Poor people's energy outlook 2014

Praise for this book

'The ENERGIA International Network greatly appreciates the Poor People's Energy Outlook series and the impact it has had on the SE4ALL development agenda. We welcome its efforts to bring the realities of women and men living in underserved communities to the fore. The PPEO series has added value to the ENERGIA Network's learning and exchange, and is an essential resource showcasing game-changing solutions that contribute to our Network's objective of women's economic empowerment through energy access.'

Sheila Oparaocha, Executive-Secretary, Energia – International Network on Gender and Sustainable Energy

'Universal access to clean, modern energy services for the people of sub-Saharan Africa is one of the most important challenges of our time. We warmly welcome the publication of this book which will help us to target our interventions better.'

Ousmane Fall Sarr, Director of Research and Information Systems, Senegalese Rural Electrification Agency, Dakar, Senegal

'It is great to see this progressive report move beyond seeing energy as an access or supply issue to a service-based definition focusing on end-uses of energy to achieve real impacts. This is reflected in the range of outcome-focused indicators described in the *Poor People's Energy Outlook 2014*, which measure how an energy service is performing, rather than simply the number of grid connections counted using traditional measures. It is also very encouraging to see a call for action, with a practical framework, on delivering energy services to meet the productive/enterprise and community-level needs of poor women and men – bringing a more holistic and ambitious set of targets which encompass education, health, communications, and income generation.'

Ben Garside, Researcher, Energy Team, International Institute for Environment and Development (IIED)

Acknowledgements

The PPEO 2014 represents a revised and updated set of chapters which can be found in their original form in PPEOS 2010, 2012, and 2013. The revisions and editions were authored and compiled by Aaron Leopold, Lucy Stevens and Mary Gallagher. The report has benefited from additional input from Astrid Walker Bourne, Mattia Vianello, Drew Corbyn, Ewan Bloomfield, Chad Monfreda, Mary Allen and Christine Comerford.

Poor people's energy outlook 2014

Key messages on energy for poverty alleviation

PRACTICAL ACTION
Technology challenging poverty

About Practical Action

Practical Action is a development charity with a difference. We use technology to challenge poverty by building the capabilities of poor people, improving their access to technical options and knowledge. We work internationally from regional offices in Latin America, Africa, Asia, and the UK. Our vision is of a sustainable world free of poverty and injustice in which technology is used for the benefit of all.

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Back cover, left: A carpenter uses a power sander, Yanacancha, Peru. (Credit: Ana Casteñeda/Practical Action)
Back cover, right: Pupils from Nyafaru school in Zimbabwe study by electric light, powered by micro-hydro. (Credit: Crispin Hughes/Practical Action)
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Foreword

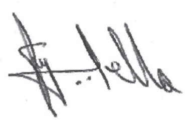
The importance of achieving universal energy access has never been higher on the international agenda. Energy is fundamental to poverty reduction and a critical enabler of development. It supports people as they seek a whole range of development benefits: from cleaner, safer homes; lives of greater dignity and less drudgery; to better livelihoods and better quality health and education. Access to affordable, clean energy services can change the lives of women and girls and help to generate local income when linked to productive activities.

At the same time, despite progress, the challenge of achieving universal access to energy remains immense. This has been well recognized by the UN Secretary-General's Sustainable Energy for All initiative (SE4ALL) and the UN Decade (2014–2024) of Sustainable Energy for All.

The contribution of the Poor People's Energy Outlook (PPEO) over the past four years has been to highlight this challenge and seek to refocus the global energy discourse onto the energy supplies and services that really matter to poor people. This edition of the PPEO provides a timely restatement of the urgent need for the world to take a more holistic approach. It reminds us of the progress we have made in getting these issues onto the international agenda, but also of the challenges that remain. Energy can enable or disable pathways to development.

In setting out a clear framework for action, *PPEO 2014* calls for a shift from 'business as usual' to an approach which will truly leave no-one behind and make access to energy services the development enabler.

For all these reasons, I warmly welcome the *Poor People's Energy Outlook 2014*.



Kandeh K. Yumkella
Special Representative of the Secretary-General
Sustainable Energy for All
CEO, Sustainable Energy for All initiative
Chair – UN-Energy

Introduction

Lifting people from energy poverty is a critical component of ending the poverty trap that consigns hundreds of millions of poor people to lives of drudgery and subsistence work. Since the first edition of the *Poor people's energy outlook* (PPEO) in 2010, the international discussion over this important issue has taken off both in the context of the Sustainable Energy for All (SE4ALL) initiative and the nascent post-2015 development agenda. Securing universal access to modern, appropriate and affordable forms of energy has since been recognized as central to the success of the broader international development agenda. The international community and national governments are now calling for evidence on the success of energy access interventions, and for new models of business and finance to deliver services and technology to the energy poor.

While these issues are central to achieving universal energy access and are rightly receiving significant and much needed attention, two important hurdles remain to achieving universal energy access:

Securing universal access to modern, appropriate forms of energy is central to the success of the broader international development agenda

1) To bring modern energy services to the 1.3 billion people who currently live without access by 2030,[1] more decentralized, off-grid energy provision will be required than conventional, grid-based energy. This has been evidenced since 2011 (IEA, 2011) but largely ignored by policymakers and the energy community thus far.
2) At the national level, most governments still view access as a 'have' / 'have not' dichotomy, rather than the multi-tiered, multi-faceted group of services and supplies that meaningful access would represent: i.e. household, community and productive services. Government energy and investment incentive policies built around such simplistic definitions of access will not spur the type of national-level change required to alleviate energy poverty.

This 2014 edition of the PPEO looks back at three years of analysis and innovative approaches to defining energy access and addressing energy poverty as presented in previous PPEOs, to re-emphasize the key enabling role that energy plays in lifting people out of poverty, and the logic of and necessity to focus on efforts to boost the nascent decentralized energy sector rather than allowing the already well-established and well-funded conventional, grid-focused energy sector to continue to dominate efforts to expand energy access.

The importance and urgency of taking a decentralized approach to energy access provision is evidenced by the recent revelation of the World Health Organization that over 4.3 million people die per annum from indoor air pollution stemming from heating and cooking with dirty and unsafe fuels and stoves. Furthermore, half of all deaths of children under five years of age are attributable to household air pollution associated with cooking with solid fuels (WHO, 2014). This should serve as an urgent call to governments to take action on access to modern energy services. It should also indicate that decentralized business and financing models for the deployment of clean, affordable and safe energy options are urgently needed to end this disastrous trend.

The purpose of the PPEO 2014 is to summarize key lessons and evidence presented thus far to reiterate that the discourse and focus of energy access must remain on what it will take to deliver access to 1.3 billion people still lacking access to modern energy services and the 2.8 billion lacking access to safe cooking facilities. In doing so, the PPEO 2014 highlights what energy poverty means for poor families and communities and how improving access enables progress across a range of important development outcomes including: agricultural productivity, education, gender, health, livelihoods, quality of life and many more.

The PPEO 2014 also revisits our multidimensional Total Energy Access (TEA) approach that defines 'access' as *when the full range of energy supplies and services required to support human social and economic development are available to households, enterprises and community service providers*. The TEA approach to defining and measuring access illustrates the depth and complexity of achieving substantive and transformational access. The report further outlines the Energy Access Ecosystem Index that analyses the policy, capacity, and finance spaces which contribute to progress on energy poverty at the national level.

Together, these topics form the basis for a revised and updated framework for scaled-up global and national action. This should facilitate the rapid deployment of technologies and services required to meaningfully end energy poverty by 2030 for millions of people in rural communities, urban settlements, health-care facilities, schools and businesses that lack access to high-quality, safe, affordable, and reliable energy today.

1. Energy for households

Energy poverty denies millions of people the basic standard of living that people want, need and have a right to. Without access to energy to cook, heat the home, earn a living and fully benefit from health, education and cultural opportunities, whole communities are trapped in lives of drudgery and subsistence. This chapter examines the impact of energy poverty on poor people and communities. It also highlights the transformational effects made possible when energy becomes available.

From the perspective of poor people, the energy service (sufficient light, warmth, etc.) is more important than the source. Although different supplies and appliances can be used for multiple services (a stove for both cooking and heating rooms in cold climates and at night), this chapter focuses on five service categories that comprise the key dimensions of energy access for households.

- lighting
- cooking and water heating
- space heating
- cooling
- information and communications

This chapter is based on data from diverse national and regional reports and studies, which have been collated from across Africa, Asia and Latin America. Project- or initiative-level data have also been incorporated, especially where national or international numbers are weak. It also draws on the testimonies of people living in energy poverty or who have recently benefited from access, via interviews and focus group discussions. In compiling this information, a marked lack of comprehensive and disaggregated international energy access data was noted. A full roll-out of the Global Tracking Framework (Banerjee et al., 2013), a recent initiative of the World Bank, supported by Practical Action, should help to address some of these gaps in future years.

For each energy service this chapter highlights the current situation for poor people and the implications of this lack of access. It discusses options for improving access and the impact this can have on the lives of poor people. A minimum standard applicable to each service is suggested. This is to some extent, controversial and country specific, however it is an important step in quantifying what universal access to energy entails in reality (one of the aims of the UN's Sustainable Energy for All Initiative (SE4ALL) by 2030).

Lighting

1.2 billion people (17% of the global population) did not have access to electricity

Lighting is a fundamental human need. People who cannot flick a switch to light their homes lose many productive hours as soon as the sun sets. The estimates are that in 2010, 1.2 billion people (17% of the global population) did not have access to electricity (Banerjee et al., 2013). As a result, people resort to lamps that are polluting, dangerous and provide low-quality light such as candles, kerosene lamps or even simply flaming brands. And yet these lights are usually more expensive than electric lighting.

Box 1.1 When wood is the only lighting source

Rosa lives in Kakuma, a border town located in north-western Kenya. Her husband left her to raise their three children alone. She sells foodstuffs at the market but loses one full day per week trekking to the surrounding hills to collect firewood. 'For me getting energy for cooking and lighting is a daily worry. I cook for my family only once a day in the evening. The fire provides the light for cooking and eating a meal with my children. After eating is bedtime.' The lack of lighting means that the children cannot do homework after dark.

Lighting without electricity

The main problems faced by poor people trying to light their homes without electricity are the low quality of the light, high costs, and the health dangers from burns and smoke.

Quality of light. Lights using energy sources other than electricity tend to be far dimmer. A kerosene wick lamp or a candle provides just 11 lumens[2] compared with

1,300 lumens from a 100W light bulb. Electric lamps are also much more efficient than kerosene in converting energy into light. A simple wick bottle lamp burns 10 ml of fuel per hour and gives out light equivalent to that from a small electric flashlight (torch) – too dim for reading. Respondents to a national rural lighting survey in Peru reported that candles and kerosene lamps provided barely enough light to walk around the house (Barnes, 2010a). They do not provide enough light for safe work or study. Households with higher incomes tended to use car batteries to power electric lights, but limited their use because of the costs and inconvenience of recharging the batteries.

Cost of lighting. Studies have repeatedly shown that the running cost of lighting from candles or kerosene is far higher than from electricity. They also show that running inefficient bulbs from large batteries is more expensive than lighting from good-quality solar lamps. The cheapest source of light is still using grid electricity with energy efficient light bulbs. A World Bank study in Guatemala (Foster et al., 2000) found that the household purchase price for a unit of light was 0.08 US$ per kWh for mains electricity compared to 5.87 for kerosene and 13.00 for candles, making them 162 times more expensive than mains electricity per unit of light. SolarAid has found that on average solar lights save African families around $70 per year.

The hurdle of the initial cost of a solar lamp, and in some cases the lack of availability, have restricted their uptake. However this is beginning to change quite rapidly with recent advances in technology design and quality standards, and the development of dynamic solar lantern markets in several countries.

The dangers of lamps: household air pollution (HAP) and burns. There are few studies on the levels of household air pollution from kerosene lamps. A preliminary laboratory study in Guatemala (Schare and Smith, 1995) indicates an average particle emission of 540 mg/hour for wick lamps and 300 mg/hour for enclosed lamps. Compared to biomass stove emissions (2–20 g/hour), this emission rate is relatively low, but the most polluting lamps emit levels that are similar to those from the cleaner types of biomass stoves. A study by Poppendieck et al. (2010) indicates that pollutants from the cheapest kerosene wick stoves have the smallest particle size, and are thus the most dangerous since they are taken more deeply into the lungs.

Unguarded candles and wick lamps are intrinsically unsafe and lead to injury and deaths, particularly among women and children. In Sri Lanka, 91 of the 221 patients (41%) who were admitted to Batticaloa General Hospital with burns

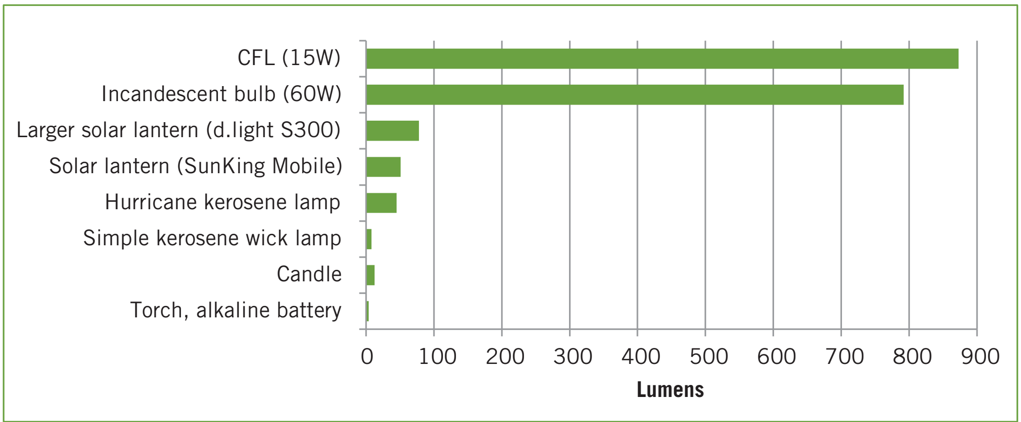


Figure 1.1 Amount of light from different sources
Source: Mills (2003) and product descriptions on Lighting Africa website

between July 1999 and June 2001 cited lighting as the cause. During 1998 and 1999, 151 of 487 patients (31%) aged 12 years and older who were admitted to the National Hospital in Colombo had accidental burns from kerosene lamps (Peck et al., 2008).

Table 1.1 compares some of the technologies that are now available. This is a rapidly developing sector and new products and innovations are coming on stream all the time.

The impact of adequate lighting

Studies suggest that having access to lighting is hugely valued by poor families. A study in Rwanda found that once grid electricity was available, 80% of households switched completely from traditional lighting sources (GTZ and Senternovem, 2009). SolarAid's impact report found that rural African families were saving around $70 per year with the money commonly spent on better food, education and farming. Children were spending an average of an extra hour studying per night. There were more qualitative impacts, with lighting bringing people together and helping them feel safe and secure after dark (SolarAid, 2013).

Minimum standard for adequate lighting

In its Energizing Development programme (EnDev), GIZ proposes that a minimum acceptable level of light in a household is 300 lumens (comparable to a 30W incandescent bulb). In workplace settings it has been found that this is a threshold below which there is a rapid increase in accidents (Reiche et al., 2010), however 300 lumens is sufficient for reading and other household tasks. This report argues that 300 lumens should be available for a minimum of four hours per night.

Cooking and water heating

Two in every five people rely on wood, charcoal or animal waste to cook their food

Cooking is a daily need, with around 80% of the foods humans consume needing to be cooked, and yet this is a relatively neglected area of intervention. In 2009 a study found that only 2% of energy strategies in the least developed countries addressed cooking (Havet et al., 2009).

Two in every five people (2.8 billion in 2010) rely on wood, charcoal or animal waste to cook their food (Banerjee et al., 2013). Only 27% of those who rely on solid fuels (biomass or coal) are estimated to use improved cookstoves. Access to these stoves is even more limited in least developed countries and sub-Saharan Africa, where only 6% of those who use traditional biomass are taking advantage of such options (Legros et al., 2009).

It is not just cooking that requires a source of heat: sterilizing water and heating water for washing and personal hygiene extend the amount of time for which a stove or fire must be lit. Stoves are also used for home-based productive activities such as cooking animal feed, brewing beer and spirits, and cooking street food (often an important source of household income).

Cooking and water heating does not only take place in the home, but also on the streets (for street foods), in cafes and restaurants, and in institutions such as schools, hospitals and at workplaces.

Table 1.1 Low-cost lighting technologies and their uses

Technology	Service	Comments
Incandescent electric bulbs	Street lighting, household lighting, small business lighting	Incandescent lamps are very low cost but have poor efficacy (15 lm/W) and short service life (1000 hours). Access to on-grid lighting is dependent on electricity pricing policies and tariff structure. Connection fee plus a 'security deposit' can make upfront costs prohibitive.
Arc-discharge electric bulbs and tubes (e.g. CFLs)	Street lighting, household lighting, small business lighting	Fluorescent (including CFL) bulb and lamp outputs are typically 50–100 lm/W and service life is around 10,000 hours. Cost is 8–10 times that of incandescent bulbs. Access to on-grid lighting is dependent on electricity pricing policies and tariff structure. Connection fee plus a 'security deposit' can make upfront costs prohibitive.
Solid state lighting (LEDs)	Street lighting, household lighting, small business lighting	LED bulbs and lamps have typical efficacies of 60–120 lm/W and service life of around 50,000 hours (although poor-quality products may be less efficient and fail much sooner). The cost of LED lamps is around 10 times that of fluorescents, but is falling over time. LEDs are most suitable when available power is limited (e.g. systems that incorporate renewables and battery storage).
Solar lanterns	Small task lighting (household tasks, homework, reading), market stalls	Rapidly expanding market. Most use LED lights, and can be bought relatively cheaply (e.g. $8 for a sturdy lamp). Zero operational cost. Portable, so can be moved to where light is needed. Environmental burden of disposable batteries is avoided. Some models also can be used to charge mobile phones or other small electronic devices.
Solar home systems	Household lighting (multiple light points)	Upfront costs are high (>$200 per household) but rental and microfinance purchasing schemes are in operation in many countries. Many models can also charge mobile phones or other small electronic devices.
Enclosed and pressurized kerosene lamps	Reading and general household lamps	High levels of particulate emissions and toxic fumes. Equipment is more expensive than wick stoves, but light is good enough for reading. Represent a safety concern with risk of burns and fires, and fuel must be regularly purchased.
Bottle lamps and other kerosene wick lamps	Low-level lighting	High levels of particulate emissions and toxic fumes. Poor lighting intensity. High risk of fire and burns to user (although safer designs are available), and fuel must be regularly purchased.

Cooking and water heating without improved stoves or fuels

There are far-reaching implications of the lack of access to improved cooking solutions. Some of the most important relate to women and children's time and workloads, health and environmental issues.

Women's time and workload. Women in particular spend many hours in drudgery, gathering fuel, cooking over inefficient stoves and cleaning soot-laden pots, clothes, walls and ceilings. Studies in various countries suggest women (and often children) spend 2–8 hours per day collecting wood (Figure 1.2). There are also wide seasonal variations affecting the availability and choice of fuel types (Box 1.2).

