assistance") program to enable qualifying low-income households to purchase LPG. Qualifying families were those with incomes less than half the minimum wage (an average daily per capita income of US\$0.34/day in 2003). The total program cost in 2002 was about half that of the LPG price subsidization. This program now forms part of the Bolsa Família, by far the largest conditional cash transfer program in the developing world. Recent LPG price increases, however, appear to have led to a reversal of the trend toward lower residential biomass consumption.

Source: IEA, 2006

Brazil and Argentina in Table 19.8. In the case of Argentina, the availability of natural gas has resulted in the replacement of LPG. The lack of availability of natural gas in Brazil has meant that LPG is the preferred fuel for the rich.

#### 19.3.3.2 Central America

The population growth of Central America has been accompanied by rural-urban migration processes, which are generally the consequence of poverty and scarce work opportunities in the rural areas. In 2005, the number of urban inhabitants reached 27.8 million people (57% of the total population) and rural inhabitants were at 21.2 million (43%).

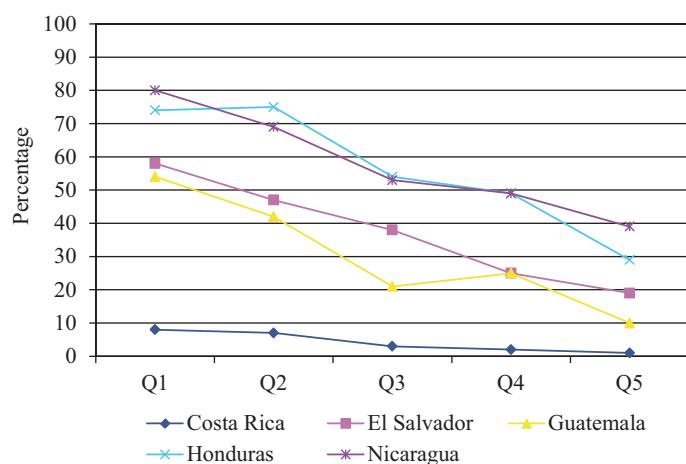
At the beginning of the 1990s, 60% of the total population in Central America lived below the poverty line and 73.7% of the poor lived in rural areas. By 2001, the percentage of the population living below the poverty line had decreased to 50.8%, with 33.6% of the poor living in urban areas and 67.9% in rural areas. Despite this percentage reduction, the

absolute number of poor people increased due to the high population growth of the region. The countries with less inequality in income distribution are Costa Rica and El Salvador, while Honduras and Nicaragua are the poorest and least developed countries of Central America.

#### Access to Electricity

The poorest populations in Central America generally have low access to electricity, as shown in Figure 19.30 for different income levels and various countries in the subregion. Honduras and Nicaragua show the highest levels of population without access to electric power, with 80% of the rural population in these two countries falling into the first quintile.

Even though significant progress may be noted in the level of electrification for every country in Central America, there are still approximately eight million people that do not have access to electricity, most of them in Nicaragua, Honduras, and Guatemala, and poor families in rural areas are generally not connected to the electricity grid (Serebrisky, 2007). Also, electricity accounts for close to, or more than, 10% of household expenditures for the poorest populations.



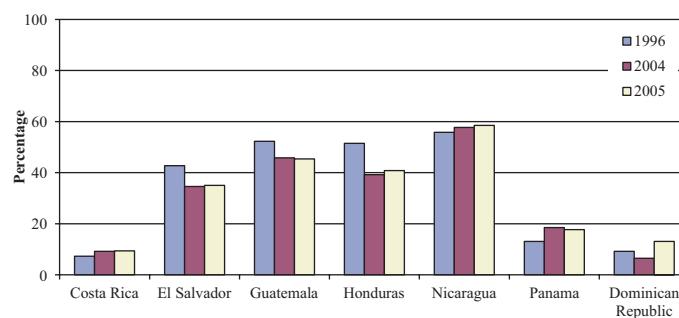
**Figure 19.30 |** Population without access to electricity in rural areas of Central America, by income level. CEPAL, 2011.

