



Poor people's energy outlook 2012



**Poor people's
energy outlook
2012**

Praise for this book...

'The *Poor people's energy outlook* will definitely contribute to the debate and actions towards addressing the needs of the energy poor.'

Stephen Gitonga, United Nations Development Programme

'It's great to see such a clear voice coming out of Practical Action on behalf of the poor – I pray the world listens!'

Abeeku Brew-Hammond, The Energy Centre, Kwame Nkrumah University of Science and Technology, Ghana

'The approach is valuable and leads us towards a better understanding of the myriad dimensions of the lack of energy access experienced by the developing world.'

Dr Priyadarshini Karve, Appropriate Rural Technology Institute (ARTI), India

'Defining and measuring energy poverty is absolutely vital to effectively address the issues and ultimately improve lives in a long-term, sustainable manner; but it isn't necessarily an easy thing to do. The *PPEO* tackles this challenge in an informed, professional and highly useful manner. It is a book worth reading.'

Samuel N. Shiroff, Bosch und Siemens Hausgeräte GmbH, Munich, Germany

'The *PPEO 2012* is a valuable contribution to better understanding the links between access to energy services and economic development.'

Morgan Bazilian, UNIDO and UN-Energy

'This is an insightful and extremely useful report, based on long experience and thoughtful analysis. In revealing the manifold importance of energy to all human enterprise it sets out powerful arguments and practical measures to break the barriers to energy access for poor people. Above all, this report encourages new and better ways of thinking about the issues and invites readers to contribute to further discussion.'

John Magrath, Oxfam

'The *PPEO* provides a valuable complement to the IEA's World Energy Outlook by widening the term "energy access" to include the increased use of modern energy services for production and income generation by poor people and not just consumption (light and cooking). Practical Action is to be commended for sustaining this major contribution.'

Andrew Barnett, The Policy Practice Limited

'The new *Poor people's energy outlook* is a useful source of information and will be of great help in highlighting the energy needs of the poor in the coming UN Year on Sustainable Energy for All.'

Dr Marlis Kees, GIZ

'The *PPEO 2012* explains concisely the complex issue of energy access. It is a useful tool to understand the challenges of and potential approaches towards Total Energy Access – both for people new to the field as well as for practitioners. It provides relevant facts and figures that are often unavailable or challenging to find.'

Barbara Boerner, Canopus Foundation, and Solar for All

'The *PPEO* is an excellent document touching on many important aspects of energy for productive income-earning opportunities essential for improving livelihoods.'

Estomih N. Sawe, TaTEDO, Tanzania

Poor people's energy outlook 2012

Energy for earning a living

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, and working with them to influence social, economic, and institutional systems. We work internationally from regional offices in Latin America, Africa, and Asia. 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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Foreword

A lack of access to modern energy services negatively affects nearly a third of humanity. While poor people remain in darkness and ill health, there can be no escape from the vicious cycle of poverty. But how can this cycle be broken, and turned to one of increasing prosperity and economic and social development? To answer that question we must constantly improve our shared understanding of the scale, causes, and evolving solutions to the multiple dimensions of energy poverty.

Technological innovation as well as innovative delivery and financing models are making new and improved energy products and services more available and more affordable. Accelerating the development and uptake of such products and services must be the focus of our efforts to dramatically scale-up the quality and quantity of energy access available in the poorest parts of the world. Likewise, building on existing national and regional plans will be crucial.

This is the objective of the UN 'Year of Sustainable Energy for All', to be observed in 2012. As mandated by the United Nations General Assembly, we will focus on generating the public and private sector commitments needed to launch a global goal of achieving universal access to modern energy services by 2030, and designing the action agenda needed to achieve it.

The *Poor people's energy outlook (PPEO) 2012* supports and contributes to this agenda with this year's theme of energy for earning a living. By revealing more comprehensively how energy access underpins wealth creation, the *PPEO* highlights the steps that turn energy access into development. By linking the needs of people and enterprises with a range of solutions, it informs immediate actions. By describing the wider energy access 'ecosystem', it points to a systemic shift that might lead to a more sustainable and equitable energy future.

It is for all of these reasons that I welcome this second edition of the *PPEO*.