Box 1.2 Energy needs to cook nutritious food

Tawisa's husband passed away a year ago, and the nearby church has helped her to obtain food relief. However, Tawisa will still sometimes go hungry because there is not enough wood for cooking. Like her neighbours, she often cooks porridge rather than the highly nutritious mixture of beans and maize because these take longer to cook and thus use substantially more woodfuel. This is despite the fact that she uses an energy-saving stove that reduces the amount of firewood she would otherwise need by half.

Tawisa gets her firewood from the riverbed during the rainy season. Each week she will walk three hours each way for fuel. She builds a fence for her homestead with the twigs and branches and then uses them as firewood during the dry season. When this runs out she has to buy firewood, with one bundle costing 20 Kenyan shillings lasting three to five meals.

Pneumonia caused by inhalation from cooking fires causes half the deaths of children under five

Health issues. For those with the lowest incomes, who cook and heat water using biomass fuels on rudimentary stoves, smoke is one of the largest causes of ill-health and death. The Global Burden of Disease study 2010 (WHO) estimates that exposure to smoke from the simple act of cooking is the fourth worst risk factor for disease in developing countries, and causes four million premature deaths per year (Lim et al., 2012), exceeding deaths attributable to HIV/AIDS, malaria and tuberculosis combined. Figures from 2012 estimate that 4.3 million die from indoor air pollution every year. More than half the deaths of children under five are due to pneumonia caused by particulate matter (soot) inhaled from household cooking fires (WHO 2014).

Exposure to smoke is greatest among women and young children, who spend the most time near open fires or traditional cookstoves. Table 1.2 provides a snapshot of three typical households in rural Kenya, showing when the woman and her youngest child were present in the kitchen with the fire alight. These fires emit fine particles, carbon monoxide, and other pollutants at levels up to 100 times higher than the recommended limits set by the World Health Organisation (WHO). This exposure causes a range of chronic and acute conditions including child pneumonia, lung cancer, chronic obstructive pulmonary disease, and heart disease, as well as low birth-weight in children. It can cause disabling effects such as cataracts: affecting more women than men, and the leading cause of blindness in developing countries.

Burns are an additional risk, with the WHO estimating that there are over 300,000 deaths per year from fires alone. Fire-related deaths rank among the 15 leading causes of death among children and young adults 5–29 years old.

Deforestation. Forests are declining worldwide and although the rate of deforestation appears to have slowed, globally around 13 million hectares of forests were lost each year between 2000 and 2010, as compared to around 16 million hectares per year during the 1990s (FAO, 2010).

The Food and Agriculture Organization (FAO) has calculated that at a global level, woodfuel collection accounts for nearly half of all removed wood (FAO, 2010) and more than three quarters in Africa and Asia. This is a complex issue because charcoal, which is in high demand in urban areas, comes predominantly from felled trees, while the wood collected by rural women for their own use is mainly dead wood taken from the trees – as they wish to conserve the tree for the future.

Fuel efficient biomass stoves could help to reduce over-harvesting and contribute to increased tree growth. Such interventions need to address the charcoal trade and use in urban areas as much (or perhaps even more) than rural wood use.

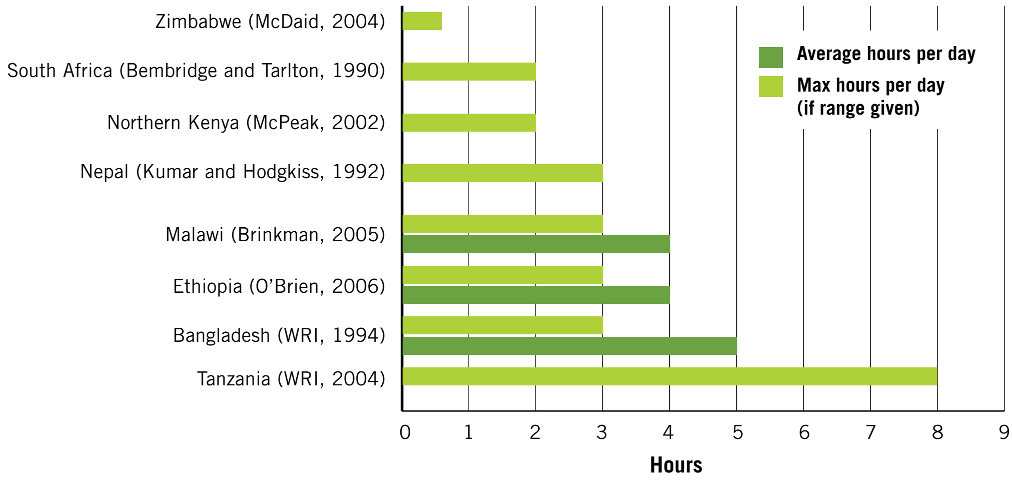
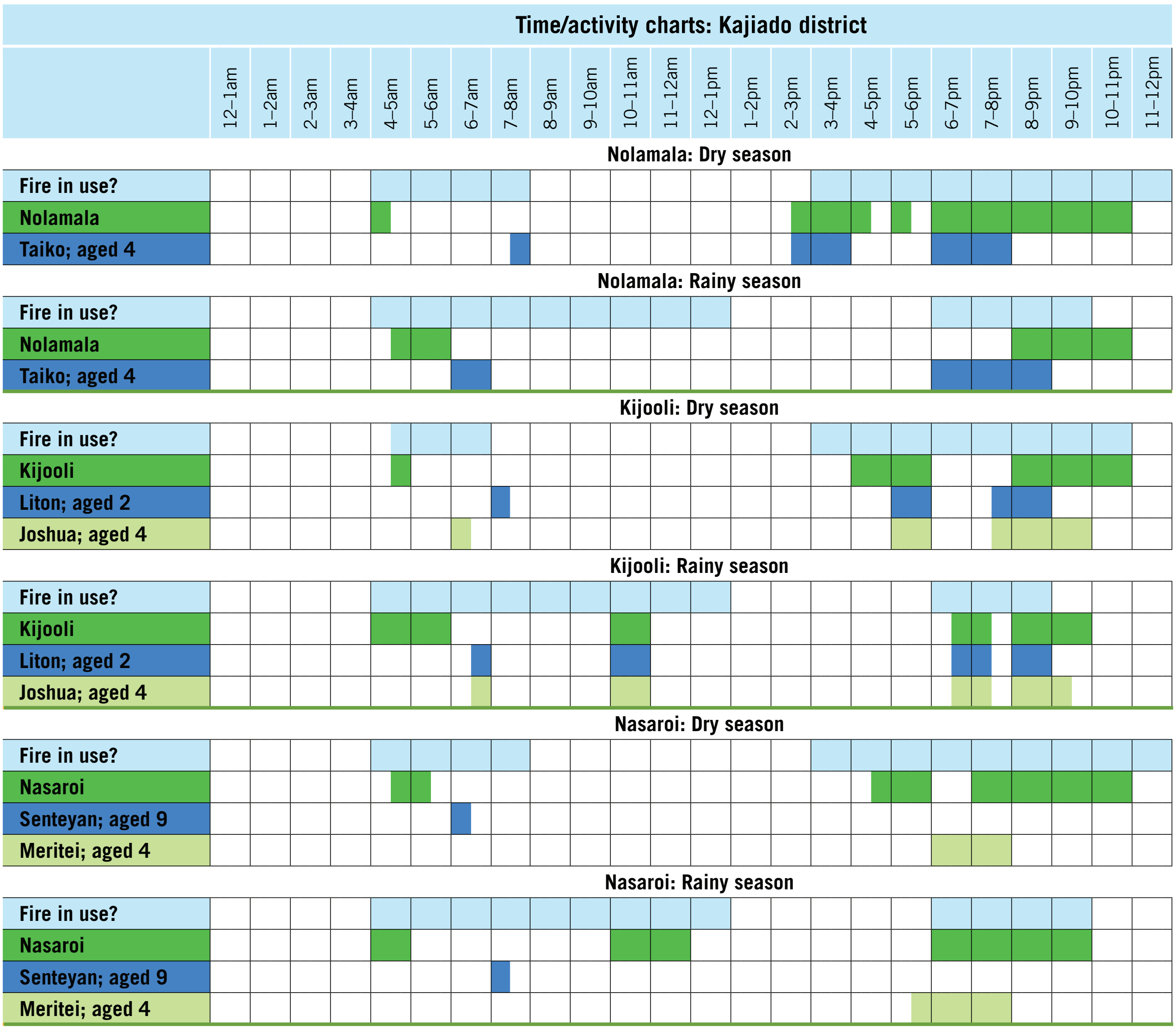


Figure 1.2 Selected data on time spent in collecting wood

Table 1.2 Time activity data from three Kenyan households



Climate change. Emissions from burning solid fuels in open areas and traditional stoves have significant global warming effects, due to incomplete combustion, and where biomass is sourced from non-renewable supplies. Per unit of energy delivered, open fires are the most greenhouse-intensive fuel system in the world (Garrett et al., 2009).

An important factor that is coming to light is the role of 'black carbon' – commonly referred to as soot. It is produced by burning fields, diesel engines and also by inefficient domestic stoves. It is hard to estimate accurately, but it is believed that stoves create around 23% of all global emissions of black carbon (Bond, 2010b). A 2013 report suggests that it plays a much bigger role in global warming than many scientists previously thought, suggesting it is second only to carbon dioxide in the amount of heat it traps in the atmosphere. It also causes faster glacial melt in the Himalayas and elsewhere (Bond et al., 2013).

On the other hand, black carbon does not remain for long in the atmosphere, and is removed by rainfall. Its short lifetime means it contributes to climate change in a different way to carbon dioxide. Cutting black carbon would provide a once-only correction to global warming, since it does not accumulate or persist, but the reduction would be substantial.

It is also important to note that although there is a climate change impact of household cooking in developing countries, it is not significant from a global perspective, not least due to the fact that these households are some of the poorest in the world and generally have very low overall carbon emission footprints. Therefore an initiative aimed at trying to reduce household air pollution should prioritize the health and livelihood benefits, rather than the climate change benefit.

Reducing fuel consumption and smoke

There are simple, low cost ways of reducing fuel consumption and exposure to smoke

The *cleanest* energy sources in the kitchen for cooking are electricity, gas and alcohol (ethanol). All these fuels emit negligible quantities of health-damaging pollutants. Unfortunately, for many low-income households, these fuels are often unavailable, partly because they are too expensive, or because supply chains that would provide a reliable source of energy do not currently exist.

Even if it is not possible to switch to cleaner fuels or an improved stove, there are simple, low-cost ways of reducing fuel consumption and exposure to smoke (Table 1.3).

Stove improvement programmes. In the past, stoves marketed as being 'improved' were not always of a sufficient quality to offer much benefit. They neither reduced fuel use or smoke, nor were they designed sufficiently in collaboration with the users (Smith, 2002). The situation has improved and many new technologies are available. This is recognized by the fact that a number of stove producers have been able to access carbon finance and use this to reduce the costs of the stove (Levallois, 2013). A process is underway to define an international ISO standard for clean cookstoves, including a set of performance tiers. The Global Tracking Framework (GTF) (Banerjee et al., 2013) has adapted these tiers, grading the technical performance of a stove from A (highest) to E (lowest) based on its efficiency, indoor pollution, overall pollution and safety, as well as assessing their appropriateness for use by the end users.

As well as looking at the performance and appropriateness of stoves, the focus of much work has moved on to efforts to catalyse the market for improved and more advanced cookstoves. This has been led by the Global Alliance for Clean Cookstoves.

Solutions for water heating. For those using a three-stone fire or traditional stove, water is often heated using the dying embers of the fire once the cooking is

Table 1.3 Approaches to reducing smoke and reducing fuel consumption

	Health benefits	Time saving	Environmental benefits
Keeping infants and young children away from the stove and making sure women know to spend as little time as possible close to the fire and to avoid the plume of smoke that occurs particularly when starting up the fire. Awareness of the risks of smoke is a key driver for this.	✓		
Cooking out of doors can help, but is often socially unacceptable	✓		
Preparing foods (such as grinding dried pulses) so they **require less cooking**. Again, this is a social issue, and requires women to change their cooking habits substantially. Cooking times are greatly reduced.	✓	✓	✓
Producing less smoke by using cleaner and faster fuels (e.g. LPG and ethanol), or by using technologies such as improved biomass stoves, or solar cookers and/or 'fireless cookers' (hayboxes). Time spent gathering fuel and cleaning is reduced substantially.	✓	✓	✓
Venting the smoke through eaves spaces, smoke hoods and chimney stoves, making the house easier to keep clean so less time is spent in washing clothes, children, household structures	✓	✓	
Using solar heaters for heating water that does not require boiling. These devices generally employ a solar collector and a storage tank, or else comprise a large strong, black polythene container, which is its own collector.	✓	✓	✓
Institutional stoves are used in schools, hospitals, refugee camps and the like. It is generally easier to **increase the efficiency of large-scale stoves** than small household stoves, because they tend to burn hotter and thus more completely, and there are smaller losses with one big stove than with many small ones.	✓	✓	✓

completed. More efficient biomass, liquid-fuel or stoves cannot be used in this way. However, studies by Practical Action in Kenya have shown that for short, rapid cooking, such as making tea, even low-income households will use modern stoves if the purchase price is affordable or revolving finance is available. This is because they save a lot of time: in the Kenya case study, around 2.6 hours per day (Bates et al., 2007).

For heating larger amounts of water for washing, simple low-cost solutions can be effective such as using black polythene containers placed in the sunshine. Direct solar water heaters comprising a tube fitted in a zigzag fashion onto a board can produce water to 60°C, even in temperate countries (Manyaapelo, 2000).

Minimum standards for cooking energy

The minimum standard for access to clean cooking solutions should cover fuel use, time, stove efficiency and pollution. As with lighting, we think the standards proposed by the GIZ EnDev programme are appropriate (GTZ-HERA, 2009), combined with WHO's indoor air quality guidelines (WHO, 2006) and a time-limit for the collection of fuels.

- 1 kg woodfuel or 0.3 kg charcoal or 0.04 kg LPG or 0.2 litres of kerosene or biofuel per person per day, taking less than 30 minutes per household per day to obtain[3]

The minimum standard for access to clean cooking solutions should cover fuel use, time, stove efficiency and pollution

- Minimum efficiency of improved solid fuel stoves to be 40% greater than a three-stone fire in terms of fuel use
- Annual mean concentrations of particulate matter ($PM_{2.5}$) <10 μg/m³ in households, with interim goals of 15 μg/m³, 25 μg/m³ and 35 μg/m³.

Space heating

Half a billion people in South and South-East Asia alone use stoves for space heating

Space heating is an important function of household stoves and heating appliances, particularly at higher altitudes and during cold seasons. Despite this, it is often overlooked by policymakers and designers of stoves programmes. Depending on customs and traditions, people either want to use their cooking stove to also provide warmth, or they have a separate stove for heating their home. It is estimated that half a billion people in South and South-East Asia alone use stoves for space heating, whether for every day use, just during cooler seasons or at night (Hulscher, 1997).

In the mountainous areas of Asia, households generally use 70–80% of primary energy directly for cooking and 20–25% directly for space heating. However, when the actual service provided by the energy is calculated, an estimated 60% contributes to heating the surrounding space and only 40% goes into cooking (Hulscher, 1997). This is because much of the heat generated by the cookstove dissipates into the surrounding air, thereby heating the room. Improved stoves focus much more of this escaped heat on the pot, funnelling smoke and hot gases out through a flue or chimney. The unfortunate trade-off of this efficiency is that householders might need to have a separate fire to keep warm.

The difficulties and risks of trying to stay warm

It can be difficult for poor people to keep indoor temperatures at a reasonable level during cold seasons. This in itself causes health problems, while some of the solutions also have health risks and involve a considerable investment of effort and money.

Health impacts of cold. Mortality rates rise progressively when outdoor air temperatures fall outside the range of 20–25°C (Table 1.4) in particular through an increase in the likelihood of cardiovascular and respiratory disease (Wu et al., 2004). HelpAge International (2009) report that older people (and small children in their care) have been severely affected in Kyrgyzstan, where the capacity to generate hydroelectric power during the long winter months has been limited. To reduce their fuel consumption and costs, people often close the doors and windows. This exacerbates the amount of smoke in the house and exposes people to greater risks associated with indoor air pollution.

Time spent. The majority of poor rural people living in mountain regions use woodfuel for space heating. Space heating requires large amounts of fuel, forcing people in cold climates to spend many hours gathering firewood or spend a larger proportion of their incomes on woodfuel. A study in Garhwal Kingdom in India showed a marked increase in the use of biomass with increasing altitude, and fuel use was shown to be two to three times greater in winter than in summer. The firewood consumption was reported at around 1.07 kg/person/day below 500 m altitude, rising by an additional fuel requirement of about 0.8 kg/person/day per 1,000 m, to reach 2.8 kg/person/day above 2,000 m (Bhatt and Sachan, 2004). A Practical Action study in the high hills in Nepal found that households spent an average of 19 hours of labour (number of people × time taken) per week gathering fuel.

Table 1.4 Health effects of various temperatures

Temperature	Health effects
24°C	Top range of comfort
21°C	Recommended living room temperature
<20°C	Mortality rate begins to rise
18°C	Recommended bedroom temperature
16°C	Resistance to respiratory diseases becomes weakened
12°C	More than two hours at this temperature raises blood pressure and increases heart attack and stroke risk
5°C	Significant risk of hypothermia

Source: Keatinge, 2006. Space heating with fires or stoves increases the risk of burns, which can often be severe. Thus, safety is an important feature of stove design where they are to be used for heating, especially in households with children, who are left unattended.

Space heating for low-income communities in cold regions

Solutions for keeping warm safely and affordably in cold regions include choosing good stoves and heaters, and combining this with changes in building design and better insulation.

Stove selection. Many modern cookstoves are designed to reduce the extent to which the fire's heat dissipates into the room. However, there are some designs that do use the heat from the stove for space heating as well as for cooking, while preventing smoke from getting into the room.

Separate heating stoves are used in countries where heat is not needed all the time. Typically, they are enclosed stoves with a flue pipe. Some allow a kettle to be placed on the stove top. Chimney stoves made of steel (for cooking and heating) are used in many countries in Asia. Well-made and well-maintained stoves can provide a good level of warmth. There are still risks of burns from the hot exterior of the stove. An option where people like to see the fire is to use a smoke hood, leaving the fire partly exposed.

Buildings designed for warmth. Passive solar design can lower energy requirements for heating. In the southern hemisphere, windows should face north (±15°) for optimal solar benefit (staying cool in summer and reducing heat loss in winter). Placing the main door away from the wind and using a buffer space such as a porch can also make a difference. The choice of materials can make a difference. Choosing those with a high thermal mass allows the material to store heat during the day and release it slowly at night.

Wall insulation. Maintaining a room's temperature is about energy balance. The energy given out by a stove has to balance the energy leaving the room through walls, floor, ceiling, doors and windows. Insulating walls and ceilings can cut the need for heat energy and substantially stabilize room temperature. Locally available materials such as straw, dung and clay can be a low-cost solution.

We propose a minimum standard for daytime indoor air temperature of 18°C

Minimum standards for space heating

Considering the health impacts of lower temperatures, we propose a minimum standard for daytime indoor air temperature of 18°C. This should be achieved by means that do not entail indoor smoke, are affordable, and do not require excessive time in collecting fuel.