### Access to Fuels

Several LAC countries have implemented subsidies on LPG, considered the fuel of the poor. The following countries, in particular, have LPG subsidies: Argentina, Bolivia, Brazil, Colombia, Cuba, Ecuador, El Salvador, Haiti, Dominican Republic, and Venezuela (OLADE, 2008).

The poorest populations in Central America as a whole also largely depend on biomass (mainly in the form of firewood), which in 2006 represented 83% of the energy used to meet cooking and heating needs. Energy sources for cooking are mainly firewood, electric power, and LPG. Modern energy sources like LPG for cooking and heating have increased, but firewood is still the most widely used in terms of percentages.

There are significant differences in the types of energy for cooking across the subregion, as shown in Figure 19.31, with the following key features:



**Figure 19.31 |** Share of firewood in final energy demand (1996, 2004, and 2005). Source: based on OLADE, 2008.

- electric power (high percentage both in urban and rural areas) – Costa Rica;
- LPG (most widely used) – Dominican Republic;
- LPG and firewood (both widely used) – El Salvador; and
- firewood (highly used) – Nicaragua, Honduras, and Guatemala.

Firewood thus plays an important role in final energy demand in Guatemala, Nicaragua, Honduras, and El Salvador, while the importance of firewood is relatively low in Costa Rica, Dominican Republic, and Panama. In general, LPG (or electricity) does not fully replace firewood in rural areas, but the different fuels are used complementarily; in some cases, firewood is used for cooking and LPG is used for water heating or precooked meal heating (Díaz, 2008).

For the whole subregion, firewood consumption accounted for 37% of the total energy supply and 83% of household energy supply in 2005. In terms of per capita consumption, Nicaragua and Guatemala are

### Box 19.12 | The Justa Stove, Guatemala

A fuel-efficient stove called the Justa stove has been developed by Trees, Water and People (a charity working in Central America), the Aprovecho Research Center, the Honduran Association for Development, and Doña Justa Nuñez, a Honduran woman who helped design her namesake stove. The stove uses up to 70% less fuel than the open wood fires and because the design and materials used are simple, it can be made locally, using local materials, and adapted to meet local needs. Because it uses less fuel, the Justa stove decreases deforestation.

The Justa stove is relatively simple in design and can be made easily by local people in a day or less using locally available materials. The new owners of the stove have to contribute materials to the building of the stove. This gives them a personal investment in the stove, making them more likely to take good care of it.

Each stove saves 7.5 tonnes of CO<sub>2</sub> over a 7.5 year period. Each stove saves an average of 1 tonne of CO<sub>2</sub> emissions/year and 78 cubic meters of firewood over a 7.5 year period.

Source: Stoves Online, 2010

**Table 19.9 | Electricity demand profile for the Caribbean region, selected countries.**

Selected countries	Installed Power Capacity (MW)	Access to electricity (Total)	Access to electricity (Rural)	Per capita consumption (kWh)
Barbados	210	98%	n/d	1941
Cuba	5430	95%	87%	2321
Dominican Republic	5518	96%	89%	168
Grenada	32	82%	n/d	53
Guyana	308	82%	n/d	1220
Haiti	244	34%	n/d	341
Jamaica	854	95%	n/d	4769
Suriname	389	97%	n/d	1941
Trinidad & Tobago	1425	92%	n/d	2321

the countries with the highest firewood consumption; Honduras, El Salvador, and Panama are at an intermediate level, while Costa Rica and Dominican Republic show the lowest per capita consumption levels. The highest consumption is by lower income families in rural areas. Firewood consumption per capita in Costa Rica, Nicaragua, and Panama has tended to increase.

Sustainable energy for cooking has been pursued by means of different approaches: the adoption of new technologies like improved stoves, the introduction of modern fuels in rural areas to substitute for or complement the use of firewood, and access to electric power through energization programs in these rural areas.

### 19.3.3.3 The Caribbean

The Caribbean subregion faces huge challenges arising from modern globalization, declining competitiveness, trade liberalization and eroding preferences, the rising cost of imported fuel, the revolution in information technology, and very high vulnerability to natural disasters. Additionally, very high debt has placed seven Caribbean countries among the 10 most indebted countries in the world. The region is also heavily dependent on fossil fuel combustion, with petroleum products accounting for an estimated 93% of commercial energy use. The islands of the Caribbean are predominantly net energy importers, with the exception of Trinidad and Tobago.