Kandeh K. Yumkella
Director-General, UNIDO
Chair, UN-Energy



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To view the interactive web version of this report please go to:
www.practicalaction.org/ppeo2012

For more information about this report, or to offer any feedback, please contact:
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Executive summary

This second edition of the *Poor people's energy outlook (PPEO)* shines a spotlight on energy access and its impact on the ability of the world's poorest people to earn a decent living. Its release is timely as 2012 marks the UN International Year of Sustainable Energy for All, and the injustice of energy poverty is rising up the international agenda.

The *PPEO* argues that where poor people have the sustainable energy access needed to grow enterprise activities small and large, it becomes possible to escape the vicious cycle of poverty.

Encouragingly more and more people and organizations are realizing this potential and joining the movement for change on energy access. This movement has as its focus the UN's goal of universal energy access by 2030 – a target that we believe can be met.

Universal energy access would create a step change in poverty reduction in the developing world and help billions out of the darkness and drudgery so many are forced to endure on a daily basis.

Without a change of course, by 2030 the total number of people without access to electricity will still be almost 900 million, 3 billion will cook on traditional fuels, and 30 million people will have died of smoke-related diseases.

Energy access may at times seem like a 'technical' issue, but its consequences are very human indeed.

Energy for earning a living – the power to work

Poverty remains the main barrier to access for the people who currently lack energy services and supplies. But talking with communities around the world whose lives are blighted by energy poverty, it is clear that lack of access to energy is also one of the main contributing factors to their poverty. Without the ability to use adequate, reliable, and affordable energy supplies of sufficient quality, enterprise activities of all types and sizes cannot thrive. It is a cruel catch-22 that those without energy access are denied the chance to work their way out of poverty.

The recent Centre for Global Development report entitled *Africa's Private Sector: What's Wrong with the Business Environment and What to Do About It* states 'There is perhaps no greater burden on African firms than the lack of a reliable supply of electric power.'

Perhaps one of the hardest hit sectors is agriculture. Farming and working on the land remains a hugely significant means of earning a living in the developing world, and energy access has a considerable impact on the productivity and returns of the sector.

Currently agriculture is the primary earning activity of some 2.5 billion people, 45 per cent of the developing world's population. Increased agricultural productivity is a key driver for food security, income generation, development of rural areas, and ultimately global poverty reduction. For smallholder farmers, the increased use of modern energy services can contribute to increasing incomes through a wide range of energy services at each step of the agricultural value chain from production, post-harvest processing and storage, to marketing.

Small farmers are also part of a wider group of micro and small-scale enterprises (MSEs), which are at the heart of economic activity, and are run by people in energy poverty in both rural and urban areas. Many hundreds of thousands of people run

“ Those without energy access are denied the chance to work their way out of poverty ”

”

MSEs such as street-side stalls, small garages, and tailors, and each MSE has its own specific set of energy needs if it is to survive and thrive. Improved energy services can enable new or improved products and services to reach customers, and improve efficiency and returns for the enterprise.

The *PPEO* also looks to the wider economy of developing countries and the implications of increased energy access on job creation. Reliable and affordable energy services access is well known to be essential for national economic development. That is shown to create job opportunities for poor people, but there are also potential risks. Where greater energy access increases automation and mechanization, this can make workers with less training and educational access redundant.

In fact the analysis presented shows that energy access alone, of which electricity is just one component, is no guarantee of an improved livelihood. Reliability, quality, and cost of energy supplies are critical success factors to enterprises – but only when coupled with access to markets, social networks, and a business proposition that has sufficient demand.

To understand better the demands and needs of enterprises for energy the *PPEO* proposes the Enterprise Energy Matrix (see below). The table below gives a clear picture of the key issues that must be tackled when providing energy for electricity, fuels, mechanical power, and appliances.

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)

“Earning a living from the supply of energy is itself a huge opportunity in a context where so many are underserved

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The potential for earning a living from the supply of energy is itself a huge opportunity in a context where so many are underserved. The transition from insufficient, unhealthy, and inefficient use of traditional energy supplies, to modern energy services associated with improved fuels, appliances, and equipment holds many opportunities for livelihoods in businesses along the supply chain. Reaching poor people with energy products and services is a market that generates social and economic returns not only in the productive use, but also in the service supply. Where low carbon energy supplies are utilized, benefits are extended to environmental impacts.

Figure 2.8 summarizes how use of improved energy services can be converted into improved incomes, and ultimately to reduction in poverty. It also highlights the series of conditions and complementary actions needed for earnings and development potential to be realized.