Cooling

Cooling is a critical energy service for the preservation of food and medicines and for keeping spaces at habitable temperatures

Cooling is a critical energy service for the preservation of food and medicines and for keeping spaces at habitable temperatures in hot countries. The majority of developing countries are located in the hottest regions of the planet; nearly four billion people live in areas with annual average ambient temperatures above 22.5°C. For more than one billion people living in South Asia and sub-Saharan Africa, the average temperature for the hottest month of the year exceeds 30°C.

Energy for cooling contributes to poverty reduction in various ways, but its contribution is not often recognized. Here we focus on cooling for households. Issues related to enterprises and health care are dealt with in the chapter on community services.

Food preservation. In hot climates, farm, fish and animal produce do not stay fresh for long. At the same time, food production is seasonal, fish can only be caught during good weather and animals are slaughtered infrequently. In 2010, roughly 830 million people were undernourished (United Nations, 2010). Improving post-harvest food preservation could help reduce this. A number of preservation methods are possible, including cooling, drying and curing. Cooling is often preferred since the produce is not significantly changed by the process. Data from five South American countries with high electrification rates show that refrigeration is a high priority for people of all income groups. Along with television, a refrigerator is a priority appliance for the poorest 20% (Kozulj, 2009).

Space cooling. Soaring temperatures can affect people's health, productivity and comfort. Household space cooling is often something people prioritize in hot and humid areas (Sparknet, 2004).

Options for cooling

Access to cooling services is low among the world's poorest people. Even for those who have access to electricity, the cost of acquiring and operating cooling and refrigeration appliances can be prohibitive.

Thus, passive cooling methods can be very effective in prolonging the life of food and dairy products. Technologies include the zeer pot (Box 1.3) and cooling chamber. Passive technologies are very economical since they require no fuel or electric input and can be built using widely available materials. However, despite their benefits there is little information available about their uptake and use (Practical Action, 2006).

Box 1.3 Zeer pots in Sudan

In Sudan, where the average annual temperature is 30°C, food does not stay fresh for long. One solution is the zeer pot: a simple passive cooling 'fridge' made of local materials. An earthenware pot is set inside another with a layer of wet sand in between. Carrots and even tomatoes stored in the pot last up to 20 days, compared to 2–4 days in usual ambient temperatures.

Minimum standards for cooling

As with space heating, cooling is not a widely recognized energy service, and yet it can be critical for poverty reduction. We propose the following two dimensions of a minimum standard for cooling for households:

- Households can extend the life of perishable products by a minimum of 50% over that allowed by ambient storage
- Maximum apparent indoor air temperature of 30°C.

Information and communications

Information and communications technologies (ICTs), defined as technologies that can process and transmit information and facilitate communication via electronic means (Marker et al., 2002), are now established as key tools for alleviating poverty. ICTs (such as radio, televisions, computers) are by their nature heavily dependent on energy and those without it lack access to information that could make a real difference in their lives: information about the composition and delivery of services from public institutions, about political activities and their human rights, about the market value of their goods and produce and about education and livelihoods options.

By mid-2012, there were 2.4 billion internet users worldwide (34% of the global population) (Internet World Stats), and 3.2 billion mobile phone subscribers. The growth in access has been rapid. However, there is still a risk that inequitable access to ICTs may exacerbate growing inequalities in income, knowledge and power between men and women, income or ethnic groups, or urban and rural populations. For example, a woman is 23% less likely than a man to own a mobile phone if she lives in sub-Saharan Africa and 37% less likely if she lives in South Asia (GSMA, 2010).

Access to energy has enabled the uptake of ICTs, even in remote rural areas of developing countries, through grid extension or the ability to charge batteries. Most people rely on batteries as their energy source for ICTs charged by solar panels or diesel generators. Numerous small enterprises have arisen that offer mobile battery charging. In Kenya, only 15% of the population has electricity access at the household level, yet the penetration of mobile phones is already 50% (Legros et al., 2009). In Peru, access to electricity from micro-hydro power has enabled villagers to access the internet through small cyber cafés.

Access to energy has enabled the uptake of ICTs, even in remote rural areas of developing countries

The increased use of ICTs is also contingent on a number of other factors: better infrastructure (such as signal towers for mobile phones), improved supply chains for ICTs (availability of products and services), improved and pro-poor technology and services from ICT providers (low-cost, high-quality products and services such as the M-PESA banking facility on mobile phones, Box 1.4), increased public awareness of products (through advertising and word of mouth) and greater consumer spending power.

Box 1.4 Safaricom, M-PESA and M-KOPA in East Africa

Mobile banking in Kenya was first designed by Safaricom and by 2010 was used by nearly 10 million Kenyans, many of whom cannot obtain accounts with commercial banks. M-PESA allows the user to deposit, withdraw and transfer money and pay bills using their mobile phone account (Safaricom, 2010).

More recently a new organization, M-KOPA has partnered with M-PESA, using their GSM platform and mobile money payment system to try to supply a range of appropriate energy technologies to households across Kenya. This approach effectively makes microfinance for energy technologies available to a much wider audience. M-KOPA is initially focused on Solar Home Systems (SHS), but has an aim to include other energy technologies in the future (http://www.m-kopa.com/).

Economic impacts of ICTs

The ICT sector's contribution to economic growth is widely recognized. It is estimated that a 10% increase in the number of telephone subscribers in a country contributes to 0.6% GDP growth, largely through impacts on small and medium-sized businesses (IDA, 2009). The ICT sector is also a major generator of revenues for governments in developing countries; the government in Bangladesh collected US$300 million from ICTs in 2005 alone (IDA, 2009).

Beyond the household, ICTs can also provide a platform from which community services such as health, education, and other government services can be delivered more effectively. These benefits are elaborated further in Chapter 2.

Minimum standards for energy for ICTs

As with other energy services, the report argues that a minimum standard needs to focus on the service provided by ICTs rather than simply access to the technology. In order to achieve sufficient development benefits, and focusing on the household level, the following is proposed:

- People can communicate electronic information from their household
- People can access electronic media relevant to their lives and livelihoods in their household.

Summarizing people's experience of energy

This chapter has outlined five essential energy services needed at the household level, drawing both on people's experiences and collated data at household, project, national and international levels. Some of these are well-known (lighting and cooking), while others are less well recognized (heating, cooling and ICTs). The report proposes minimum standards across this full range, which together comprise a level of energy access which would be transformational. These can form a checklist allowing comparisons and improvements to be tracked in the dimensions that matter to people.

Chapter 5 describes the progress that has been made to build service-level thinking into a global system for measuring energy access.

2. Energy for earning a living

For billions of the world's poorest people, the ability to earn a living depends on access to energy. Having lighting after dark to keep a shop open longer, or fuel for an engine to mill grain or a pump to irrigate land, can be the difference between earning a decent livelihood and remaining at or below the subsistence level and in poverty. It is this direct connection between energy and poverty reduction that is most cited in the discussion over energy poverty, but is least well understood in practice.

The vast majority of poor people work in the informal sector generating incomes from often a multitude poorly or unpaid, insecure and physically demanding work. However, revenues generated in the informal sector are not generally included in national statistics or gross domestic product (GDP). Whilst there is a correlation between per capita energy consumption and GDP at national levels (Ozturk, 2010), to understand the impact of energy on poor people's ability to earn a living and escape poverty, it is not enough to look at national economic statistics on energy consumption, or even those of large enterprises.

This chapter explores how energy access affects the ability of poor people to earn a living, and how increased energy access can expand and enhance, but also sometimes reduce, their opportunities to do so. In examining these issues, the chapter looks at how energy interacts with the four principal ways in which poor people earn a living: earning a living off the land, running a micro or small enterprise (MSE), being employed and earning from supplying energy to others.

Energy and earning off the land

Increasing agricultural productivity requires improved energy access and services at each stage of the agro-food production chain

Agriculture contributes significantly to the economic and social foundations of most developing countries.

Some 2.5 billion people, 45% of the developing world's population, live in households depending primarily on agriculture and an agri-based economy for their livelihoods. In many developing countries, the agricultural sector generates on average 29% of GDP whilst it provides work to 65% of the labour force, with a disproportionate number being income and energy poor (GIZ, 2011). Hence, increased agricultural productivity is a primary driver for food security, income generation, development of rural areas, and therefore global poverty reduction.

To feed the 9 billion people expected to populate the world in 2050, it is estimated that agricultural productivity must increase by 70% (FAO, 2009). Improving agricultural productivity requires improved energy access and services at each stage of the agro-food production chain.

This is particularly true for women farmers who make up the majority of agricultural labourers in sub-Saharan Africa (World Bank, FAO, IFAD, 2009) and currently have the least access to technological inputs and energy services (Gill et al., 2012). It is projected that if these women had the same access to productive resources as men, they could increase yields on their farms by 20–30%, which could reduce the number of hungry people by 100 to 150 million people (FAO, 2011). Energy is central to

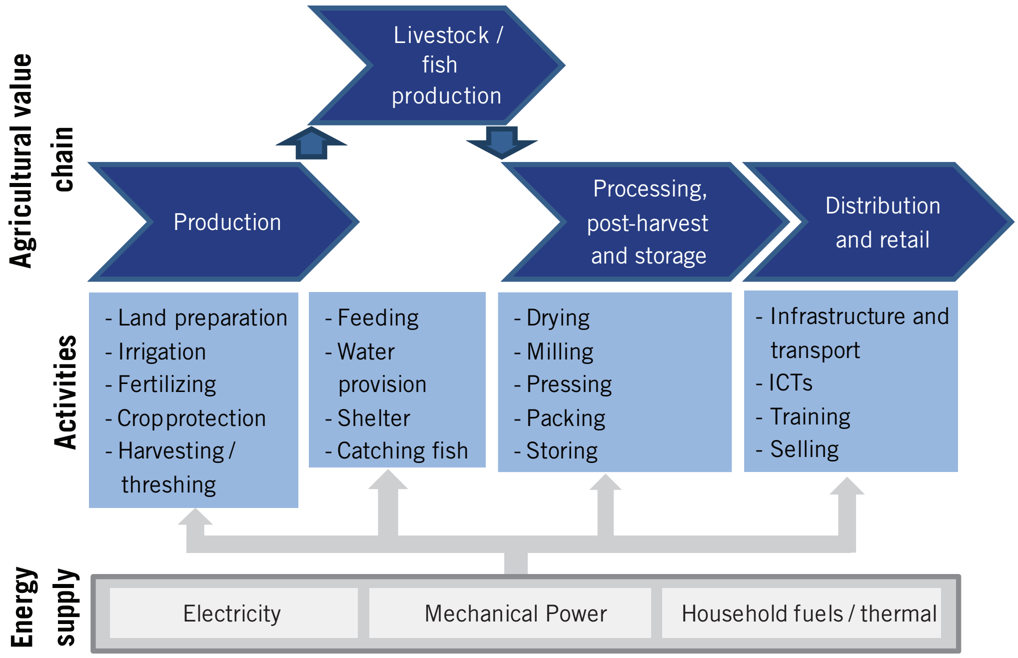


Figure 2.1 Energy inputs for agricultural value chain

fulfilling this potential, and as such, the differing needs of men and women farmers must be integrated into energy planning, service delivery and access.

Increasing productivity

For poor farmers, agricultural production activities are based to a large extent on human and animal energy, as there is often insufficient mechanical, electrical, and chemical (fuels) energy available. Mechanical power is a particularly important input in any farming system, used in land preparation, planting, cultivation, irrigation, and harvesting. Three distinct types of farm-power systems can be identified according to the relative contribution of humans, draught animals, and machinery (GIZ, 2011):

1. **Human work** for tilling, harvesting and processing
2. **Animal work** to provide various energy inputs
3. **Energy technologies** including renewable energy (e.g. solar or wind pumps, solar dryers, water wheels, biomass conversion technologies), fossil fuel-based technologies (e.g. diesel engines and pumps) and hybrid systems (a combination of fossil and renewable energies for motive and stationary power applications and processing agricultural products).

The type of farm-power system available to farmers is a significant factor in determining the area of land they can cultivate; human-powered farms typically cultivate 1–2 hectares (ha) per year, farmers hiring draught animals cultivate 2 ha, farmers owning draught animals cultivate 3–4 ha, farmers hiring tractors cultivate about 8 ha, and farmers owning tractors cultivate more than 20 ha (FAO, 2006).

While mechanization offers opportunities to increase cultivated area, reduce drudgery, and use external inputs to maximize productivity, its consequences often outweigh its benefits for poor farmers. This is because most smallholder farmers, and particularly female farmers, cannot afford the machinery, equipment or inputs needed for intensive agriculture. Where productive land is in short supply it is at risk of being displaced by the more wealthy farmers who are able to expand through mechanization and fossil fuel-dependent intensification. Introducing intensive, mechanized agriculture to impoverished agricultural areas can have further negative social and economic impacts by pushing down prices to a level other local producers cannot compete with, meaning rural households can lose their livelihoods and, the men in particular, are often compelled to migrate to urban areas in search of work. The expansion of commercial farms breaks the connection between rural populations and the land. It puts impossible pressures on the remaining populations, their communal areas and the social structure. Finally, there are also often negative environmental impacts that result from mechanization including increased greenhouse gas emissions, water use, soil degradation, and others.

Box 2.1 Farming in Sudan

For Kaltoum Mohammed Abdalla, a mother of four children in western Sudan, using a donkey and plough enabled her to double the area of land she cultivated to 5.4 ha. She now grows and sells enough that she has bought ten goats for her family and can send two of her children to school.
Source: Practical Action

However, appropriate intermediate, energy efficient and environmentally friendly production systems do exist. Systems, such as Integrated Food Energy Systems

(IFES), can enable sustainable crop intensification by producing food and energy simultaneously (FAO, 2011a). They minimize external agricultural inputs by using and improving local knowledge and on-farm resources. Energy-reducing practices include: nutrient cycling (use of manures and organic fertilizers); mixed cropping and integrated pest management to control pests and diseases; drip irrigation to improve efficiency in the use of water; solar or wind power for pumping water; renewable energy for milling or other post-harvest processing; local production for local markets to reduce transportation costs.

Unfortunately such practices are less attractive to commercial investors as they have lower yields and do not always maximize profit. Similarly they are often less attractive to politicians as they do not show rapid or dramatic results. To escape low-yielding, climatically vulnerable, subsistence agriculture, innovative business and community models are required for smallholder farmers to access affordable energy efficient technologies, for example through rental schemes or co-operatives. One of the most critical ways energy can quickly increase agricultural earnings is through irrigation.

One of the most critical ways energy can quickly increase agricultural earnings is through irrigation

Irrigated land productivity is more than double that of rain-fed land (World Bank, 2008). It increases farm productivity by allowing additional crop rotations per year, increasing crop yields, and reducing the risk of crop failure caused by erratic rainfall and drought.

In sub-Saharan Africa, only 4% of the area in production is under irrigation, compared with 39% in South Asia and 29% in East Asia (World Bank, 2008). So despite significantly less land being irrigated than rain-fed, 59% of cereal yields produced in developing countries in 1997 came from irrigated land (FAO, 2003). For poor farmers, mechanically assisted manual irrigation methods are often the most appropriate technology due to low capital costs, small areas being irrigated, being human-powered and suitable for village-level maintenance. Irrigating with a treadle pump can increase crop yields by 50–80% (UNDP/PAC, 2009), and deliver profits of $528 per crop cycle (GNESD, 2007).

Renewable energy technologies such as solar PV systems, wind pumps or hydraulic ram pumps have also been demonstrated as economically viable for irrigation (FAO, 2000). These technologies are capable of very low running costs, but high capital costs, challenges of village-level maintenance, and availability and awareness of the technologies remain barriers to increased uptake.

Information and communications technologies (ICTs) also have the potential to contribute to increased farm productivity by improving communications and knowledge sharing. Mobile phones can help better organize service providers that could assist in land preparation. The use of radio for agricultural extension and to promote use of new technologies for improved agriculture formed the basis for improvements in farm productivity in Asia. Weather forecasts via TV and radio have an important economic significance in regions such as Mongolia where 80% of adult community members listen to weather forecasts for productive uses. Forecasts have a positive impact also on herd productivity by reducing risks of herd management (Van Campen et al., 2000).

Improved agro-processing and marketing

For many poor rural households who rely on their own farm produce for the basic staple of their diet, processing crops by hand at home is the only option. This role is typically performed by women and is extremely labour intensive. Households may also need to carry or transport heavy produce long distances to be processed by powered machinery, often at great expense.

Agro-processing extends markets in which goods can be sold and permits sales at higher prices and in larger quantities (FAO, 2009). Furthermore it transforms agricultural produce into both food and non-food commodities through processes ranging from simple preservation (e.g. sun drying) or transformation (e.g. milling) to the production of goods by more capital- and energy-intensive methods (e.g. food industry, textiles, paper). Agro-processing often depends on resources and expertise of small enterprises, co-operative millers, or other specialists who provide important energy services to farmers. It allows agricultural products to be conveniently:

- **cooked/heated**: withering tea leaves, roasting coffee
- **stored**: chilling and freezing, transport
- **preserved**: smoking, forced air drying, sun drying
- **transformed to higher-quality/added-value forms**: flour, de-husked rice, expelled nut oil, fibre extraction.

Modern energy services can significantly reduce the time and heavy work involved in traditional agro-processing while improving incomes for smallholder farmers with higher prices from finished products. For example, the multifunctional platform project in Mali that is widely used for agro-processing saved women customers on average 2–6 hours per day (UNDP, 2004). Economies of scale and specialization can often be achieved by semi-centralizing processing, for example, through community watermills. Processing at the farm or co-operative level can create opportunities for farmers to access more reliable markets and diversify products through processing and use of agricultural residues or by-products, such as molasses and rice husks.

Modern energy can reduce the heavy work of traditional agro-processing and improve incomes

Box 2.2 Improved watermills bring benefits in Nepal

Traditional watermills have been used in Nepal for centuries to provide mechanical power for agricultural processing, such as grinding wheat. However, the rudimentary design can be improved with simple adjustments to increase the power, efficiency and durability of the mill. This has increased the mill's throughput and reduced the waiting times for customers from 3–4 hours to 1–2 hours. Mill-owners' incomes have increased by an average of 25%.

'It's much easier with a watermill here in the village… In the dry season we had problems before because there was not enough water for the watermill. These days the watermill will run with less water' (Mathura Mahat).

Source: Ashden Awards 2009

Getting agricultural produce from the farm to the consumer involves numerous interconnected post-harvest activities including grading, packing, transport, storage, distribution, marketing, and sale. These activities cannot take place without the exchange of information, which is greatly facilitated by modern energy services and ICTs.

Timely and accurate information about markets allows farmers to secure the best returns on their produce. Poor farmers with limited knowledge about the markets in which they are operating can benefit from electronic information about pricing and market requirements. This can reduce the risk that farmers will sell at a loss or waste time and resources travelling to markets where prices are low. It can also alter the power imbalance with middlemen, who farmers can interact with from a more informed position. In sum, improved information availability via ICTs, either at household or community/co-operative levels, offer opportunities to strengthen participation in underserviced rural agricultural markets, thus increasing poor farmers' income.