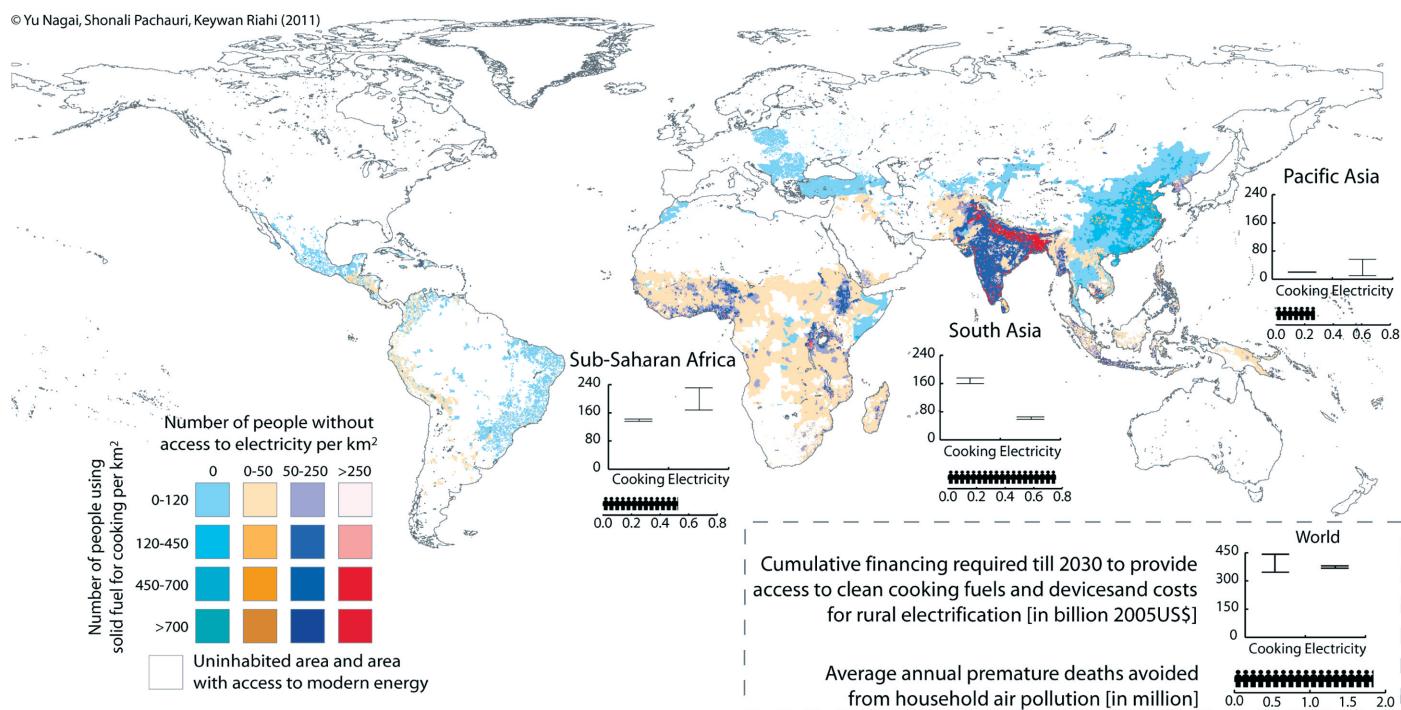
#### Access to Electricity

With the exception of Cuba, Haiti, Dominican Republic, and Jamaica, the Caribbean countries are generally very small island states with populations of around one million or less and with a very important share of rural population. As shown in Table 19.9, yearly electricity consumption for these countries is well below 5000 kWh. However, data on access levels are difficult to find.