Refining total energy access

The Total Energy Access (TEA) concept in the first *PPEO* was welcomed by many as a better way of understanding and defining people's experience of energy. TEA is defined at point of use in terms of the energy services people need, want, and have a right to: lighting, cooking and water heating, space heating, cooling, and information and communications technologies.

In this report we have refined and improved the TEA minimum standards to distinguish between household TEA, energy for enterprises, and energy for community services, to better understand these differing, but sometimes overlapping, needs.

The TEA standards and Energy Supply Index (ESI) – which sets qualitative levels for the main supply dimensions: household fuels, electricity, and mechanical power – have been used to assess the energy access situation in six communities in Kenya, Nepal, and Peru. This consultation with 300 households has provided valuable insights into how people use, access, and value the total range of energy services, and how the quality of supply available influences the energy services enjoyed. The results highlight the commonalities as well as the variations in experience of energy poverty worldwide.

Such information is invaluable to practitioners and policymakers in order to identify and target energy service and supply gaps in the dimensions that matter to people, and to track real change as energy products and services are made available.

While the *PPEO* encourages international institutions and national statistics systems to take this perspective on board in their work, and such processes are ongoing, the *PPEO* also seeks to enable a more decentralized approach to filling the energy access data gap. The Total Energy Wiki is being piloted on the Energypedia platform to allow anyone with access to the internet, anywhere in the world, to upload and share with the global community the energy access data they have collected using the TEA and ESI questionnaire (provided in Annex 1). If enough people participate, this could start to crowd-source part of the answer to the energy access data gap (www.energypedia.info/totalenergywiki).

Creating healthy energy access ecosystems

Change on energy access can start with one person, but it must eventually be at the level of the whole system. This year's *PPEO* also builds more detail into the perspective of the energy access ecosystem, describing the interconnected network of organizations working on the supply of modern energy services to poor people. Understanding the systems constraining energy access for poor people can help find the levers to change it.

From national governments, donors, utilities, and businesses, to NGOs, civil society, community groups, and individual consumers, all of these actors have a crucial role to play in creating universal energy access. No single body can do this alone. Indeed, these organizations are interconnected and their success is linked both to each other and the system as a whole.

“ TEA is defined at point of use in terms of the energy services people need, want, and have a right to

”

If TEA is to be accelerated via the full range of resources, appliances, and equipment required, many more people and organizations will have to be in the business of providing energy access to an increasing number of poor people in ways that are more complementary to each other than today.

“Where energy access ecosystems are healthier, then progress on energy access is accelerated”

In order to promote the transition of energy access ecosystems from thin and weak systems with a few players, little competition, little innovation, and little activity, to vibrant, inclusive, and sustainable systems, change must happen in the health of the energy access ecosystem – as visualized in Figure 4.1.

It is proposed that the health of energy access ecosystems can be both understood and improved by considering the policy, capacity, and financing characteristics of the ecosystem. An ‘energy access ecosystem health index’ is proposed for further discussion and development in Table 4.1. It is suggested that where energy access ecosystems are healthier, then progress on energy access is accelerated.

Building on this perspective, the *PPEO* proposes the policy, financing, and capacity approaches that can accelerate energy access outcomes via ecosystem health improvements.

A question of finance – how will universal energy access be funded?

The amount of investment needed to achieve universal energy access by 2030 was estimated by both the AGECC and IEA at between US\$35 billion and \$40 billion a year. So far investments have been far below needs, especially in sub-Saharan Africa.

International funds, public/private partnerships, bank finance at multilateral, bilateral, and local levels, and targeted subsidies will all be vital. In the initial stages public money is particularly important as the financial returns in supplying energy to low-income families are not attractive to commercial operations.

And while we need big money we also need smart money. The financing mechanisms adopted will need to be matched to the particular characteristics of the financing need: for example, the financial mechanisms appropriate to electrification differ hugely depending on the scale of the project and also differ from those required for expanding access to clean cooking facilities.

Currently much of the finance earmarked to improve energy access is spent on large-scale electricity infrastructure, generation, grid, and regional interconnection projects. Sadly these projects often fail to directly address the energy needs of poor communities for cleaner cooking and mechanical services – as well as ignoring the contribution of decentralized and renewable electrification.

“A significant proportion of large funds must be made accessible as local-level financing”

To solve this issue a significant proportion of large funds must be made accessible as local-level financing. This can include financing to community initiatives, enterprises, and consumers – often through local banks and microfinance, and credit and loan schemes.