Energy and micro and small-scale enterprises (MSEs)

Micro and small-scale enterprises have specific energy needs

Many poor people in the developing world earn their living running businesses such as street-side stalls, food stalls, or workshops. These micro and small-scale enterprises (MSEs) have specific energy needs, in addition to those of households. In order to better understand the ways energy access contributes to earning a living through small enterprise activity, this section considers the range of energy services used in MSEs and the steps needed to realize increased incomes from those services.

Energy activities in MSEs – service, manufacture, and processing sectors

The manufacture, service, and processing sectors have different energy needs. In service enterprises, appliances are typically limited to lighting and other appliances for comfort (e.g. fans, TV) and communication (e.g. computers and telephones). Manufacturing enterprises require particular kinds of appliances that demand high amounts of energy for mechanical power, heat for processing, or electricity for welding or other activities. Food and other processing enterprises share energy needs with both the service and manufacturing sectors.

To fully understand the energy demands of MSEs, it is necessary to look at the range of ways energy services are used. Table 2.1 shows the diversity of urban poor enterprise activities, and their corresponding energy supplies and appliances in Kibera, a large slum in Nairobi, Kenya. Whilst many of these enterprises are also found in rural towns and villages, such as shops, grain milling, or small bakeries, their variety and quantity in those areas is significantly less due to the low density of rural customers.

Common energy services in enterprises

MSEs require many of the same energy services as households. Lighting for work after dark can improve productivity and incomes, particularly in areas where customers have a demand for evening services. Other energy services provide a better environment for customers, entrepreneurs, and workers, such as cooling from electric fans, heating, and ICT applications including TV and radio. Cooking and water heating also serves customers and employees alike.

Enterprises relying on these energy services for their main activity, such as cooking for a food vendor, or refrigeration for a bar, are likely to have greater demands than households for energy supplies and appliances that provide energy service more conveniently or efficiently.

Table 2.1 Service-, manufacture- and production-based activities employing or owned by the urban poor in Kibera, Kenya

Services-based activities			
Activity	**Main energy supply**	**Appliance used**	**Improved alternative inputs/devices**
Food kiosks	Charcoal, kerosene	Stoves	LPG, efficient biofuel stoves
Small restaurants	Charcoal, kerosene, electricity, gas	Stoves, electric cookers	Efficient biofuel stoves, and more efficient electricity stoves
Small shops	Kerosene, electricity	Fridges, stoves, lanterns	More energy efficient devices
Laundry	Charcoal, electricity, solar	Flat iron, washing board	
Tailoring	Mechanical power, electricity	Sewing machines, flat irons	Sewing machines with efficient motors
Bars	Kerosene, electricity	Fridges, stoves, electric cookers	LPG, efficient biofuel stoves and more efficient electric cookers
Taxi service and commercial pick-up transport	Petroleum	Petrol and diesel engines	Efficient internal combustion engines, improved engine tuning & maintenance
Vehicle repair	Electricity, gas, mechanical power	Welding equipment, grinders, compressors	Efficient motors for welding
Tyre puncture repair	Kerosene	Heaters, compressors	Efficient heaters and motors
Electrical goods repair	Electricity	Soldering equipment	
Butcheries	Mechanical power, electricity	Incandescent lights	Tubes and CFLs
Manufacture-based activities			
Activity	**Main energy supply**	**Appliance used**	**Improved alternative inputs/devices**
Metal works	Electricity, gas	Welding equipment, lathe machines, grinders, incandescent lights	Efficient electric motors, tubes and CFLs
Metal household items	Charcoal, electricity	Heaters	Use of efficient heaters, and electricity
Pottery / clay products	Mechanical power, wood	Rollers	Solar dryers, electric rollers
Woodwork and furniture	Mechanical power, electricity	Cutting and planing equipment	Efficient motors
Basket makers	Mechanical power	Sewing machines, flat irons	Efficient motors
Construction	Electricity		
Paint manufacture	Mechanical power, electricity	Mixers, incandescent lights	Efficient motors, tubes and CFLs
Processing-based activities			
Activity	**Main energy supply**	**Appliance used**	**Improved alternative inputs/devices**
Bakeries	Electricity, mechanical power	Mixers	Efficient motors and ovens
Fabric production	Electricity, mechanical power	Motors	Efficient motors
Coffee processing	Electricity, firewood	Heaters, blowers, motors	Efficient dryers, blowers and motors
Grain milling	Electricity, diesel	Electric motors	Efficient motors

Box 2.3 Lighting up a small business in Yanacancha, Peru

Beatriz Sanchez, 27, is a mother of four young children and runs one of only a handful of stores and restaurants in Yanacancha Baja, a village nestled in the highlands of northern Peru. Until the installation of a micro-hydro plant by Practical Action four years ago, candles, kerosene and firewood were Beatriz's primary source of energy for light and cooking. Since the installation of the village's hydroelectric plant, she has transformed her business, as well as the quality of life for her young family.

'We've got electricity in the store, so I can run a fridge and the lights as well as the television which the customers like to watch while they eat. With the fridge and freezer, we are able to store pork and trout which previously would have been thrown away. My girls help me make ice pops too; they sell really quickly amongst the kids.'

'We used to close up at six o'clock', Beatriz explains, 'There was no point staying open later because no one would walk around after nightfall. Now with the new streetlights people come and go until much later and we regularly stay open until eight, sometimes nine.'

Enterprise-specific energy services

MSEs have energy service needs which can require varying amounts and forms of energy supply, depending on the enterprise's activities, scales of operation, and tradition. Primary categories of energy services for MSEs are:

Process heating and cooking: Energy services for heating are diverse. Only some enterprises can meet their needs with the same services required for household cooking and water heating. For cooking food, scale influences preferred energy supplies. Restaurants' demands for speed, flexibility, taste, and cleanliness require LPG, kerosene, and fuelwood. Cooking on a larger scale typically favours cheaper fuelwood or coal to limit expenditures for fuel.

Process heating can involve boilers, ovens or kilns which, depending on heat requirements, local fuel prices and availability, may use firewood, charcoal, coal or fuel oil. For metalworking, welding requires electricity, while traditional blacksmiths make use of coal and bark for heating.

Mechanical processing: Milling of grains is one of the most common non-farm enterprise sectors. Power demands are met by diesel engines or electric motors, or by direct mechanical power supply from hydropower. Other processing of agricultural products can include oil expelling, removing husks or shells, producing fibres, and more.

Cooling: Cooling is used extensively in the food production chain and includes transporting from primary producers to processors to storing at retailers. Cooling is important to maintain freshness of food products, which increases revenues and reduces waste.

Manufacturing and repair: Transforming raw materials into end or intermediate products such as timber planks or wooden furniture can be done by hand, but is speeded up and made more efficient through energy services. Plastic, metal and other manufactured goods require process heat and mechanical power. Repair of equipment, including vehicles and engines, also often requires welding or powered equipment such as drills and other workshop machinery.

Powering ICTs: ICTs for communication and entertainment often spread quickly when electricity is available. Appliances such as television, radio, and hi-fi can bring more clients to the shop, bar or restaurant, and shops can offer internet and mobile phone services. These services are sometimes clustered in kiosks providing a range of charging and ICT-related services.

Energy services – what matters to MSEs

As described above, enterprises require multiple energy services at different stages of production and processing. Tea production, for example, uses a series of energy services including withering, shredding, fermenting, and drying, and typically uses electricity, fuels, and mechanical power at different stages. The amount of energy required is also variable, based on the scale of the enterprise. Four aspects of energy access are especially important to enterprises and entrepreneurs (Table 2.2):

Table 2.2 Enterprise energy access matrix

	Energy supply Electricity	Fuels	Mechanical power	Appliance
Reliability	Availability (hours per day) Predictability (timetabled or intermittent)	Availability (days per year)	Availability (days per year)	Downtime (%), linked to ease of maintenance and availability of spare parts
Quality	Voltage and frequency fluctuation (+/- 10%)	Moisture content (%)	Controllability	Convenience, health and safety, and cleanliness of operation
Affordability	Proportion of operating costs (%) – including capital cost payback if financed	Proportion of operating costs (%) Time to gather as proportion of working day (%)	Proportion of operating costs (%) Time spent (if human powered) as proportion of working day (%)	Proportion of operating costs (%) – including capital cost payback if financed
Adequacy	Peak power availability (kW)	Energy density/ calorific value (MJ/Kg)	Peak power availability (kW)	Capacity compared with available resource and market (% capacity)

- **Reliability of the supply**: the number of hours of supply or availability, the predictability of outages or lack of supply, and availability during hours of the day energy is required.
- **Quality of the supply**: the voltage of electricity, and moisture content of solid fuels such as fuelwood.
- **Affordability of supply**: as a proportion of running costs and as a proportion of the price people are willing to pay for the end product or service.
- **Adequacy of supply**: capacity to meet enterprise needs in terms of peak power or duration of operation.

Box 2.4 Power outages bring down incomes in Nepal

Gagan's grocery shop sells food and other small items such as bread, sweets and cold drinks. He says *'We use energy for lighting, charging cell phones, and operating the refrigerator. We sell lots of cold drinks and make lots of money from this'*. The electric-powered refrigerator is at the mercy of load shedding, the prolonged daily power cuts that grid-connected Nepalis experience during the hot, dry season when their national hydro-generation is less effective. During this period, the refrigerator mainly remains off.

The income from the shop has been severely affected due to shorter opening hours and lack of power for refrigeration. *'I close down the grocery shop early evening and cannot sell cold drinks as per the demand of customers because of no supply of electricity'*.

Converting energy into improved MSE returns

Improved energy access, while an important enabler, is no guarantee of an increase in viability of MSEs, or the incomes of the people running them. An adequate supply of energy means required energy services can be delivered at the time and cost appropriate to the entrepreneur.

Enterprise activities and incomes largely depend on markets for the products and services provided. Most micro-scale enterprises sell to local markets. In impoverished rural areas, the local customer base is limited and has low expenditure capacity and flexibility. For new enterprise products and services, and also for increased volumes of production, saturation of local markets is a risk, and disappointing profits due to emerging competition are widespread phenomena.

Poor entrepreneurs may need to expand their markets by providing products or services that have pent-up demand in their local area, or by accessing larger external markets or higher income customers (Aterido and Hallward-Driemeier, 2010). Accessing such markets is a major barrier to rural development (Reardon et al., 1998)

For improvements in efficiency of production through modern energy services to lead to higher returns for MSEs, either costs of operation must be reduced, or the number of products/services sold must increase, or the sale price of each product/service must increase. In owner-operator MSEs, improvements in efficiency and product sale price via use of energy services are likely to return to the owners, while in larger enterprises they may actually cut jobs.

For this reason, programmes supporting energy access to rural MSEs should always integrate a demand-side element based on an assessment of the overall market system, and in particular demand volume and characteristics. Without support for enterprises to expand their markets, the benefits of energy access on incomes may not reach poor people.

Gendered impacts of increasing energy access in MSEs

For increased energy access to have a transformative impact on all MSEs, the specific needs of women, who run millions of MSEs around the world, must be taken into account. Gender divisions exist within and amongst sectors and scales of enterprise, whether they are based in households or separate establishments. Though the income generated by women is frequently not recorded, they provide a vital source of income for their families and rely heavily on energy to do so.

Typically women's economic activities are heat intensive with food processing being a common source of income, labour intensive because technology markets are usually biased towards appliances for men (who have more readily available credit), and light intensive as women often work indoors (Dutta and Clancy, 2005). The distribution of benefits of high power electricity supply normally benefits men as they tend to work with heavy electric appliances such as welding and carpentry.

Women's lack of energy access relative to men's hinders their economic and social potential

Energy use is not gender neutral either. Women's lack of appropriate energy access relative to their male counterparts means that they are less able to fulfil their economic or social potential. They are often poorer, have limited time outside of work and family duties, and suffer considerable health problems due to their dependence on unclean and inefficient energy sources.

Women are not simply important end users of energy though; they are also disproportionately burdened with the sourcing of energy. Most women have little option but to rely on woodfuel for cooking and heating, and so can spend hours collecting firewood every day. Thus increased access to alternative, cleaner fuels such as liquid petroleum gas (LPG) and kerosene is of vital importance. Better fuels would have an immediate impact on their health, productive time and income-earning potential.

Energy and employment

Many poor people are employed in unskilled, low-skilled or even skilled labour in both the informal and formal sectors. Increased energy use in enterprises can have both positive and negative effects on their employment opportunities, depending on the sector and enterprises in question, and the national regulations for worker rights and organization. In some cases better energy services can reduce the need for their labour. At the same time, increased energy services enhance the efficiency and quality – and hence growth prospects – of agriculture, industry and services.

In general, improving energy access is correlated with increases in economic growth and the availability of jobs – however the relationship is complex and increased employment is not guaranteed (UNDP, 2012). The relationship between energy access and job availability depends on growth of the enterprises, and employment intensity of that growth. In an enterprise survey in Sub-Saharan Africa (CGDEV, 2009), electricity was cited as the top constraint on enterprise growth in 11 of the 30 countries surveyed, and second in 9 more countries, compared with issues as critical to enterprise success as access to finance and macro-economic stability. While energy costs as a proportion of total costs can be calculated, the impacts of low-quality and unreliable power on enterprise success and job creation are more difficult to calculate.

Improving energy access is correlated with increases in economic growth – but the relationship is complex

Improved viability of enterprises may resolve itself more into profits for proprietors before increased returns in terms of wages to employees, or expansion of the enterprise to take on more employees. Additionally, cheap sources of energy can mean enterprises favour investments in automation over labour. Yet, automation may also increase demand for skilled workers. ICTs, for example, require personnel with specialized skills and high levels of education. A lack of support or training can therefore exclude poor people who have not had access to education, and for whom lack of energy services in the home, such as electricity for lighting and ICTs, has held back skills development.

Skills requirements however also go beyond academic education, and in developing employment, practical training and skills development also have an important role. This is particularly true in the provision of technical products and services, including energy – as discussed in Box 2.5.

Box 2.5 Practitioner's perspective – appropriate technology training

The training institutions tend to maintain uniform, standard curricula most of which are borrowed from developed economies and the academic world. Attention must be paid to the use of local materials and the ability to maintain and repair technologies. We need more innovative ways of combining academic knowledge with the actual problems requiring attention, and come up with solutions that are pertinent to the actual needs of our societies.

Albert Butare, Former Minister of State for Infrastructure of Rwanda

Earning from supplying energy

The supply of energy represents an important employment sector with growth potential in and of itself

While previous sections outlined the role productive uses of energy play in enabling poor people to earn a better living, the supply of energy also represents an important employment sector with growth potential in and of itself. Increasing the number and quality of suppliers is also an obvious prerequisite to successfully increasing access to energy supplies and services. To gain a deeper understanding of this potential it is useful to separate energy supply into three elements:

- **Fuel** – the energy source. All fossil-fuelled energy supplies and services, as well as bioenergy supplies including fuelwood, charcoal and biofuels.
- **Conversion equipment** – how the energy source is transformed into an energy supply is very important for renewables, and includes solar panels, wind turbines, hydro schemes, and charcoal kilns, but is also key for fossil-fuelled systems including generators for producing electricity for households or enterprises.
- **Appliances** – the way energy produces a service. This includes light bulbs, cookstoves, pumps, refrigerators, fans, and mobile phones.

Each element required to produce an energy service has its own supply chain, which can be extensive. Opportunities to earn a living from production through distribution, sales, and maintenance are present throughout the main chain, and relating to by-products and wastes.

The significance of bioenergy

Currently the bioenergy sector is the most important for providing energy supply earnings to poor people. In rural areas, fuelwood and charcoal in particular are important sources of earnings, often second only to agriculture (PPEO 2010). Improved efficiency technologies in production, and formalization of these sub-sectors would improve, and make more sustainable, returns for the millions of poor people working in this sector. Bioenergy has particularly long and pervasive value chains including agri-forestry, processing (e.g. carbonization), and distribution. Figure 2.2 illustrates the value chain and livelihood opportunities associated with charcoal and char briquettes, a principal form of bioenergy, in a town in Senegal. Improved cookstoves are linked to manufacturing value chains providing appliances for fuel consumption.

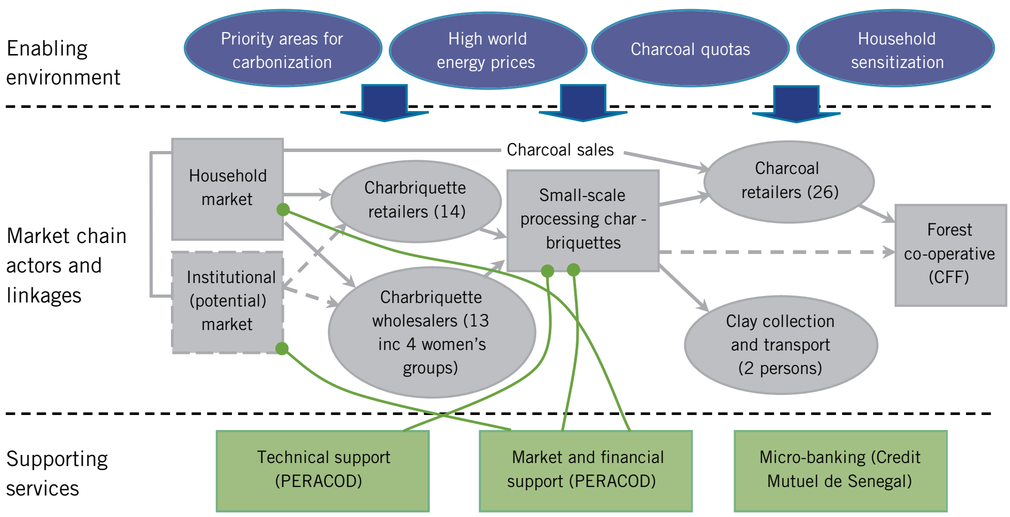


Figure 2.2 Market system for charbriquettes in St Louis, Senegal

Biofuels, another form of bioenergy, are emerging as an earning opportunity in rural areas, providing a valued product alongside existing cash crops. However it is challenging for poor farmers to understand how and whether to engage with this emerging market, which is driven by export promotion and external priorities. Furthermore, there are uncertainties associated with switching to, or integrating, biofuel crops into existing ones. But for those farmers for whom producing their normal crops is no longer competitive, biofuels can provide new earning opportunities so long as legal protections and broader appropriate governance structures are in place (FAO, 2011b).

The earning opportunities from improving energy access

Improving energy supplies will entail widespread changes in the existing energy sectors of developing countries. Table 2.3 on the following page summarizes the key earning opportunities and risks (or transitions) associated with improvements in energy access in the dimensions of the energy services and supply dimensions. The provision of new energy services creates earning opportunities with little risk for existing workers. The displacement of one supply with another however, of human power with mechanical power for example, can reduce employment. That said, such losses are normally counterbalanced through the improvement of efficiency and returns, and the reduction of drudgery and opportunity costs.

Improving energy supplies will entail widespread changes in the existing energy sectors of developing countries

The impacts of local production versus importation

Switching to locally produced energy services such as biofuels, improved stoves or mini-grids can have a positive effect on local job creation throughout the supply and maintenance chain (FAO/PISCES, 2009). However, the end cost per unit of energy produced, or appliance affordability, is critical to the viability of providing the service. For example, commercial solar lanterns are overwhelmingly produced at low cost in China, making the product more affordable in poor countries, but pre-empting jobs that could be created from local manufacturing. Overall however, providing universal energy access by 2030 will create a huge number of jobs in the decentralized energy sector. An estimated 952 TWh of electricity generation will be required annually under a universal access scenario, with 400 TWh coming from mini-grids and 172 TWh from isolated, off-grid systems (IEA, 2010). Expansion of grid power would also create jobs, although radically fewer per GWh than decentralized systems would, as illustrated in Figure 2.3 on the following page.