## 19.4 Conclusions for the Way Forward

Access to affordable modern forms of energy for populations currently without is a necessary albeit insufficient step toward poverty alleviation and the achievement of the MDGs. Providing universal access to electricity and modern fuels is not just a moral imperative. A growing body of knowledge shows that it also fosters significant social benefits and environmental improvements. It can also bring significant economic returns, particularly if policies and programs encourage the productive uses of energy to create new employment and income-generating activities through more conducive institutional mechanisms. A greater focus on scaling up pilot and demonstration projects to larger populations is also needed. The assessment of past policies and programs to improve access across different regions of the world carried out in this chapter point to the need for a paradigm shift in the approach to energy planning to meet the energy needs of the poor. An explicit focus is required on energy services. This should include a comprehensive demand-side analysis of the energy needs of poor people to support their livelihood functions, taking into account their particular constraints and opportunities. Current supply-side approaches that simply take as their starting point the provision of modern energy carriers such as electricity, petroleum, or gas, or equipment of a particular type (solar technology, improved cook stoves, biogas) are not sufficient to reap the full potential of social and economic improvements that follow from improved energy access.

A first step to achieving the paradigm shift needed in energy planning for the poor is establishing effective data collection systems based on accepted definitions and indicators of access to measure progress towards energy access targets or goals. The review included in this chapter points to significant data gaps regarding the existing energy access and use patterns in the poorest regions and for the poorest communities. Indicators that adequately assess the energy needs and describe the living conditions of such communities are required. Consistent measurement frameworks and regular data collection systems on assessing



**Figure 19.32** | Density of population lacking access to modern energy in 2005 and costs and health benefits of achieving a universal clean cooking and electrification goal by 2030. Colored areas show densities of people per  $\text{km}^2$  without access to electricity and those that use solid fuels for cooking, e.g., dark blue and brown areas are where people do not have access to electricity and cook predominately by solid fuels. Cumulative investment requirements between 2010 and 2030 are shown for three GEA world regions and for the globe as a whole in billion 2005 US\$. Also shown is the estimated population that would die prematurely from household air pollution if universal access is not achieved by 2030 (in million).

the energy situation of the poor are still lacking in many nations. In addition, the evaluation of many energy access programs and projects often fail to provide a comprehensive assessment of the impacts. An increase in the evidence base of the positive and significant impacts of such policies and projects can be instrumental in increasing efforts to enhance access activities globally.

Experience to date has resulted in a number of lessons that we must keep in mind when designing policies and programs to improve energy access in the future. Access programs and efforts are more likely to succeed if communities have an adequate understanding rather than act as passive recipients. Those designing and implementing programs need to understand that encouraging uses of energy for income generation, if built into the design of the access programs, is likely to improve sustainability. Programs that have built-in components for community training on operation and maintenance, as well as follow up with providers also have a higher likelihood of success. The extent of government commitment in creating an enabling environment is also paramount to the success of all policies. Improved access to capital that can help secure adequate financial resources, and market development that puts the customer at the center, are important for the successful scale-up of activities. Chapter 23 provides a more in-depth assessment of the full range of policies that are needed to achieve the ambitious energy access targets discussed in this chapter.

The GEA access scenarios<sup>14</sup> explore global strategies toward universal access to affordable and modern sources of energy by 2030. Specifically, the target calls for the provision of electricity and clean cooking fuels, including distribution of improved end-use devices to all those who currently lack access. Achieving the access goals creates multiple benefits for broader development goals, including increased productivity and decreased household air pollution and land degradation. The GEA scenarios indicate that such ambitious targets are feasible as long as financial support for dedicated access policies is provided. With respect to policies for energy access to clean cooking, the assessment suggests that fuel subsidies alone would be neither sufficient nor cost-effective in terms of achieving ambitious energy access objectives. Financial mechanisms, such as microcredit or capital grants, will need to complement subsidies to make critical end-use devices such as clean cooking stoves and connection costs affordable to the poor. The GEA scenarios estimate that the total costs for providing clean cooking services are between US\$17–22 billion/year until 2030, with the difference of about US\$4.7 billion/year an estimate of the capital cost associated with stove purchases that could be either met through public grants or microfinance options. While the subsidy component of this cost is substantial, it represents less than 5% of present day global fossil fuel subsidies.

<sup>14</sup> Please refer to Chapter 17 for a detailed description of the GEA access scenario results.