With systems like this in place poor people can overcome the financial barriers which stop them connecting to a local power supply, buying PV solar panels, and purchasing a cleaner stove, or an alternative to kerosene lamps.

Join the movement for change

If the momentum building around universal energy access in the run up to the 2012 UN ‘Year of Sustainable Energy for All’ is to be translated into real change, it is not enough to know what we are aiming for, or even what to do – we need the will to do it. The will for change on energy access must permeate actions and perspectives from top to bottom of the energy ecosystem, translating into improved and expanded commitments to policy, financing, and capacity for energy access. Here is how you can help achieve universal energy access by 2030:

- **Government leadership** – Set national targets for universal energy access by 2030 and formulate and implement plans to deliver these targets (targets should recognize Total Energy Access minimum standards and the Energy Supply Index of supply quality).
- **Donor/lender leadership** – Increase investment in energy access, targeting stimulation of the ecosystem delivering energy services and meeting the needs of poor people at the level of the household, enterprise, and community institutions.
- **Civil society leadership** – *In developing countries* – demonstrate and report on good practice, create awareness of the benefits of energy access on health and development amongst communities, represent people living in energy poverty internationally. *In donor countries* – raise awareness amongst the general public, donor, and private sector of the importance of access to energy services in achieving development and environment goals.
- **Private sector leadership** – *In developing countries* – respond to government and donor incentive structures on expanding the quality and quantity of energy access products and services. *In donor countries* – increase investment and activities in energy access sectors in developing countries targeting base-of-the-pyramid markets.
- **International institutions** – Pursue international agreement and commitment on the goal of universal access to energy by 2030. Create high points of support for energy access that have an inspiring and galvanizing effect in forming a movement for change.

“ It is not enough to know what we are aiming for, or even what to do – we need the will to do it

”



1. Introduction



The *Poor people's energy outlook* seeks to understand and communicate the real experience of people living in energy poverty, and show how people's lives can be changed by energy access. 'Energy access' is used as shorthand in this report for the 'use of modern energy services by unserved and underserved people'.

By understanding the ways in which energy poverty locks people into a cycle of wider poverty, the *PPEO* seeks to stimulate more extensive, effective, and concerted action to end the injustice of energy poverty. By illustrating the change when access is achieved, the *PPEO* shows that an end to energy poverty is possible – and the ways in which the target of universal access to energy by 2030 can be made real.

In order to develop this perspective, the testimonies of people living in energy poverty have been brought together with perspectives from practitioners with decades of experience working to create access. Lessons from projects have been compared with internationally collected data. Where there is no available data, processes have been proposed to collect it. The *PPEO* seeks to connect the experience of a single family with analysis of the overall system that continues to fail that family, trapping them in energy poverty.