Demand-side earning implications of improved energy use

Improved energy access for households also generates potential impacts on paid employment now and in the future. Children who cannot study at night due to a lack of light face reduced educational attainment with implications on their future employability (PPEO, 2010). Household chores due to lack of energy access is also connected to a series of opportunity costs constraining earnings.

Inefficient cookstoves that burn traditional fuels incur significant opportunity costs, both in terms of time spent collecting firewood that could otherwise be spent in income-earning activities, and through the devastating health impacts noted in Chapter 1, that both restrict family members' ability to earn a living due to illness and early death, as well as draining family finances on costly medical treatment (WHO, 2014). A further WHO study (2006) found the shift from solid to gas and liquid fuels, and cleaner-burning stoves, delivered various economic benefits

Table 2.3 Earning opportunities from supplying energy

	Example energy transitions	Earning opportunities (in fuel, equipment, and/or appliance provision)	Earning risks/transitions
Energy services			
Lighting	Candles/kerosene to electric lighting	Marketing and sale of solar lanterns and grid-based systems Maintenance of electric lighting systems	Reduced revenues for kerosene and candle suppliers
Cooking and water heating	3-stone wood to improved cookstove and ventilation (e.g. smoke hoods)	Manufacture and sale of improved stoves and smoke hoods	Moderately reduced demand for woodfuel/charcoal suppliers
	Switch to a biofuelled cookstove or LPG cookstove	Manufacture and sale of stoves and fuel	Reduced demand for woodfuel/ charcoal (see household fuels below)
Heating	Insulation of houses	Installation of building insulation	Reduced demand for heating fuel
	Use of purpose- made or multi-purpose heating stoves	New stove production and supply chains	Reduced demand for fuel
Cooling	Installation of ceiling fans	Distribution and marketing of ceiling fans	None
	Use of refrigerators	Distribution and marketing of refrigerators	None
ICTs	Increased access to mobile phones	Earning in mobile phones sector, top-up card sales, system maintenance, charging	Reduced need for transport and postal services
	Increased access to the internet	Running internet cafes, producing local content for internet	Reduced need for postal services
Energy supplies			
Electricity	No electricity to household supply e.g. solar home system	Marketing, sales, financing and installation of SHS, maintenance	Reduced demand for kerosene for lighting and battery charging
	No electricity to mini-grid supply (e.g. hydropower or biomass fired)	Installation of system, operation and management of system, tariff collection and accounting	Reduced demand for SHS, kerosene and battery charging
	No electricity to grid-based supply	Growth in jobs for utility locally	As above
Household fuels	Switch from woodfuel/charcoal to biofuel (e.g. ethanol)	In agricultural production of biofuel Manufacture and sale of stoves Participation in new fuel supply chain	Reduced demand for woodfuel/ charcoal and for mud/clay improved stoves
	Switch from woodfuel/charcoal to LPG	Expanding LPG distribution system	As above
Mechanical power	Create availability of community mechanical services (e.g. milling with multi-functional platform)	In running the MFP/mill services In supplying fuel to MFP/mill	Reduced manual labour required in grinding flour by hand (if paid)

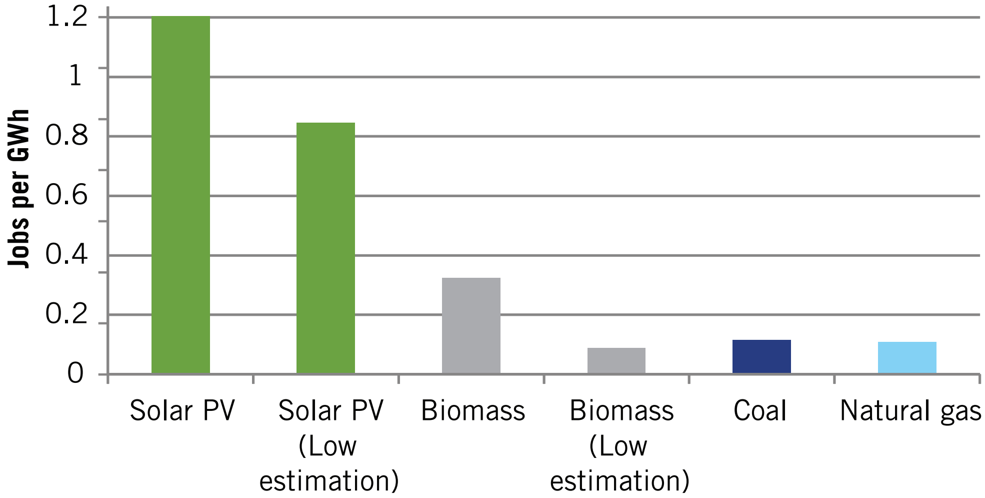


Figure 2.3 Estimated jobs created per GWh

including a reduction of health-related expenditures and productivity gains from time savings due to the shorter time required for fuel collection and cooking.

Summarizing energy for earning a living

In this chapter, energy has been shown to have important connections with earning a living for poor people through opportunities to: earn from the land, earn from running an MSE, be employed, and supply energy. In each case, energy access has a critical role to play in income generation through either improving existing activities or reducing opportunity costs.

As some MSEs are only possible with improved energy access, **new earning opportunities** emerge with access, which is therefore also correlated with enterprise growth and new job creation. Furthermore, achieving universal energy access, particularly in rural areas, will require rapid and radical expansion of markets for decentralized renewable energy, with huge new employment opportunities emerging as a result (see Figure 2.4).

Agriculture is one of the most significant contributors to the ability of poor people to earn a living and is one of the areas where energy can have the greatest impact in terms of **improving existing earnings**. Energy plays a key role along the entire agricultural production chain, improving productivity, producing better-quality products, and earning more from produce. Improved agricultural processing and storage/cooling are energy services that expand incomes for farmers while creating employment in the MSE sector. Many MSEs can lower costs, improve efficiency, broaden service offering, and improve returns via more affordable, reliable, and quality energy supplies.

A number of **opportunity costs** associated with not having access to energy greatly impact earning potential and lock people in a cycle of poverty. This includes drudgery in enterprise activities such as grinding, milling and aspects of farming. Furthermore, lack of light to work or study in the evening, affects earning and educational attainment potential. Lastly, time spent collecting firewood or cleaning pots from a smoky fire, and time spent in ill health due to indoor smoke inhalation steal countless hours from the billions of people still cooking from dirty biomass around the world.

Potentially negative impacts from increased energy access also exist in the form of labour displacement and skills lock-out for poor people, in particular via transitions towards automation and between fuel types. Additionally, the benefits of energy access in earning a living are not automatic and must be proactively overcome. Steps between improved access and greater incomes, however, have been identified. Figure 2.4 summarizes the steps along the way to realizing the potential of energy access to improve incomes and achieve development objectives, and presents tools for policymakers and practitioners to overcome the barriers to progress.

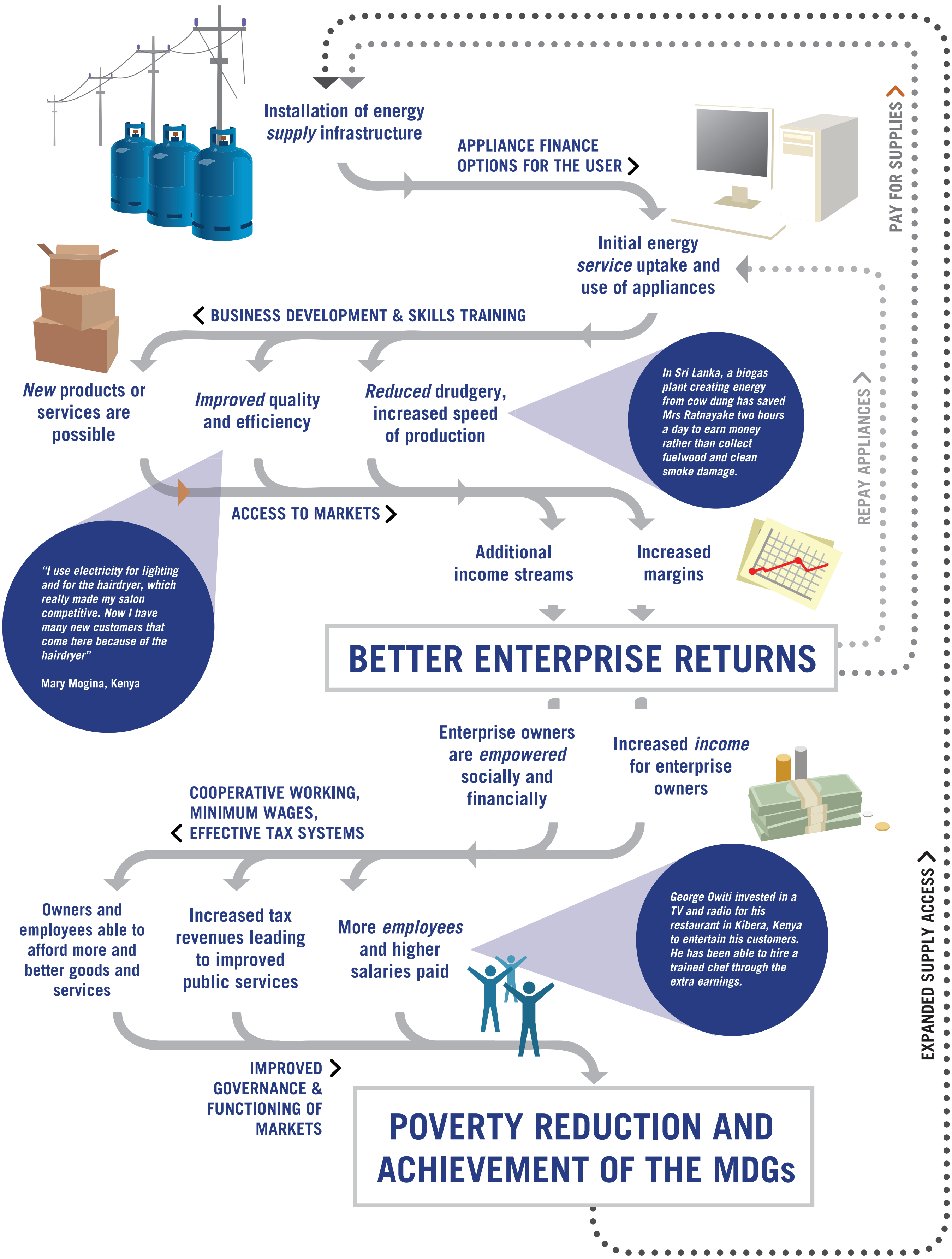


Figure 2.4 Steps from energy supply to earning a living

3. Energy for community services

Energy is crucial to community services, which are themselves fundamental to improving the lives of poor people, and achieving the Millennium Development Goals and the objectives of the nascent post-2015 development agenda. This chapter focuses on the role of, obstacles to, and opportunities for, energy provision in four key community service areas:

- **Health care**: hospitals, clinics and health posts;
- **Education**: schools, universities, and training centres;
- **Public institutions**: government offices, police stations, religious buildings, etc.;
- **Infrastructure services**: water and street lighting.

These categories provide a useful way of analysing community services, and defining and measuring access to energy.

Health care

Health-care systems are a cornerstone of development and central to improving people's lives. The health sector includes a broad range of institutions from rural health posts to specialist hospitals in large cities, administered through a variety of public, private and faith-based service providers.

A critical component of an effective health-care facility is access to energy. People have little chance of receiving adequate care where health-care facilities lack electric lighting, refrigerators or sterilization equipment. Yet an estimated one billion people in the world are served by health facilities that are completely without electricity.[4] Problems due to a lack of access to energy in health facilities include (EC, 2006):

- inability to provide clinical services after sunset;
- poor lighting conditions for performing operations;
- poor storage facilities for vaccines and medicines requiring refrigeration;
- poor facilities for sterilization of medical tools;
- inability to power laboratory equipment to diagnose patients' diseases;
- poor ability to communicate with medical specialists or to call for transport to a health facility with a higher degree of specialization;
- limitation to traditional cooking facilities, resulting in inefficiencies, poor air quality, and possible inadequate food intake by patients;
- difficulty in deploying health officers in remote rural areas; and
- difficulty attracting and retaining skilled staff to work in such conditions.

An estimated one billion people in the world are served by health facilities that are completely without electricity

While the relationship between health facilities' energy access and people's health is subject to many factors, energy is vital for improving health services. The following section provides a more detailed description of how energy is used to improve health-care provision.

Energy use in health-care facilities

Energy supports a broad range of medical services and equipment for diagnosis, treatment, and surgery, including: vaccinations, sterilized equipment, incubators for premature babies, ultrasound, X-ray machines, and ELISA equipment for HIV/AIDS diagnosis (Table 3.1). Improved equipment often requires electricity or thermal energy from solid, liquid and gas fuels.

Electric lighting can greatly benefit facilities dependent on low-quality light from paraffin lamps, candles or torches, which are more dangerous and expensive per unit of energy than electric lighting (see Chapter 2). A lack of high-quality lighting also increases the risk of critical and urgent health services such as emergency treatments and childbirth.

Modern communication can also benefit health-care services. Mobile phones and VHF radios can direct support during emergency situations and enable better treatment by connecting to specialists from referral hospitals (Musoke, 2002). Communications technologies can also ensure timely supply of materials such as essential medicines and vaccines. This is particularly important where traditional birth attendants (TBAs) or midwives are often the only link women have to health-care services during their pregnancy and childbirth. A project in Uganda used solar-powered VHF radios to link TBAs with the formal health system. The VHF radio is used to relay advice to the TBA or, if they cannot manage the case,

Table 3.1 Energy services required for general-service readiness and specific health services

Purpose/service	Energy service / equipment
General amenities / infrastructure	
Basic amenities and equipment	Lighting – clinical/theatre, ward, offices/administrative, public/security mobile phone charger, VHF radio, office appliances (computer, printer, internet router, etc.) Cooking, water heating and space heating Refrigerators, air circulation (electric fans) Sterilization equipment (dry heat sterilizer or an autoclave) Space heating
Potable water for consumption, cleaning and sanitation	Water pump (when gravity-fed water not available) and purification
Health-care waste management[1]	Waste autoclave and grinder
Service-specific medical devices	
Cold chain and Expanded Program on Immunization (EPI) refrigeration	Vaccine refrigerator
Maternity and mother/child health	Suction apparatus, incubator, other equipment
HIV diagnostic capacity	ELISA test equipment (washer, reader, incubator)
Outpatient department (OPD)	Portable X-ray, other equipment
Laboratory and diagnostic equipment	Centrifuge, haematology mixer, microscope, blood storage, blood typing equipment (37°C incubator and centrifuge), blood glucose meter, X-ray, ECG, ultrasound, CT scan, peak respiratory flow meter
Surgical equipment	Equipment and facilities for: tracheostomy; tubal ligation; vasectomy; dilatation and curettage; obstetric fistula repair; episiotomy; appendectomy; neonatal surgery; skin grafting; open treatment of fracture; amputation; cataract surgery
Additional infrastructure	
External lighting	Security lights at front gate, main doors and around buildings, outside toilet block, walkway lights
Staff housing	Lighting, TV, AM/FM stereo, other appliances (mobile phone charger, electric fan, etc), cooking and water heating
Emergency transportation	Vehicle or motorbike

1 While the current SARA facility survey tool relates only to incineration, the most recent WHO advice on health-care waste management recommends use of an electric-powered autoclave and grinder; therefore power demand for this equipment is cited here.

Source: extracted by World Bank/ESMAP from WHO's service readiness indicators (USAID/WHO, 2012) for the Defining and Measuring Energy Access project.

transport is dispatched from the health unit with a midwife to collect the patient. This led to a reduction in maternal mortality from 500 per 100,000 to 271 in just three years (Musoke, 2002).

Improved refrigeration is needed for the vaccines and immunizations that could prevent diseases that kill around 1.7 million children each year, predominantly in developing countries (GAVI, 2012). Vaccines and other medications must be refrigerated with reliable energy supplies because they lose their potency when exposed to temperatures outside their storage range. Health centres with functioning refrigeration facilities help build vaccinations and treatment of diseases such as HIV and AIDS, measles, and polio into routine service delivery. Refrigeration also enables storage of blood, medicines and testing reagents. Currently however, nearly half of all vaccines delivered to developing countries are ruined due to poor cold chain services (Vaxess, 2012).

In the absence of a grid connection, or where grid connectivity is unreliable, paraffin- and LPG-powered refrigerators can be effective, although they require more attention and maintenance than electric ones.

Sterilization of equipment is crucial in the developing world, where 50–60 million people suffer wounds each year, and one in five of these patients suffer from post-operation infection (WHO, 2012b). Boiling water is a common method used to sterilize instruments, but is not fully effective. Satisfactory sterilization can be achieved with dry heat sterilizers and autoclaves that can be solar thermal, paraffin or electric powered (USAID/WHO, 2012).

In addition to the delivery of health care, from a Total Energy Access perspective, lack of access to energy carries health impacts in other sectors as well.

Household: cooking on open fires and kerosene lighting causes indoor air pollution, which has recently been billed as the single most deadly environmental hazard by the WHO (see Chapter 2).

Earning a living: traditional labour practices can have detrimental health effects. Activities such as grinding staples, carrying wood to sell it directly or to make charcoal, and cooking as part of a small business increase exposure to smoke and add to physical strain (Chapter 3).

Community services: lack of clean water has detrimental effects on health and a lack of street lighting can lead to accidents.

Box 3.1 Powerless to deliver health care in the Bangladesh chars

North Channel health and family planning day centre is in the remote and chronically poor char lands of Bangladesh. The three full-time staff serve 50–60 patients daily, providing basic/emergency treatments and all family planning services. The facility has no electricity supply or vehicle support. With no cooling devices, staff struggle to work during hot seasons and patients become dehydrated. Without lighting, the facility does not operate in the evening.

A patient recalls her experience: 'Without any treatment my baby Nargis died, but death spared me from longer sufferings. If there were electricity, we could get health care at night as the doctor would reside in the centre premises. So many political regimes have ruled but none ensured electricity for our hospital. No one values a poor's life.'

Even during the day, the natural light indoors is not sufficient for many tasks; doctors need to use torches for IUD insertion. The IUD device, like all other equipment and apparatus, is sterilized in boiling water using a kerosene stove. Despite having some electrical medical equipment such as a suction apparatus, they cannot use it without a power source. Lack of a computer makes it difficult to share data with the district hospital.

Electrification rates in health-care facilities

Electrification rates are especially low for health facilities in South Asia and sub-Saharan Africa (Figure 3.1). In India 46% of the health facilities, serving an estimated 580 million people, are without electricity. In sub-Saharan Africa more than 30% of health facilities, serving an estimated 255 million people, are without electricity.

Rural areas are most affected (Table 3.2), where facilities do have electricity they often struggle with the high cost and limited availability of diesel for generators. In Uganda, for instance, only 1% of rural outpatient clinics are connected to the grid (Harsdorff and Bamanyaki, 2009).