Scenarios regarding future electrification across world regions vary tremendously, as the base level of electrification across regions is already significantly different and costs for providing grid access, which is dependent on population density, also vary enormously. The GEA electricity access scenarios, described in greater detail in Chapter 17, suggest that the investments required for additional electricity generation, operation and maintenance of plants, and rural grid expansion to reach the almost universal access target by 2030 would be between US\$18.4–19 billion/year.

This suggests that the total cost for providing almost universal access to electricity and clean cooking by 2030 is between US\$36–41 billion/year. There are two underlying reasons for the large range in the cost estimates derived from the GEA access scenarios. First, in the case of the estimates for providing clean cooking, the range in the estimates reflects whether the costs of new LPG stoves are assumed to be included or not. If these costs are assumed to be met through microfinance institutions, they are not included in the total cost estimate. However, if the cost of stoves is met from public grants, they are included in the estimate. The range in the cost estimates for electrification stems from differences

in the modeling approaches used. A large range of estimates for the costs of providing access is also evident from a review of the literature. Typically, the global estimates range between US\$30–40 billion/year (see Bazilian et al., 2010 for a recent review), though much higher estimates also exist specially for electrification. The wide range in global estimates parallel the wide range in the costs of providing access across different regions. The investment gap varies tremendously by region (see Figure 19.32). Chapter 23 provides a more in-depth and detailed discussion of the sources of funding that will need to be tapped to meet this investment gap and the kind of regional policies that will be needed for enhancing energy access. Spending on policies and measures to achieve access goals by 2030 will improve the welfare of those benefiting in several ways. Health impacts from improved household air quality have been quantified in Chapter 17. Access policies will result in averting between 0.6 and 1.8 million premature deaths, on average, every year until 2030 and saving about 24 million Disability Adjusted Life Years annually. Additional benefits that are likely to be substantial include time savings for women and children and the potential for improved livelihood opportunities.

## Appendix A

Table A19.1. | Cookstove Project Details

	ID	Stove Name	Description	Stove Construction	Fuel Type	Typical Efficiency	Price/Cost	Number of stoves distributed	Project Date	Project Location	Financing	Reference(s)
1	Orjia	Metal stove	Manufactured	Pellet	NA	US\$15 (INR 675) – 2010	65,000 families	2006	India	Full cost	Smith, 2007; Sundar, 2007	
2	Envirofit G-3300	Metal (patented alloy) stove	Manufactured	Fuelwood	NA	US\$10–40 – 2009	60,000	2008–2009	India	Full cost	Ritch, 2008; Envirofit, 2010	
3	Envirofit B-1200	Ceramic liner stove										
5	Astra Chulha (2 and 3 pots)	Chulha models	trained masons, artisans	Fuelwood, dung cakes, agri waste	30–45% (lab test)	US\$1.8–3.3 (two pot), US\$4 (3 pots) – 2003	1,522,195	1984–2003 (2)	India	Max US\$1.6 subsidy	Westhoff and Germann, 1995; Jagadish, 2004	
6	Down-draft stoves (9 models)	Down-draft stoves, single mouth portable, single	Artisans, HH members with training	Fuel wood	NA	US\$0.7 (w/o chimney), US\$43 (w/ chimney), 2010	180,421	1994–2001	Bangladesh	Full cost	Khan, 2002; Hossain, 2003	
8	Nada	Improved Chulha stove	Potters, trained masons	Mustard stalk, Fuelwood, dung cake, agri residues	NA	3.2 US\$3 – 1993	NA	1986 – ongoing	India	78% subsidized	Westhoff and Germann, 1995	
ASIA	Sahyog Chulha				NA		NA	NA		65% subsidized	Westhoff and Germann, 1995	
	Laxmi				22%	US\$2.2 – 2.8 – 1993	105,000	1988–1993		US\$1.6 paid in kind	Westhoff and Germann, 1995	
	Sugham				28.20%						Westhoff and Germann, 1995	
9	ARAVALI-U Chulha	Improved Chulha Stove	Potters, HH members	Fuelwood, straw, dung cake, agri residues	25.30%	US\$2.2 – 2.8 – 1993	20,000	1991–1993	India	50% subsidized or US\$1.6 in-kind	Westhoff and Germann, 1995	
	DOACHHI Chulha				20.20%	US\$1.8 – 2.6 – 1993	500,000	1990–1993			Westhoff and Germann, 1995	
	TNAU Chulha				26%	US\$1.9 – 1993	NA	1993–1993		75% subsidized or US\$2.4 in-kind	Westhoff and Germann, 1995	
10	3-pot stove	Mud stove	Trained artisans	Straw and twigs	15–18%	US\$1.8 – 1994	Several thousands	1988–1993 (ongoing)	Vietnam	Full cost	Westhoff and Germann, 1995	
11	Sikalan	Mud stove, rice-husk stove	Artisans, clay potters, manufactured	Fuelwood	25.2%	US\$7.4 – 1993	> 10,000	1987 – 1993	Philippines	Full cost	Westhoff and Germann, 1995	