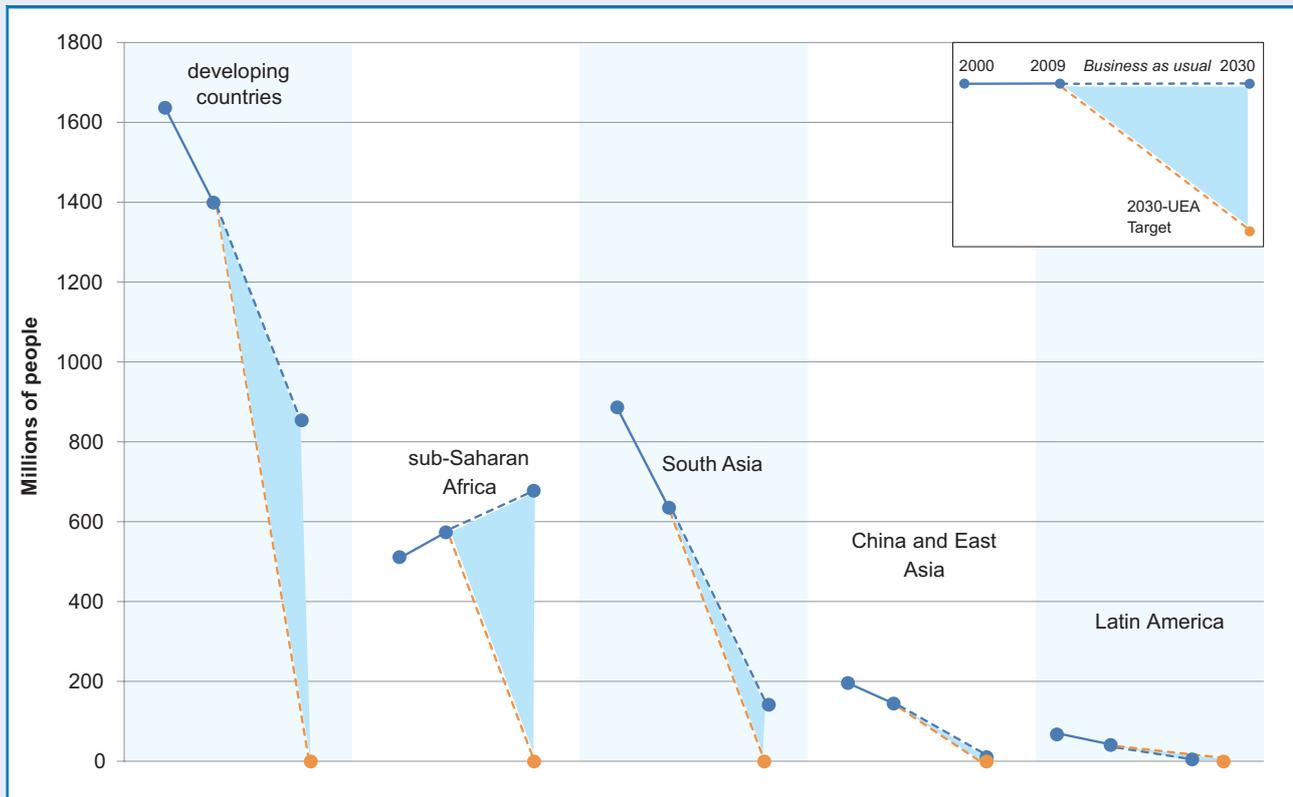
“ The *PPEO* seeks to connect the experience of a single family with analysis of the overall system that continues to fail that family ”

The global challenge

The failure to provide energy access continues in many parts of the world today. Figures 1.1 and 1.2 illustrate the scale of the issue in the two dimensions of energy poverty, which are collected at an international level today: access to electricity and access to 'modern fuels'. They contrast the business as usual trajectory with the 2030 Universal Energy Access target, in absolute numbers rather than percentages, enabling population growth to be taken into account. Figure 1.1 illustrates the case of electricity.

Although progress is being made on electricity access overall, this is not consistent across continents. Particularly in sub-Saharan Africa, new connections are failing even to keep up with population growth. While percentages of people without access to electricity in sub-Saharan Africa (*PPEO 2010*) were projected to decline by 10 per cent between 2000 and 2015 compared with business as usual, the graph of absolute numbers presented here shows an increase of 100 million people in the period to 2030. This means that with no substantial changes in current policies and practices, the total number of people without access to electricity in sub-Saharan Africa will increase to 691 million by 2030.

Figure 1.1 Number of people without access to electricity: comparing business as usual with Universal Energy Access by 2030



Source: IEA, 2002; IEA, 2010; UNDP/WHO, 2009; UNDESA, 2010; Practical Action, 2010

Box 1.1 Practitioner's perspective – large-scale electricity initiatives in Africa

In all northern African countries, access to modern energy on a large scale was dependent on infrastructure that was funded by the state. Morocco and Tunisia are interesting cases as they have made the transition from a low level of electricity access (below 30 per cent in 1996) to a very high level (above 96 per cent in 2009) in a relatively short period of time. The strategy was based on both decentralized off-grid electrification for small villages, and grid extension for larger villages, financed by public funds including external funding.