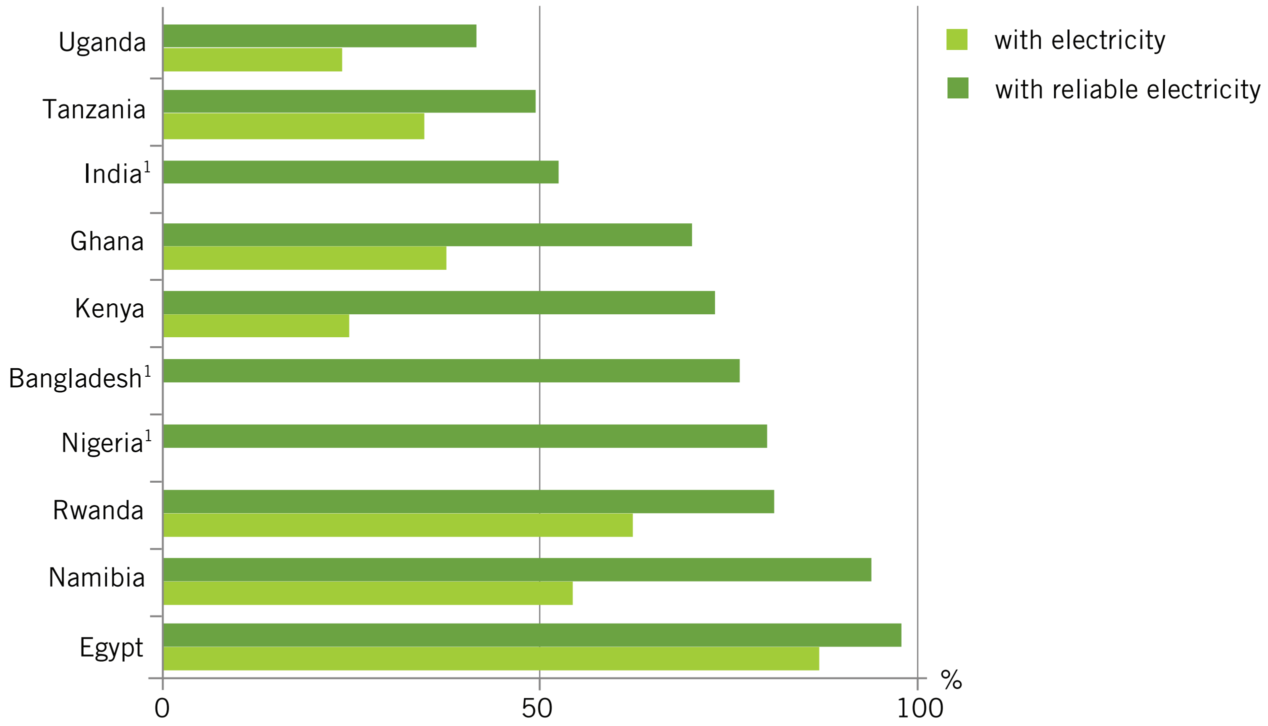


Figure 3.1 Electricity access rates in health facilities for the few developing countries with available data

Note: Definitions of 'reliable' vary, usually either an uninterrupted supply during working hours or having a backup system, or not unavailable for more than two hours at a time.
1 No data are available on the regularity of supply in Bangladesh, India and Nigeria.

Source: all data taken from the USAID Demographic Health Survey's Service Provision Assessments in each country (USAID, 2012), except for India (IIPS, 2011).

Table 3.2 Electricity indicators for health facilities in Rwanda's Service Provision Assessment survey

	Health facilities			
Electricity indicators	**Hospital (%)**	**Health centre/ polyclinic (%)**	**Dispensary/clinic/ health post (%)**	**Total (%)**
No electricity or generator	2	18	25	*18*
Generator observed with fuel	95	22	32	*29*
Regular[1] electricity or generator	95	59	67	*63*

1 'Regular' is defined as electricity routinely available during service hours, or backup generator with fuel available

Source: NIS (2008)

Even where electrification exists, it may be unreliable. In Kenya, only 25% of facilities have a reliable supply of electricity, and frequent blackouts are a major problem (NCAPD et al., 2011; World Bank, 2007). An unreliable supply directly affects services such as childbirth and emergency treatment, limits night-time services, and wastes vaccines, blood, and medicines that require constant storage temperatures.

While stand-alone electrical devices, such as solar lanterns or VHF radios, and thermal applications, including paraffin refrigerators, sterilizers, incinerators or cooking facilities, make a significant contribution to health-care service delivery, very few data exist to assess their impact. At the same time, it is clear that resourcing of the health service in terms of equipment needs to go hand in hand with improving access to electricity. In Rwanda, for example, 63% of health facilities have regular electricity, but only 17% have examination lights.

Energy supply options for health-care facilities

The full range of energy services required by health facilities cannot be met by electricity alone. Solid, liquid and/or gas fuels are a necessary complement.

The supply of energy for thermal needs – cooking, water heating, space heating and incineration – can represent a large proportion of a health facility's energy consumption and expenditure. As with households, a range of traditional biomass and modern fuels are typically used. Improved fuels and stoves reduce indoor air pollution and mitigate health problems. Energy efficient stoves and boilers can reduce the cost or collection burden of fuels.

For facilities far from the grid, a range of decentralized technologies are available, including renewable energy, diesel engine generators, or hybrid systems. Well-designed and maintained off-grid systems can provide an affordable, adequate and reliable electricity supply. Small stand-alone systems, while unable to meet all energy service needs, can provide essential energy services. Such systems include solar lanterns in clinic delivery rooms and at night, solar refrigerators for vaccine and blood storage, wind-powered water pumps, and biogas for cooking.

Table 3.3 presents options for providing electricity to a rural health clinic, based on the capital, operation, and maintenance costs of the system. The hypothetical rural clinic assumes 120 beds and equipment for general service readiness, as well as some service-specific equipment such as diagnostic devices.

The use of stand-alone electricity supply systems, especially solar PV systems with batteries, has been driven by higher fuel prices since around 2004, and the declining cost and increasing availability of solar technology. Solar PV systems with storage are now usually cheaper than diesel generators for the provision of off-grid electricity (IRENA, 2012).

Decision-makers must pay particular attention to the cost and reliability of these systems. Where there is no grid electricity, or supply is intermittent, diesel generation is often a reliable and easily available option. Whatever the context, careful consideration should be given when choosing and integrating energy technologies, specifically in regard to policy, planning, management, financing, service infrastructure, community participation, and user interface (Jimenez and Olson, 1998).

The full range of energy services required by health facilities cannot be met by electricity alone

Measuring access to energy for health

There is a glaring lack of data about energy supplies or services in health facilities. The planned expansion of the SE4ALL initiative's Global Tracking Framework should address this, although it will take time to be rolled out. It will need to build on existing national data collection initiatives such as the Service Provision Assessment (SPA) survey and the Service Ability and Readiness Assessment (SARA).

Table 3.3 Comparison of electricity supply options to provide a reliable 25 kWh/day supply

Technology	System size	Capital (US$)	Operating (US$/year)	Operation and maintenance assumptions
Solar PV system with batteries	6000 W panels 100 kWh batteries	$55,000 system $10,000 batteries	$2,550	1% system cost per year (includes maintenance and component replacement, does not include security); amortized cost of replacing the batteries every five years (20% of battery cost)
Wind turbine with batteries	8750 W turbine 100 kWh batteries	$44,000 system $10,000 batteries	$2,900	2% system cost per year; amortized cost of replacing the batteries every five years
Diesel engine generator	2.5 kW	$2,000	$6,400	$0.0075/kWh maintenance, $0.67/kWh fuel ($1/litre for fuel used), operating at 15 kWh per day at 67% capacity, and replacement of engine every ten years
Hybrid system	6000 W panels 50 kWh batteries 2.5 kW engine	$55,000 system $5,000 batteries $2,000 generator	$2,200	1% PV system cost per year; battery replacement every five years; 200 hours of engine operation per year; replacement of engine every ten years
Grid extension	n/a	$10,000+ per mile	$900	$0.10/kWh power

Source: USAID (2007)

Education

More than 50% of all children in the developing world go to primary schools without access to electricity

Quality education is crucial for increasing incomes and economic activity, and improving health and social development and well-being. An individual's expected income, and level of economic activity, is strongly related to the number of years spent in education. The UNESCO Education for All (EFA) initiative describes five enabling inputs for quality education (UNESCO, 2005):

- teaching and learning (learning time, teaching methods, assessment/ feedback/incentives, class size)
- teaching and learning materials
- physical infrastructure and facilities
- human resources: teachers, principals, inspectors, supervisors, administrators
- school governance.

Access to energy improves or facilitates each of these enabling inputs for a quality education. Yet an estimated 291 million children – more than 50% of all children in the developing world – go to primary schools without access to electricity.[5]

Energy use in schools

Electric lighting allows schools to operate outside daylight hours, extending the working hours for students, adults, and teachers. Longer classroom hours can allow additional classes to accommodate more students and reduce class sizes. Students without electric lighting at home can stay at school to study and complete homework, leading to better grades. Evening classes can also be run for other members of the community. Teachers can prepare for lessons, mark homework, conduct staff meetings and carry out administrative tasks.

Given the importance of balanced nutrition for child development and concentration, some governments and NGOs in developing countries run programmes to provide meals in schools. In the absence of modern cooking solutions, many schools that provide meals have to rely on wood burnt in open fires or rudimentary stoves for cooking and heating. Often, students and staff collect fuelwood, decreasing time available for teaching and learning. In addition to nutrition, in cold climates, concentration and comfort can be helped by space heating of classrooms. Cold, damp, and poorly ventilated rooms create an unhealthy environment and exacerbate health problems.[6] Heating is required not only in the temperate regions of the world, but also in high altitude areas (Practical Action, 2010).

Extremely warm conditions can also exacerbate illnesses such as dehydration, fatigue, and heat stroke. Space cooling can be important to keep rooms and offices at a comfortable temperature for staff and students – low-power electric fans can make a significant difference.

Energy access is not only critical at primary school levels. It is widely accepted that secondary schools, higher education institutes, and vocational centres need electricity to provide relevant education services. Experience and confidence with computers is increasingly important in jobs markets; computer classes not only interest school students but also attract adults looking to gain extra skills. Internet access is essential for institutes of higher education to conduct research and communicate with international colleagues. Vocational training centres teaching carpentry, welding and manufacturing require a good-quality energy supply and high-power machinery.

As with the link between energy access and health-care performance, the relationship between energy access and education is relevant beyond the scope of educational institutions. For example, at household level, access to improved cooking solutions such as gas or kerosene prevents children, especially girls, from spending hours collecting firewood. Lighting at home can also give children the opportunity to study and do homework.

Electrification rates in schools

Given the fundamental nature of electrification for educational purposes, sub-Saharan Africa has the lowest rate of primary school access to electricity at 35%, compared to 48% in South Asia, and 93% in Latin America (Figure 3.2). This represents 90 million, 94 million and 4 million pupils who attend school without electricity in the respective regions.[7]

As with the health sector, rural areas are disproportionally affected. In Peru, for example, fewer than half of village schools have electricity, whereas nearly all urban schools have electricity. Where electricity availability for schools is low, computers are often scarce as well. Only 48% of Indian schools have electricity and only 13% have a computer for administrative purposes. In Paraguay, 97% of schools have electricity, but only 7% have computers for student use (World Bank, 2010).

Energy supply options for schools

The electricity supply options for a school are comparable to those of a health centre. The system size and cost depend upon the size of the school and the specific energy needs.

As with health-care supply options, stand-alone systems can provide essential energy services for rural schools. Their use, particularly solar PV systems, is growing due to falling costs and better availability of products and services. Micro systems have become widely available and can benefit teachers with night lighting from solar lanterns or with mobile phone charging.

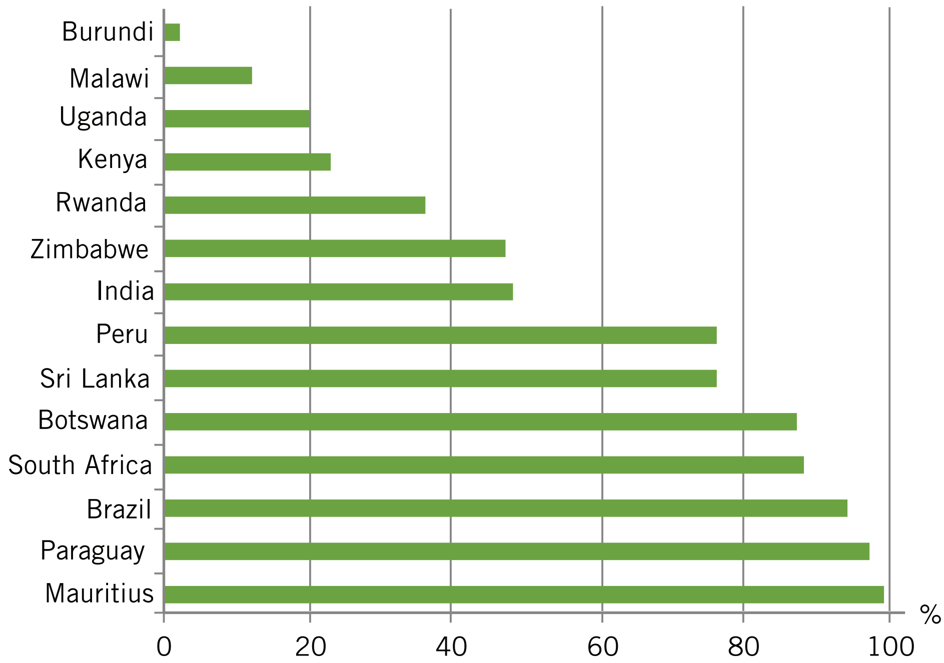


Figure 3.2 Percentage of primary schools with access to electricity in selected countries

Source: UNESCO, 2007, 2008, 2011

The supply of energy for thermal needs – cooking, water heating and space heating – can represent a large portion of a school's energy consumption and expenditure. As with households and health facilities, a range of traditional biomass and modern fuels is typical. Improved fuels and stoves reduce health problems by reducing indoor air pollution, while energy efficient stoves and boilers can help manage the cost or collection burden of fuel consumption.

Public institutions

A variety of public, private, non-governmental, and faith-based institutions contribute to the functioning and well-being of communities. They provide a broad range of functions: organization and administration of government services and operations; promotion of security and safety for individuals and property; promotion of social, cultural and spiritual health; and social care. Local public institutions may include:

Services of all public institutions can be improved and expanded through access to energy

- government administrative offices
- police stations
- religious buildings
- prisons
- community centres
- public libraries
- orphanages and
- sports facilities.

Services of all public institutions can be improved and expanded through access to energy. Electricity is needed for lighting, cooling and ICTs. Lighting and entertainment equipment can lengthen social events and make them more vibrant.

Microphones and loudspeakers are used for political announcements, social gatherings and prayer sessions. Clean cooking water and heating are needed in public institutions as well.

Local government offices and police stations are often responsible for keeping public records and coordinating development work – tasks made more efficient with computers, photocopiers, and printers. Increased information and communication also facilitate governance, human resource management, skills training, and infrastructure.

The development impacts of community institutions can be hard to define and attribute, and even harder to quantify. Often these benefits are more important to local people than development activities (Bigg and Satterthwaite, 2005). In Liberia, for instance, solar PV systems were installed in police offices in areas that lacked grid connections, leading to increased security and police presence, and improving the image and trust of the national police among rural populations (GIZ, 2012).

Energy supply options for public institutions

As with health centres and schools, electrical and thermal energy supplies are important for public institutions, and both centralized and decentralized technologies have an important role to play. For rural areas, off-grid electrical systems are often the most appropriate option.

Infrastructure services

Infrastructure services are a foundation of economic and social life. A safe and healthy community typically enjoys clean water, sanitation facilities, proper drainage, roads, waste disposal, public transport, communications services, and street lighting. Access to energy is a key enabler of infrastructure services, particularly water pumping and street lighting.

Access to energy is a key enabler of infrastructure services, particularly water pumping and street lighting

Street lighting

Street lighting promotes safety and security, encourages attendance at school, enables economic activity, and brightens social occasions. Many people, particularly women, avoid going outside at night for fear of being robbed or attacked, and from the threat of dangerous animals (DFID, 2011). Lighting can enable markets and food stalls to function more effectively after dark and boost evening activity. Street lights make it easier for health workers and police to respond to emergencies. Midwives, who often need to visit villages at short notice, are better able to reach the birthing mother more quickly and safely when adequate lighting is available.

It is not known how many communities are without street lighting. However, the majority of the 1.3 billion people without electricity in their homes are unlikely to have electricity in the streets outside. Street lighting is of course greater in urban areas than rural, although many cities and towns also have little and unreliable street lighting, particularly in low-income or informal settlements.

The roads in many developing countries are notoriously dangerous for drivers, passengers and pedestrians alike. Poor road conditions and poor enforcement of speed limits and other important regulations make road use risky. Unreliable power supplies often cut street lights and play havoc with road junctions controlled by traffic lights.

By 2020, an estimated 2.3 million people will die each year in road traffic accidents, 90% of them in low- and middle-income countries. The risk of accidents is higher in the dark than in daylight, and street lighting is a relatively low-cost intervention that can prevent accidents and save lives (Beyer and Ker, 2009).

In areas where grid electricity is not available, solar PV has proven to be an alternative solution for stand-alone street lights (DFID, 2011). Although such systems often encounter issues around management, battery maintenance, and even theft, community approaches, including local ownership and maintenance, appear to be effective solutions in some places (Frame et al., 2011).

Water pumping

More than 780 million people lack access to improved sources of drinking water, and 2.5 billion people lack improved sanitation facilities (UNICEF/WHO, 2012). This contributes to over 3.4 million deaths each year, nearly all (99%) in the developing world (WHO, 2008).

Sub-Saharan Africa remains the worst affected region, with 40% of people using unimproved water sources, compared with 13% in South Asia, and 7% in Latin America and the Caribbean. Urban areas are generally better served worldwide; 84% of people without an improved water source live in rural areas. In cities however, rapidly growing populations are outpacing the rate at which people gain access to improved supplies (WHO/UNICEF, 2010). In schools, lack of access to water and sanitation facilities has a large impact on girls' attendance. About one in ten school-age African girls do not attend school during menstruation or drop out at puberty because of the lack of clean and private sanitation facilities in schools (UNICEF, 2005).

Water access is largely determined by geography. In areas where the only clean water is distant or underground, pumps and associated energy supplies are required, as well as pipes and taps. In many areas, water is not suitable for drinking and must be purified, commonly using electric-powered devices.

At least two billion people use powered pumps to draw their water from boreholes and dug wells

At least two billion people who currently get their water from boreholes and dug wells rely on pumps and energy to run them (UNICEF/WHO, 2012). A range of pumping technologies exist, powered by human effort, renewable energy resources, diesel or electricity. The amount of energy required depends on the volume of water to be pumped, the height through which it will be delivered, and the efficiency of the pump. The pump may represent only a small proportion of total installation costs, but ongoing costs for maintenance and fuel or electricity can be significant, especially with high local fuel costs.