	ID	Stove Name	Description	Stove Construction	Fuel Type	Typical Efficiency	Price/Cost	Number of stoves distributed	Project Date	Project Location	Financing	Reference(s)	
ASIA (cont.)	12	Improved Tamang Stove	Local blacksmith, welder, trained person	Fuelwood, agri residue	24.70%	US\$2.0–3.0 – 1993	5,000	1986 – 1993	Nepal	40 – 90% subsidized	Westhoff and German, 1995		
	13	Tungku SAE	Clay stove	Potters	Fuelwood	12% kitchen performance test	US\$0.5 – 1993	50,000	1983 – 1999	Indonesia	Full cost	Westhoff and German, 1995	
	14	Coal Briquettes Stove	Clay stove	Workshops, crafters	Coal briquettes	40%	NA	300,000	1980 – 1994 (ongoing)	China	NA	Westhoff and German, 1995	
	15	Anagi	Clay stove	Local potters	Fuelwood, residues	17.40%	US\$1.1 – 1.5 – 1994	500,000	1987 – 1997	China	NA	Westhoff and German, 1995	
	16	Priagni Chulha	Single-pot, portable stoves	Manufactured, small scale industry	Firewood, dung cakes, agri residues	26% HU, wood	US\$3.6 – 6.0 – 1993	3,000,000	1983 – 1994	India	Full cost	Westhoff and German, 1995; Mäkelä, 2008	
	Harsha Chulha					24.8% HU, wood	US\$4.6 – 1993	100	NA				
		Tara Chulha				26% HU, wood	NA	NA	1991 – 1994				
	17	Bekely-Darfur stove	Metal stove	Manufactured/ hand made	Fuelwood	NA	US\$20.0 (15 in Sudan) – 2006	5,000	2006	Sudan	Subsidized (US\$5 – 7.5)	Galtksy et al., 2006; Amrose et al., 2008	
	18	Kenya Ceramic Jiko (KCJ)	Charcoal burning metal ceramic stove	Artisan, manufactured	Charcoal	Thermal 30%	280 to 600 ksh	250,000 – 780,000 different reports	1982 – 1986, to 1995	Kenya	NA	Boiling Point, 1989; Westhoff and German, 1995; Kammen, 2001; Ingwe, 2007; GTZ and HERA, 2009	
AFRICA													
20	Rocket Lorena	2 pot rest stove (earth, grass, water)	Artisan built	Fuelwood	NA	4.0 € – 2006	211,220	1999 – 2005	Uganda	Full cost	GTZ, 2006; Komuhangi, 2006; Habermehl, 2007		
21	Shielded Fire	Rocket stove	Artisan built	Fuelwood	NA	US\$3.0 – 9.0 – 2008	291,900	2004 – 2008	Uganda	NA	Ingvae, 2007; GTZ, 2008; GTZ and HERA, 2009		
	One-pot rocket mud stove					US\$1.5 – 2.0 – 2008	35,000	2006 – 208	Kenya	NA			