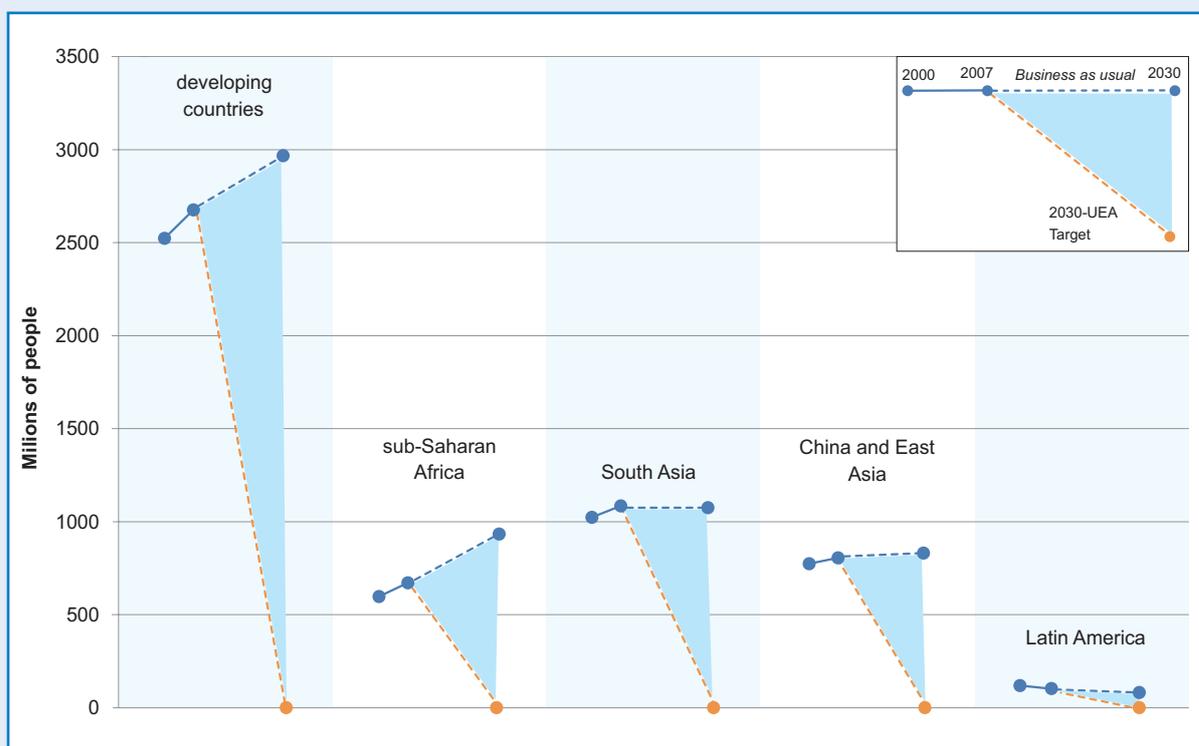
In sub-Saharan Africa, energy initiatives today are mainly focused on electricity, with the creation of power pools in the whole region (e.g. East Africa Power Pool, West African Power Pool, Central African Power Pool and South African Power Pool). The increased infrastructure will improve the general rate of access to electricity, and its efficiency and security, through power sharing. It will reduce the cost per kilowatt as a result of electricity supply coming from the least-cost power plant, which in most cases saves fossil fuels.

However, there are tens of thousands of villages in sub-Saharan Africa, far from the grid, for which decentralized options are the least-cost option. Furthermore, most interconnections are based on large hydro-schemes with significant environmental and social impacts, in particular displacements of people, which must be fairly addressed.

Smail Khennas, Independent Energy Expert

The picture in terms of cooking fuels is even worse than that for electricity. As Figure 1.2 shows, more people are being born each year than are getting access to so-called ‘modern fuels’ (liquid or gas cooking fuels) for cooking. On current projections, by 2030 around 200 million more people will cook on traditional fuels than today, with increases in both Africa and South Asia. While use of woodfuel in itself does not constitute energy poverty in the *PPEO* definition of Total Energy Access (see Chapter 3), an ongoing reliance on traditional fuels makes requirements for improved appliances and ventilation ever more important if the human and environmental impact of this practice is to be positive.

Figure 1.2 Number of people without access to ‘modern fuels’: comparing business as usual with Universal Energy Access by 2030



Source: IEA 2002; IEA 2006; UNDP/WHO, 2009; UNDESA, 2010; Practical Action, 2010

In order for universal energy access to be achieved, about 150 million more people per year must get lifetime access to clean cooking facilities and about 75 million people per year must get access to reliable and adequate electricity by 2030.

On current projections for the *PPEO* drawing together available data, in 2030:

- 3 billion people will still cook with traditional fuels;
- almost 900 million people will not have access to electricity;
- in the next 20 years more than 30 million people will die due to smoke-related diseases;
- many hundreds of millions will be confined to poverty as their incomes are constrained by lack of energy access