Attracting and retaining professionals – the role of energy

Capable and motivated staff are at the heart of effective services. Health centres, schools, and public institutions in rural areas typically suffer from a dearth of qualified and experienced personnel. In Zambia, for example, there are seven times as many doctors, and two-and-a-half times as many nurses per capita in urban compared with rural areas (World Bank, 2010).

This discrepancy is due to both the greater density of health facilities in urban areas, and the extra financial and non-financial incentives needed to attract staff to rural areas, where standards of living are lower and infrastructure is often lacking.

The reasons that rural areas struggle to retain sufficient numbers of qualified staff are not well documented. Standard of living is a major consideration in any individual's choice of where to live and work. Frustration among rural workers often stems from the lack of support staff and supplies, and low-quality infrastructure and social services (Rao et al., 2010). Professionals are often unwilling to live and work in areas without decent housing, communications, and modern energy services.[8] Rural economies are also weak and dispersed, making private practice more attractive in urban markets with higher concentrations of potential clients.

Poor access to energy in the workplace is also a major concern for professionals whose tasks are constrained by a lack of proper equipment. Staff in facilities constrained by, among other things, poor energy access, can often be demotivated and have higher levels of absenteeism (Ghuman and Lloyd, 2007).

Access to modern energy services does not automatically attract and retain qualified staff in rural areas, but it does enable amenities that people rightly expect: lighting, safe water and sanitation, clean and fast cooking, reliable communications, and entertainment.

Professionals are often unwilling to live and work in areas without decent housing, communications, and modern energy services

Summarizing energy for community services

Energy services for community institutions have been neglected in discussions about energy access. The limited data available indicate poor energy access for community services in many countries, with little evidence of progress, particularly in isolated areas.

People want and need improved energy services in their homes and places of work. Governments, donors and utilities focus mostly on domestic use and access for enterprise as it supports people's well-being and incomes. Yet some of the most important aspects of people's daily well-being also depend on the reliable delivery of modern energy to schools, clinics, institutions, and community infrastructure.

Increasing the technical capacity of governments in policy and planning, as well as at the community level, is needed to design, deliver and maintain energy services, while making good use of modern technologies (UNDP, 2011). The incentives and enabling conditions must also be right for governments, which play a critical role in planning and financing energy investments.

Three community service-related priorities must be addressed to meet the targets for universal energy access by 2030:

- **Increased awareness** among governments, international organizations, and local institutions of the need to improve energy for community services, and the technical options available, including the costs and benefits offered by energy efficiency, supply technologies, and end-use energy appliances.
- **National-level targets and monitoring**, possibly linked to a regional or international framework that sets ambitious goals and tracks energy services for community use. Data are very sparse, so more systematic and better-resourced monitoring is needed to improve the knowledge base.
- **Better targeted public investment** to deliver energy access for community services in remote and impoverished regions. Effective public–private partnerships are needed with the involvement of NGOs, government, and the private sector.

4. Defining and measuring energy access

Measuring energy access in a more accurate and appropriate way, informed by what really matters to poor people, throws new light on the problem of energy access. It also points us to better solutions. The PPEO series has therefore consistently argued for having the right definitions and ways of measuring energy access as key tools for setting targets and guiding policies and investments.

The current quantity and quality of data on energy access at national levels are very poor. There are no accurate figures, for example, of the capacity and output of decentralized electricity systems (off-grid and mini-grid) compared to the grid. Access is traditionally measured in terms of household connections to grid electricity (often even the *potential* for a household connection counts as 'having access' in some countries: Ethiopia, Ghana and Uganda for instance), and the use of a modern fuel for cooking. This fails to recognize the use of energy for productive ends or community services, neglects the role of mechanical power and intermediate technologies, and does not consider how people use and ultimately benefit from energy.

The result is that there is currently no clear overview of the status of energy access at national levels. Existing figures fail to give an accurate picture of the extent to which people are or are not able to access the energy services that matter to them. Current definitions do this by:

There is currently no clear overview of the status of energy access at national levels

- **Over-counting**: Counting those with a grid connection to electricity as having energy irrespective of affordability or reliability of the supply. In many developing countries, load-shedding and break-downs mean electricity is often unavailable at certain times of day and that unplanned outages regularly occur. This means although someone has a connection, they may not have access to minimum levels of evening lighting, cooling, space heating, or energy for productive uses.
- **Under-counting**: Using grid connectedness fails to count people who have a reasonable level of energy services (lighting, ICTs, a fan for cooling) supplied from sources beyond the grid. It also fails to count those with good-quality biomass cookstoves.

A second problem with the binary system of measuring access is its insufficient ability to analyse inequalities (between those with the best access and those with the worst), or the setting of specific national or sub-national targets to try to address those inequalities. It also does not recognize progress that might have been made through improving access to decentralized electricity, or improved biomass cookstoves.

In an effort to address these weaknesses, Practical Action developed and tested a set of criteria that provide a more accurate picture of access to energy supplies and services. The PPEO 2010 and 2012 proposed and refined an **Energy Supply Index** and a set of **Minimum Standards for Household Energy Services** (see Tables 4.1, 4.2 and Chapter 1 of this document), which illustrate a flow of impacts from the right kind of *energy supply*, leading to a minimum level of *energy services*, to enable the realization of *development goals*.

In addition, the **enterprise energy access matrix** (see Table 2.2 in Chapter 2 of this document) looks at attributes of energy supply that are particularly important for enterprises: reliability, quality, affordability and adequacy across the energy supply types of electricity, fuels and mechanical power. It also highlights the energy services that are particularly important through the proxy of various basic appliances.

The PPEO 2012 applied these measures to six communities in Kenya, Nepal and Peru (see Figure 4.1). In each country, one community was mostly grid-connected, and the other was beyond the grid. The two communities in Kenya were urban slums, whilst the others were rural villages. The results highlighted how, despite grid connections, there were significant gaps in people's levels of energy access. In all the rural examples, the lack of access to mechanical power was particularly striking. In line with the global norm, lower proportions of households had access to a minimum acceptable level of cooking fuels and stoves than had access to electricity. It was further found that those with a grid connection were not able to use it regularly because they could not afford the connection fee or bills, or because of grid supply unreliability.

In addition to our work developing the Energy Supply Index and Minimum Standards for Household Energy Access, Practical Action is part of the steering committee drafting the Sustainable Energy for All's (SE4ALL) Global Tracking

Table 4.1 Energy Supply Index 2012

Energy supply	Level	Quality of supply
Household fuels	0	Using non-standard solid fuels such as plastics
	1	Using solid fuel in an open/three-stone fire
	2	Using solid fuel in an improved stove
	3	Using solid fuel in an improved stove with smoke extraction/ chimney
	4	Mainly using a liquid or gas fuel or electricity, and associated stove
	5	Using only a liquid or gas fuel or electricity, and associated stove
Electricity	0	No access to electricity at all
	1	Access to third party battery charging only
	2	Access to stand-alone electrical appliance (e.g. solar lantern, solar phone charger)
	3	Own limited power access for multiple home applications (e.g. solar home systems or power-limited off-grid)
	4	Poor-quality and/or intermittent AC connection
	5	Reliable AC connection available for all uses
Mechanical power	0	No household access to tools or mechanical advantages
	1	Hand tools available for household tasks
	2	Mechanical advantage devices available to magnify human/ animal effort for most household tasks
	3	Powered mechanical devices available for some household tasks
	4	Powered mechanical devices available for most household tasks
	5	Mainly purchasing mechanically processed goods and services.

Table 4.2 Minimum standards for household energy access

Energy service		Minimum standard
Lighting	1.1	300 lm for a minimum of 4 hours per night at household level
Cooking and water heating	2.1	1 kg woodfuel or 0.3 kg charcoal or 0.04 kg LPG or 0.2 litres of kerosene biofuel per person per day, taking less than 30 minutes per household per day to obtain
	2.2	Minimum efficiency of improved solid fuel stoves to be 40% greater than a three-stone fire in terms of fuel use
	2.3	Annual mean concentrations of particulate matter ($PM_{2.5}$) < 10 μg/m^3 in households, with interim goals of 15 μg/m^3, 25 μg/m^3 and 35 μg/m^3
Space heating	3.1	Minimum daytime indoor air temperature of 18^{0}C
Cooling	4.1	Households can extend life of perishable products by a minimum of 50% over that allowed by ambient storage
	4.2	Maximum apparent indoor air temperature of 30^{0}C
Information and communications	5.1	People can communicate electronic information from their household
	5.2	People can access electronic media relevant to their lives and livelihoods in their household

Framework (GTF) (Banerjee et al., 2013), which incorporates many principles advocated by the PPEO series:

- It measures both energy supplies and services;
- It covers (or is planned to cover) all spheres of a Total Energy Access approach: household, earning a living, and community services;
- It is a multi-tier framework, moving away from binary measures of access; and
- It recognizes and validates the importance of intermediate technologies, off-grid and decentralized supplies, in providing adequate energy services.

As Figure 4.2 illustrates, the GTF identifies energy supplies relevant to households, productive uses, and community services, with mechanical power included under productive uses. These supplies are graded across a multi-tier framework as does our energy supply index, but the GTF applies a wider range of attributes (quantity, duration, evening supply, affordability, legality and quality). Important attributes specific to energy supply for productive uses and community services will be included in the framework. This will allow an assessment of levels of access to decentralized compared to grid-supplied electricity at national levels. In a second stage, the framework then looks at energy services. For household electricity this means the use of particular appliances such as a radio or mobile phone charging at lower tiers, up to a refrigerator and electric space heating and cooling at the highest tiers. For cooking, the features considered in terms of the energy service are around convenience (time spent on collecting and preparing fuel), conformity to ensure indoor air pollution is reduced, and adequacy to meet all local cooking needs.

While the GTF multi-tier framework is extremely useful at national levels and in highlighting inequalities, there is still an urgent need for a global cut-off point to be defined, below which people cannot be considered as 'having access' to energy. How else will we judge whether we have achieved the goal of universal energy access proposed by SE4ALL? Thus Practical Action proposes, based on a comparison of Minimum Standards and the Energy Supply Index with the framework, that Tier 3 represents a level of energy access which begins to be truly enabling and at which people should be counted as having adequate 'energy access'.

There is still an urgent need for a global cut-off point to be defined, below which people cannot be considered as 'having access' to energy

The new demands on data collection which this framework presents are challenging. For example in terms of household cooking solutions, there is a wide range of stoves whose performance can be highly context-specific. The SE4ALL tracking framework proposes a network of designated certification agencies and testing laboratories for country-level certification and labelling. Data collection is being supported for SE4ALL opt-in countries, but may need to be rolled out globally if this framework is adopted for post-2015 goals on energy access.

Collecting meaningful data is a fundamental stepping stone in the SE4ALL ambition to deliver universal energy access by 2030. Having the right definition and measures will be critical to ensuring an energy access target in the post-2015 development framework is set at a level which will drive positive change. The value for poor people will come not in the application of the Global Tracking Framework itself, but the use of its findings as a tool to highlight gaps, inequalities, and to guide investment and policy focus to the places they are needed most.

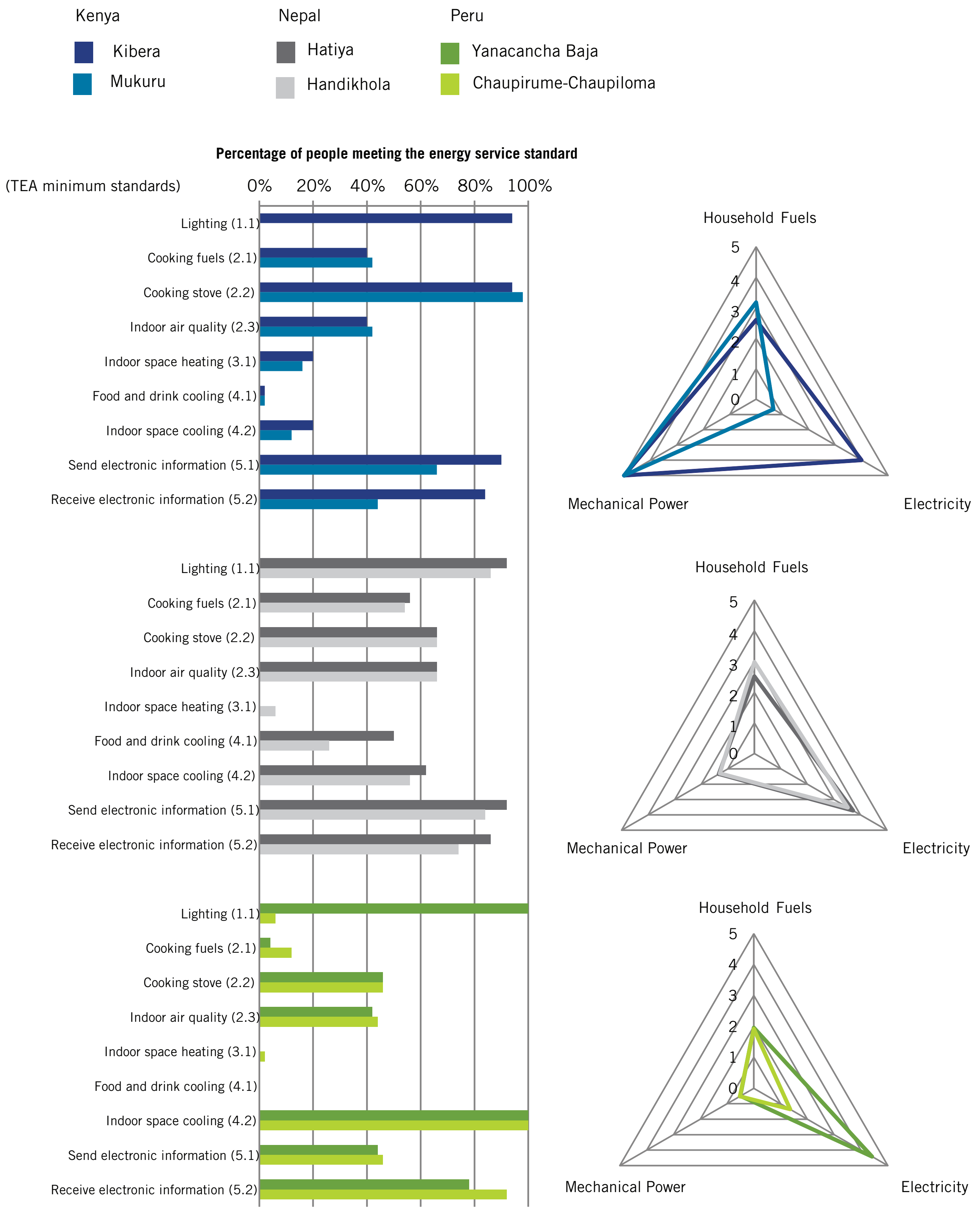


Figure 4.1 TEA and ESI scores in the six communities of Kenya, Nepal, and Peru

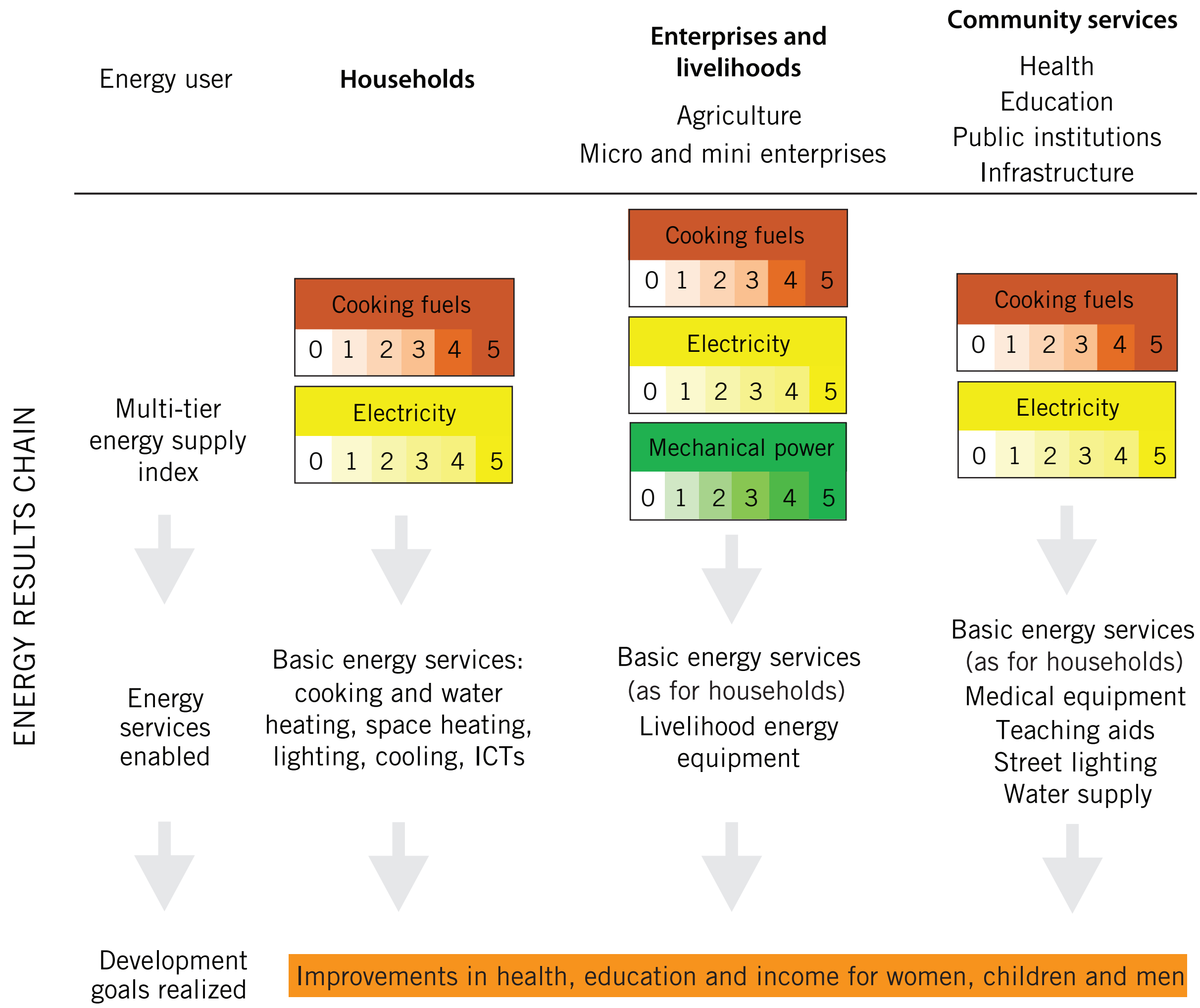


Figure 4.2 Framework for defining and measuring access to energy

Source: Practical Action in coordination with the World Bank / ESMAP for the ongoing work on Defining and Measuring Access to Energy for Socio-Economic Development

5. The Energy Access Ecosystem Index

The International Energy Agency (IEA) has indicated that 'business as usual' will not deliver universal energy access by 2030 (IEA, 2011). However, the situation is actually more critical than the IEA analysis suggests, as their analysis only considered household energy, and not the full range of energy services needed for earning a living or for community services. Indeed, to achieve Total Energy Access, an even more significant and urgent shift of priorities, and changes across the energy sector, are required.