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	ID	Stove Name	Description	Stove Construction	Fuel Type	Typical Efficiency	Price/Cost	Number of stoves distributed	Project Date	Project Location	Financing	Reference(s)
AFRICA (cont.)	22	Albarka/Troi Pierres Ameliore	Improved 3 stove	Trained masons, artisans, HH	Fuelwood	26–28% lab test	US\$0.7 – 1.4 – 2003	12,642 120,000	1989 – 1992 1990 – 1993	Niger Rwanda	Full Cost	Westhoff and German, 1995
	23	Ambo stove (Ambo Metat)	Mud stove (3 sizes)	Mud technicians, trained masons	Fuelwood	20 – 25 %	US\$4.0 – 6.0 – 1993	150,000	1991–1992	Burkina Faso		
	24	Maendeleo	Mud stove (2 sizes)	Artisans, trained HH members	Fuelwood	24 – 30% thermal	US\$0.6 – 0.9 – 1993	200,000	1985 – 1994	Kenya	Full cost	Westhoff and German, 1995
		Maendeleo portable	Metal Stove	Workshops, crafters							Free Distribution	
		Maendeleo liner (kubimbil)	Metal cladded firewood stove	Manufactured	Fuelwood	NA	KE\$250–300, US\$3.50–4.20 –	290,000	2006 – ongoing	Kenya	Fullcost	Ingvre, 2007
	25	Chingwa	Multi-pot stove	Local trained artisans	Fuelwood	33% thermal	US\$15.4 (\$100) – 1993	15,000	1988 – 2001	Zimbabwe	50% subsidized	Westhoff and German, 1995; Maya et al., 2001
	26	Ouaga Ceramique	Ceramic stove, clay stove	Potters	Fuelwood	30%	1,000 (FCFA) 1994	5,700	1983–1992 (ongoing)	Burkina Faso	NA *subsidized*	Westhoff and German, 1995
	27	Tso-tso stove	Metal stove	Manufactured, sheet metal workshops	Smallpieces of wood, briquettes	23% (PHU)	US\$25.4 – 1993	40,000 (18,000 refugee camps)	1986 – 1994 (ongoing)	Zimbabwe	NA, 100% subsidized	Westhoff and German, 1995
	28	Katinbe Njamdi	Metal stove – in various sizes	Manufactured, sheet metal worker	Fuelwood	20 – 30%	1,300–5,500 FCFA – 1993	NA	1989 – 1993	Cameroon	NA (full cost0	Westhoff and German, 1995
	29	Metal stove	metal stove	Manufactured, trained tinsmiths	Fuelwood, peat	28%	US\$4.2 – 1993	25,000	1993	Rwanda	Refugee camps 100% subsidized, fami?	Westhoff and German, 1995
LATIN AND SOUTH AMERICA	30	Teliman	Metal Stove	Manufactured, trained smiths	Fuelwood	26–30%	600–6000 FCFA – 1994	40,000	1988–1994	Mali	Full cost	Westhoff and German, 1995
		Mai Sauki					550–950 FCFA – 1994	34,800	1989–1992	Niger		
	31	Modified CETA stove	Mud rocket stove	trained artisans	Fuelwood, Briquette, Agri-residue	22–26%	US\$30.0 – 1994	1,500	1994	Burkina Faso	85% Subsidized	Westhoff and German, 1995; Alvarez et al., 2004
	32	Finlandia	Rocket stove	Household members	Fuelwood, agri-residue	30%	US\$15 (\$VC130) – 1994	500	1992 – 1997	El Salvador	60% subsidized	Westhoff and German, 1995; OAS, 2000; Alvarez et al., 2004