Poor people's perspective

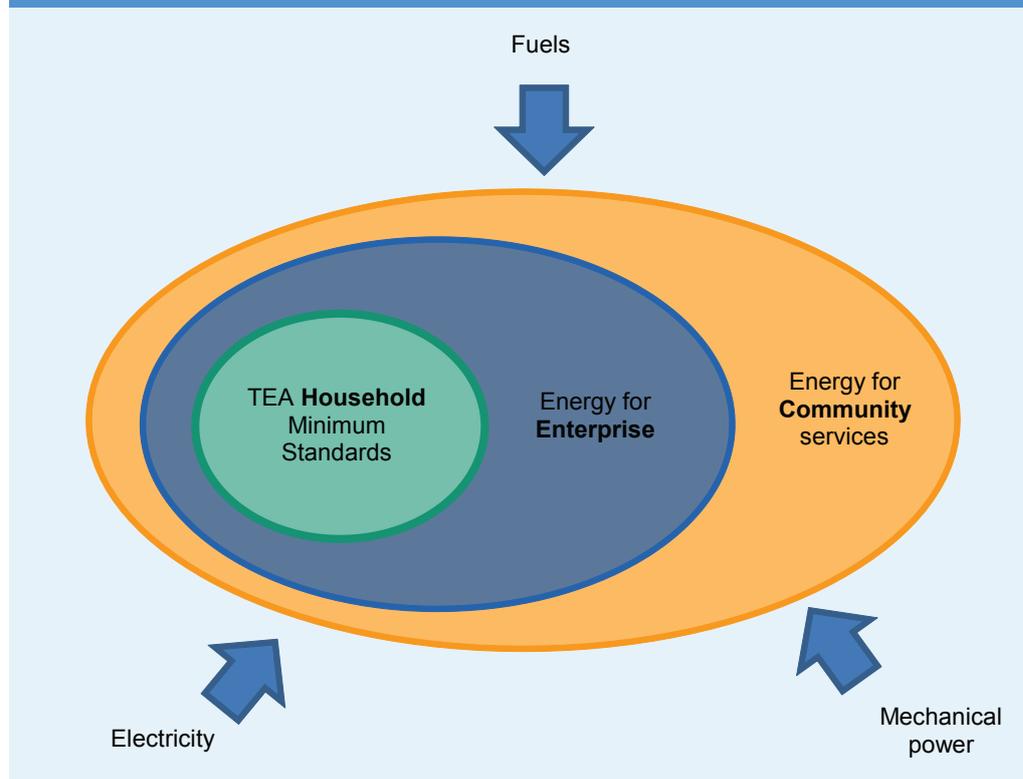
It is this last point, the extent to which a lack of energy holds people in poverty, on which this year's *Poor people's energy outlook* focuses.

The *PPEO 2010* sought to delve beneath the macro-figures on access to electricity and modern fuels to describe the real experience of energy poverty and access. This perspective used energy services at point of use, as well as a qualitative index of energy supply, as better reflections of access than 'connection' (however intermittent) to the grid, or access to 'modern fuels', while a range of improved appliances exist to use wood in a healthier and more sustainable way.

This perspective resonated with many people worldwide and building on feedback – including via an e-consultation held with GIZ on the HEDON platform (www.hedon.info/forum18) and piloting in three countries – this year an update is proposed to the Total Energy Access (TEA) standards and Energy Supply Index (ESI) in Chapter 3. As part of the update, it was recognized the TEA standard applied most to household energy access, and that the treatment of energy for productive uses in enterprises and in shared community services should be expanded.

Figure 1.3 illustrates the overlapping energy access units of: the household, the enterprise, and the community. Members of a household have energy needs for basic services as defined by the TEA Minimum Standards. Each household however also has to earn income and whether that takes place in the household, in a field, or in an office or workshop – that enterprise activity also needs energy. Finally both households and enterprises exist within a community, which requires energy for shared services used by all, including schools, health centres, telecommunication networks, and street lighting.

Figure 1.3 Units of Total Energy Access: Households, enterprises, and communities



Energy access for earning a living via enterprise activities, from cottage industries to jobs in larger firms, is the theme of this year's *PPEO*. Although some enterprise activities are done in the household, and the basic supplies of fuels, electricity, and mechanical power remain the same, the services required can often be different, and the amounts of energy required are not governed by human rights or health, but by the success and scale of the enterprise. Chapter 2 explores the ways in which energy poverty compounds income poverty, and how energy access can be converted into improved incomes.

It is proposed that the next edition of the *PPEO* will take as its focus the unit of energy for community services, and in this way, after consultation and agreement, complete the set of scales of analysis of energy access in the dimensions which matter to poor people, whether they are in urban or rural locations, and whether they are in a hot or a cold climate. Although contexts differ, there is an important universality to the experience of energy poverty.