Improving access to energy in developing countries is about more than simply supplying new or different products and services. It requires analysing each national context and engaging with all actors: energy users, policymakers, businesses, investors, international organizations and civil society organizations. The PPEO 2012 introduced the concept of an Energy Access Ecosystem as a way of understanding the wider national context that can support or hinder energy access. Its aim is to analyse and measure policy, finance and capacity dimensions of the energy sector at the national level to gauge the extent to which they are supporting a broad-based and rapid increase in energy access. This analysis can help identify pathways for action (see Box 5.1).

The concept has its roots in the idea of a business ecosystem, adapted from management theory. The analogy with natural ecosystems highlights the role of co-evolution, collaboration and competition in driving the production of goods and services. It highlights the importance of governance systems, the flow of money, and the availability of skills for creating and maintaining the system. On the ground, energy markets serving poor communities are often 'thin', with few players, little competition, little innovation and little activity. A lack of effective demand from consumers drives a vicious cycle, reinforcing 'weak' ecosystems. If energy access is to be accelerated, we must create vibrant, inclusive and sustainable market systems in which more and stronger organizations are delivering a range of energy supplies and services to more and poorer people.

If energy access is to be accelerated, we must create vibrant, inclusive and sustainable market systems

The Energy Access Ecosystem Index (Table 5.1) comprises nine indicators: three each from policy, finance and capacity. Each indicator is scored 0–3 against a set of qualitative benchmarks. In PPEO 2012 we applied the index to Kenya, Nepal and Peru. The PPEO 2013 (using the revised set of indicators presented here) looked at Bangladesh, Rwanda and Bolivia.

The value of the index is in enabling different stakeholders to see where important changes are needed, and in holding governments to account. The index can usefully be implemented as part of an annual review process at national levels, and is best carried out through a multi-stakeholder consultation as the starting point for dialogue amongst, and participation from, a wide range of actors.

Box 5.1 Defining the Energy Access Ecosystem

A healthy energy access ecosystem is one in which expanding access to more and poorer people is a priority outcome valued within the system.

The Energy Access Ecosystem model recognizes that there are multiple inter-related sub-systems (e.g. for solar PV, small-hydro, or biogas) in any given energy sector, which collectively deliver energy supplies and appliances using a mix of energy sources and a range of technologies. Policy, capacity and finance are critical dimensions driving change and setting incentives across these sub-systems.

The Energy Access Ecosystem Index assesses *potential*: the national capability for making progress towards universal energy access. It does not reflect the current energy access status of a country, but highlights barriers and opportunities on the pathway to change. Two countries with similar energy access levels, therefore, might have very different ecosystem scores.

Table 5.1 The Energy Access Ecosystem Index

Policy
1 Energy access prioritized in national policy National policy should include clear targets for achieving energy access in terms of electricity and modern cooking fuels/devices, and have clear targets for households, schools, hospitals and enterprises.
0 Little reference to EA in the PRSP or other flagship national policy 1 National policy has references to EA but no clear targets 2 National policy has specific energy targets including electricity, household cooking, health centres/school and enterprises 3 As above, with good evidence of secondary legislation to deliver targets
2 Effective rural energy agency or equivalent An effective rural energy agency or equivalent can help to plan and deliver decentralized energy services.
0 Lack of clarity on which institution (or no institution) is leading on EA to rural areas 1 Rural energy agency or equivalent has been mandated, but is under-resourced or shows limited progress on improved access 2 Rural energy agency or equivalent has been mandated, has appropriate resources and shows progress on improved access. 3 As above and on track towards national EA targets
3 Transparent and accountable multi-stakeholder processes utilized in current energy policy formulation Transparent and accountable multi-stakeholder processes are more effective, engaging investors, project developers, donors, consumers and NGOs.
0 No formal procedure for transparent and accountable processes 1 Formal procedures for transparent and accountable processes in place, but not used by all stakeholders 2 Transparent and accountable processes used by all stakeholders, with transparent information systems and accountable relationships, with internal recognition 3 Widespread external recognition of transparent and accountable processes used by all stakeholders, with transparent information systems and accountable relationships.
Finance
4 National government budget and targeting of EA Governments play a major role in planning and delivering energy access, not only through enabling policies, but also by allocating and disbursing necessary funds for improving energy access.
0 No specific EA budget 1 Sector investment plan exists but the necessary funds are not being disbursed 2 Sector investment plan exists and necessary funds for EA are being disbursed 3 Sector investment plan xists with evidence of good progress on EA
5 Private sector investment in EA infrastructure Growing private sector investment in energy access infrastructure is a sign of a healthy and improving energy sector; although it is problematic to calculate, it is possible to track trends.
0 Private sector investment in EA infrastructure is static 1 Private sector investment in EA infrastructure is increasing but not sufficient to deliver access targets 2 Private sector investment in EA infrastructure is increasing at a rate that will help deliver access targets 3 Private sector investment in EA infrastructure is delivering access targets
6 MFIs engaged in EA markets A vibrant range of competing microfinance institutions (MFIs) can be an enabler for microentrepreneurs, communities, and households to invest in energy access technologies.
0 Minimal proportion of active MFIs engaging in EA markets 1 Small and static proportion of active MFIs engaging in EA markets 2 A growing proportion of active MFIs engaging in EA markets 3 A high proportion of active MFIs engaging in EA markets

Capacity
7 Number and growth in ecosystem members A measurable indication of a healthy ecosystem is the growing number of its members, reflecting a more diversified sector that can respond to consumer demand. 0 A limited and static number of ecosystem members (firms, NGOs, etc.) from a limited range of sectors 1 A wide but static number of ecosystem members from a range of sectors 2 A growing number of ecosystem members from different sectors 3 A wide number of ecosystem members from different sectors are well established
8 Availability of decentralized EA products/models: improved cookstoves, electrical charging and lighting products, other products Wide availability of energy access products is a good indicator of market development, including users' demand for energy access equipment. 0 EA products not easily available for households and enterprises 1 EA products available in capital city, but limited range of products/brands for a limited number of applications 2 A wide range of EA products and brands available in the capital city 3 A wide range of EA products and brands available in most markets in the country
9 Availability of data on energy access and energy resources within the country for **a) households (electricity and cooking)** **b) enterprises (electricity, cooking and mechanical power)** **c) schools, health centres, etc.** Reliable data-gathering systems are essential in order to design and monitor energy access programmes. 0 Data on energy access are not available for all EA levels and not regularly updated 1 Data on energy access are available, but not consistently, for energy resources for households, enterprises and community services, and are not regularly updated 2 Data on energy access and energy resources for households, enterprises and community services available from different sources (internet, national surveys, reports, etc.) but not systematized or regularly updated 3 Systematized procedures for continuous EA data collection and data-sharing platforms are in place

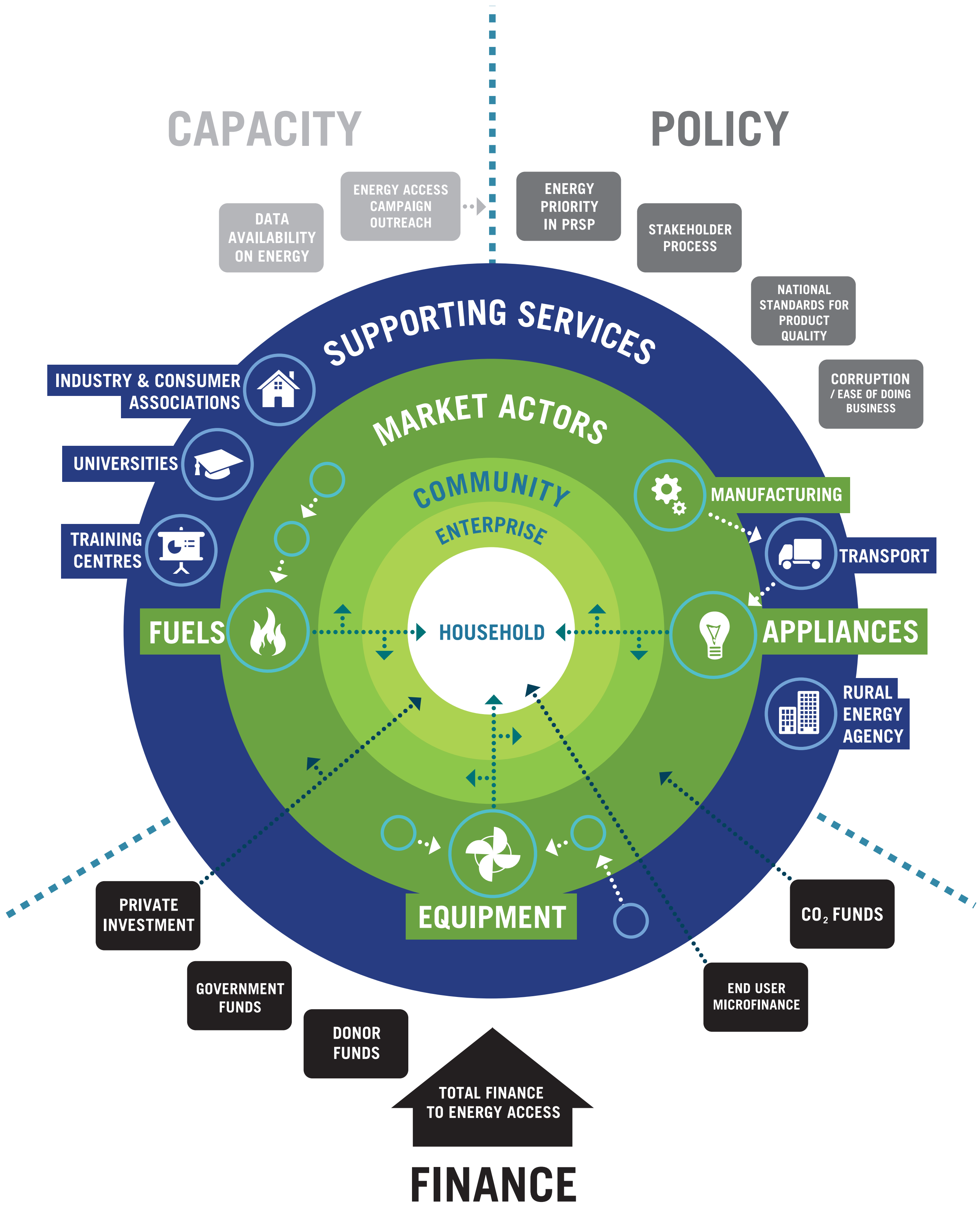


Figure 5.1 The Energy Access Ecosystem

6. A framework for action

Energy is rightfully regarded as a pillar of development. Its transformative role is critical to all other aspects of human, social and economic progress. This edition of the PPEO has recapped the key messages and tools presented over the course of the series in an effort to restate the importance of ramping up national action that aspires to bring Total Energy Access to the billions of people who still lack access to modern energy.

If large-scale infrastructure investments continue to dominate, universal energy access will not be achieved

Achieving universal energy access by 2030 is central to the SE4ALL initiative and is likely to be a key pillar of the post-2015 development agenda. However, to date donors, multilateral institutions, and developing-country governments continue to focus most of their attention not on what is needed to achieve this aim, but on what has always been done, which has not worked for the poor. If large-scale infrastructure investments continue to dominate the access discourse, boosting power supplies to cities and industry, then universal energy access will remain as distant a prospect as it was decades ago. Today more than ever, it is neither feasible, affordable nor desirable to connect many rural populations to centralized grids that are slow to deploy, prohibitively expensive, often unreliable, provide minimal long-term employment, and are mostly dependent on fossil fuels.

To achieve universal energy access by 2030, a new energy narrative is needed. One which recognizes: the reality of energy poverty on the ground; the full range of services that poor people want, need, and have a right to; and that encourages the development of healthier energy ecosystems that value all technologies, finance and actors required to bring energy to all people. In line with this, and based on decades of experience working on energy access across Latin America, South Asia and sub-Saharan Africa, the report concludes by offering a framework for action. This should act as a means to ensure the success of the SE4ALL initiative, the post-2015 development agenda, and other global efforts to eradicate global energy poverty.

Promote a service-based rather than supply-based approach to energy definition and delivery

An approach using a definition of energy access based on household grid connections will not end energy poverty. Rather, a definition is required that encapsulates the full range of people's energy needs at the household, enterprise and community services levels. We welcome the standardized multi-tier approach of the SE4ALL Global Tracking Framework, and strongly urge that its third tier be used as a baseline for an adequate initial level of access in households.

Furthermore, we urge that the Global Tracking Framework be used as a guide for public and private investors who finance energy access to ensure investments foster increased energy access within and beyond the household context. Finally, **we call on donors, international institutions and national governments to adopt the multi-tier framework of the SE4ALL Global Tracking Framework and use it to guide the delivery, monitoring and evaluation of energy interventions**.

Increase financing for decentralized solutions

To achieve universal energy access by 2030, the International Energy Agency (2011) indicates that 55% of additional electricity generated will need to be in mini- and off-grid solutions. Furthermore, the World Health Organization (2014) has recently announced that indoor air pollution causes millions more deaths per annum than previously estimated and calls for rapid deployment of clean cooking options for the 2.8 billion people who still lack them. Combined, these are unequivocal messages to governments and the international community that they must urgently increase investments in decentralized energy and clean cooking solutions. Thus **we call on countries producing investment prospectuses as part of the SE4ALL initiative to focus heavily on planning for and encouraging investments in decentralized Total Energy Access**.

Governments and the international community must urgently increase investments in decentralized energy and clean cooking solutions

There are very few examples of the private sector funding energy access to poor people. Banks see the various decentralized energy sectors as being in their infancy and because of the atypical customer base, financiers have to date been largely unwilling to provide capital for energy poverty interventions. This state of affairs, combined with the fact that it may never be commercially viable to bring energy to some poor, remote populations, means there is a clear and immediate need for increased public support for the decentralized energy sector. **We call for the urgent creation, expansion and support of new and existing finance windows for mini-grids, off-grid systems, improved cookstoves, and fuel supply chains**.

Encourage an ecosystems understanding of the energy landscape

For the 82 countries that have opted in to the SE4ALL initiative as of April 2014 to successfully deliver on their national plans and develop their investment prospectuses, a multi-stakeholder approach to the strategic identification and assessment of deficits in policy, finance and capacity is required. **We call on governments developing such plans to ensure that they can deliver Total Energy Access by using the Energy Access Ecosystem Index, or a similar tool, to enable better measurement and integration of the full range of people, organizations, policies, technologies and types of financing necessary to achieve meaningful universal access**.

Creating space and support for civil society

Whilst civil society has been officially recognized as the third pillar of the SE4ALL initiative alongside business and government, to date integration of civil society has been meagre at best. Civil society provides an accountability mechanism and a link to the voices and needs of poor people; delivers capacity building and awareness raising; and contributes evidence of innovative approaches, models and technologies that work in terms of impact, cost and performance.

Without the key activities of civil society, meaningful universal energy access will remain a distant dream. **We therefore call on the SE4ALL initiative and other energy access endeavours to develop clear and considered**

programmes of engagement with civil society at national and international levels. This needs to be supported by financing to operationalize these plans in both the short and long term.

Fostering the right capacities

Terms such as *global energy revolution*, *global energy transformation*, and *leapfrogging* have all been used to describe what is needed to sustainably provide modern energy services to the billions of people who live without them today. However, while the technologies have become more readily available, the capacities of national governments, universities and other training facilities, local businesses, civil society organizations, and most importantly, of the energy poor themselves to understand what this will mean for, and require of them, is almost entirely lacking. **We therefore call for: the design of, and support for national energy literacy campaigns; vocational training for the millions of technicians and others required to deploy, maintain and repair the energy technologies; and capacity building for governments and national energy authorities on the need for, and methods of, providing Total Energy Access.**

It is not 'any' action that is required, but rather the very specific and holistic types of actions outlined in this report

A final call for action

There is exceptional global momentum to end energy poverty and provide sustainable energy for all by 2030. To realize this ambition however, the international community must recognize that it is not 'any' action that is required, but rather the very specific and holistic types of actions outlined in this report and summarized in this framework for action. **Therefore this edition of the PPEO closes by asking you, the reader, to join Practical Action's call to refocus the energy access discourse and practice in order to provide sustainable and affordable decentralized energy services to poor people.**

Notes

1 Representing the top line goal of the Sustainable Energy for All (SE4ALL) initiative.
2 A lumen is a measure of light energy radiated by a light source.
3 Access to cooking fuels is likely going to come from a range of fuel types with a range of performance indicators in the short to medium term. Although the end goal is that all households should have access to clean fuels in the long term (Tier 4 or 5 of the GTF), this is unlikely to occur immediately as these tiers require access to relatively expensive stoves and fuels that need to be paid for, which is not possible for the very poor. What is important is to start to move households up the tiers, from Tier 0 to Tier 1, and so on, until they can eventually reach Tier 4/5. This will mean that wood, charcoal and kerosene are likely to still be used, although the cooking technologies need to be improved concerning emissions and safety.
4 Extrapolated statistic from NCAPD et al. (2011), MOHSS (2010), Saha (2002), NBS and Macro International (2007), MOH and Macro International (2008), Amanyeiwe et al. (2008) collected in seven countries in sub-Saharan Africa (Kenya, Namibia, Rwanda, Ghana, Tanzania, Uganda and Nigeria – with a combined population representing 37% of the total in the region) and from two countries in South Asia (India and Bangladesh – a combined population representing 84% of the total in the region).
5 Extrapolated statistic from data collected in 31 countries in sub-Saharan Africa, two countries in South Asia and five countries in Latin America (data taken from UNESCO, 2007; UNESCO, 2008; UNESCO, 2011). The 38 countries have a combined primary age population representing 43% of the developing-world total.
6 It is recommended that all rooms used by children have a temperature of 19°C (WHO, 2007b).
7 Based on the extrapolation of data from these regions (taken from UNESCO, 2007; UNESCO, 2008; UNESCO, 2011), the figures for East Asia and the Pacific / Central Asia are 91 million and 11 million respectively.
8 For health care see cohort studies in 2011 by the Consortium for Research on Equitable Health Systems (CREHS) www.crehs.lshtm.ac.uk/publications.html. For education, see Mulkeen (2005).

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Photo captions and credits

Page 1. Uganda Arua, West Nile Province. Eight-year-old Peace Dratery (middle) and her classmates do their homework under the light of a Philips Solar Light System in the village of Offaka (Credit: Sven Torfinn/Panos)

Page 3. A Ugandan woman lights a fires under a traditional three-stone fire (Credit: Karin Desmarowitz/GIZ)

Page 17. A miller in Nepal using an upgraded watermill, which grinds grain down to flour more quickly and efficiently (Credit: Martin Wright/Ashden Awards www.ashdenawards.org)

Page 34. Mothers bring their babies for vaccinations in Nyafaru, Nyanga, in the Eastern highlands of Zimbabwe. A community micro-hydro system provides electricity for lighting, a sterilization unit, and incubator at the Medical Centre (Credit: Practical Action/ Crispin Hughes).

Page 46. Two men and a boy transport bricks by bicycle and trailer in Bangladesh (Credit: Zul Mukhida/Practical Action)

Page 52. Rickshaws travel through the streets of Dhaka at night, lit by streetlights. This allows for safer travel travel – especially for women – extended work hours, and fewer accidents (Credit: Practical Action/Anisuzzaman Ujjal)

Page 57. A community works to build a micro-hydro system in Zimbabwe, using the power of the river to generate electricity for their local services (Practical Action)