	ID	Stove Name	Description	Stove Construction	Fuel Type	Typical Efficiency	Price/Cost	Number of stoves distributed	Project Date	Project Location	Financing	Reference(s)
	33	Justa Rocket stove	Brick built rocket stove	Artisan built	Fuelwood	NA	US\$60.0 – 2005	4,000	1998 – 2005	Honduras	70% Subsidized	Wheldon, 2005
	34	Tezulutlán improved stove	Metal-plancha stove	Artisan built/ manufactured parts	Fuelwood	NA	US\$64.0 – 2002	13,000	since 1999	Latin America	NA	
	36	INTERVIDA-type stove	Metal-plancha stove	Artisan built/ manufactured parts	Fuelwood	NA	US\$88.0 – 2002	4,129	1998–2001	Guatemala	60% subsidized	Álvarez et al., 2004
	37	SIF improved stove	Metal-plancha stove	Artisan built/ manufactured parts	Fuelwood	NA	US\$149.0 – 2002	90,000	1998–2001	Guatemala	70% Subsidized	Álvarez et al., 2004
	38	Improved stove	Based on Indian Damruhu Chulha	Artisans trained by ICATTI	Fuelwood, charcoal, briquettes, corncobs	22%	US\$7.0 – 1993	1,500	1992–1993	El Salvador	NA	Westhoff and German, 1995
LATIN AND SOUTH AMERICA (cont.)	39	FOBLOCO	HH members trained	HH members trained	Fuelwood	0.85 KG/Mcal	US\$15.0 – 20.0 –	900	1988–1992, 1996	Paraguay	NA	Westhoff and German, 1995
		SEAG complete stove				NA	US\$79.0 – 1994					
	40	Chefina	Technicians, trained masons	Fuelwood	NA		US\$52.6 – 70.2 –	800	1986 – 1994 (ongoing)	Guatemala	NA	Westhoff and German, 1995
	41	Improved stove	Stove as Asphan	Built by Ngo	Fuelwood	NA	US\$74.3 – 1994	600	1991–1994 (Ongoing)	El Salvador	100% subsidized	Westhoff and German, 1995
	42	Improved Lorena	With chimney, one piece construction	trained builders	Fuelwood	NA	US\$36.0 – 1994	1,200	1976–1994 (ongoing)	Dominican Republic	55% subsidized	Westhoff and German, 1995
	43	Improved household stove	trained HH members	Fuelwood, carob, sapote (marmalade?)	NA		US\$32.0 – 1994	50	1993 – 1996	Peru	Special group subsidy	Westhoff and German, 1995
	44	Lorena improved stove	Various models	Trained Artisans, bricklayers, HH members	Fuelwood	NA	US\$45.7 – 1994	300	1991–1994	El Salvador	40% subsidized	Westhoff and German, 1995
							US\$21.3 – 25.5 –	176	199,019,911,993	Bolivia	US\$17.2 in-kind	
							US\$20.0 – 1994		NA (Schools & restaurant)	Peru	NA	
							US\$20.0 – 1994	NA	NA	Bolivia	NA	

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	ID	Stove Name	Stove Description	Stove Construction	Fuel Type	Typical Efficiency	Price/Cost	Number of stoves distributed	Project Date	Project Location	Financing	Reference(s)
LATIN AND SOUTH AMERICA (cont.)	45	Fogon Cilindrico Mejorado	Improved Cylindrical Stove	Artisans, project	Fuelwood	NA	US\$70.0 – 1994	2,500	1992-1994 (ongoing)	Ecuador	71.5% subsidized	Westhoff and Germani, 1995
	46	Villanueva		Builders	Fuelwood	NA	US\$100.0 – 1994	500	1991-1994 (Ongoing)	Venezuela	NA	Westhoff and Germani, 1995
	47	Ecotec Rural		Trained potters,	Fuelwood, agri-residue	NA	US\$22.0 – 1994	3,500	1992-1993	Guatemala	NA (full cost)	Westhoff and Germani, 1995
	48	Cocina Mejorada	Improved stove	Artisans, potters	Fuelwood, dung cakes, agri waste		US\$1.5 – 1994	200	1992 – 1993	Bolivia	100% subsidized	Westhoff and Germani, 1995
	49	Onil Stove		Manufactured, locally installed	Fuelwood	NA	US\$150-2010	5,000	2003-2010	Guatemala	Help program 100% subsidized	Help International, 2010; Onilstove, 2010
	50	Inkawasi	Based on rocket elbow stove designs	Manufactured, built by artisans	Fuelwood, dung, shrubs, etc	28.19%	36 eur – 2008	14,000	2005 – 2007	Peru	NA	Klingshim, 2006; GTZ and HERA, 2007
INTERNATIONAL	51	Stovetec	Portable rocket stove	Manufactured	Fuelwood, charcoal, briquettes, corncobs		US\$3.0 – 12.0 FOB US – 2010	200	1999	South Africa	Full Cost	MacCarty et al., 2008; Stovetec, 2010
								500	NA	South Africa		
								70,000	2008-2010	International		

## References to Appendix

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