Changing the system

That universality also extends to many of the challenges and levers in achieving energy access. In Chapter 4, we seek to put the energy poverty of each individual household, enterprise, and community in the context of the ecosystem that is failing to address their needs. We develop a picture of a healthy energy access 'ecosystem' in which more and more actors serve the energy needs of poor people via the full range of energy resources, equipment, and appliances. And we learn from the policy, financing, and capacity building approaches that have worked in different parts of the world, to make recommendations for the course correction needed if energy access is to be achieved.

Total Energy Access is the destination, improving energy access ecosystems is the way to get there. The final section describes what you can do to help make that happen.



2. Energy for earning a living



For billions of the world's poorest people, the ability to earn a living depends heavily on access to energy. Having lighting after dark so a shop can stay open for longer, or fuel for an engine to mill grain or a pump to irrigate land, can be the difference between earning a decent livelihood or not, between escaping a subsistence lifestyle and the cycle of poverty, or not. It is this direct connection between energy and poverty reduction, the first Millennium Development Goal, that is typically amongst the most mentioned in discourses on energy poverty, but the least understood in practice.

Certainly the connection between energy and economic activities is widely recognized, with a strong correlation between per capita energy consumption and GDP – although the direction of causality remains in debate (Ozturk, 2010). The constraint of lack of affordable and reliable energy is also clearly felt at national levels, with more than a third of economies in the developing world citing lack of reliable electricity as the top elemental constraint on enterprise growth. Interviews with business leaders in Africa for example have concluded, 'There is perhaps no greater burden on African firms than the lack of a reliable supply of electric power.' (CGDEV, 2009)

However 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 and energy consumption, or even those of large enterprises. Poor people's incomes and enterprises are generally not well reflected in national statistics, including GDP. Paradoxically, greater energy access in enterprises can sometimes produce threats, at least in the short term, to poor people's ability to earn a living, displacing traditional employment opportunities. Equally, a job for a company only delivers 'decent employment' if wage levels are above that designating the working poor. While income is an important dimension, it must also be understood alongside health and safety conditions at work, as well as factors such as income security, benefits, and risk ownership.

To understand the impact of energy access on the ability of poor people to earn a living, the *PPEO* has focused first on the ways in which poor people currently earn a living – and then looked at how these opportunities may be expanded and enhanced, or in some cases reduced, by energy access.

The *PPEO 2010* identified the basic connections between energy access and earning a living as being via one of three mechanisms:

- **creating new earning opportunities** not possible without energy access;
- **improving existing earning activities** in terms of returns by increasing productivity, lowering costs, and improving the quality of goods and services;
- **reducing opportunity costs**, reducing drudgery, and releasing time to enable new earning activities.

It was also recognized that energy access did not automatically create any of these outcomes, and that there were a series of steps between energy access having been created, and impacts on earnings and development outcomes.

This year, in the following chapter, the *PPEO* explores these three mechanisms and the steps connecting energy access with earnings and development in more depth, by looking at how energy interacts with the four principle ways in which poor people earn a living: **earning off the land**, **running a micro or small enterprise** (MSE), **getting a job**, and – on the supply side of the energy access system – **earning from supplying energy**.

It is recognized that individuals and households are often involved in one or more of these livelihoods activities to earn a living, and indeed that these categories overlap to a degree – a farm for example is a particular type of micro or small enterprise. However, it is proposed that this categorization enables a useful analysis of how energy interacts with the earning opportunities that are available to poor people.

Energy and earning off the land

Agriculture contributes significantly to the economic and social makeup of the vast majority of developing countries. Increased agricultural productivity is a primary driver for food security, income generation, development of rural areas, and therefore global poverty reduction. Agriculture provides foodstuffs and drinks, produces animal feeds and products, and also delivers a wide range of non-food goods and services, including fibres for clothes and fuel, in the form of biofuels.

Some 2.5 billion people, 45 per cent of the developing world's population, live in households depending primarily on agriculture and the agri-based economy for their livelihoods. In agriculture-based countries, the agricultural sector generates on average 29 per cent of gross domestic product (GDP). However its impact on employment is even more marked, accounting for 65 per cent of the labour force, with a disproportionate number being income and energy poor (GIZ, 2011).

Poor people participate in agriculture as smallholder farmers or as farm labourers on other people's land – and some do both at different times of the year. In India, statistics from 2001 show 54.4 per cent of agricultural workers were cultivators (smallholder farmers) and 45.6 per cent were labourers, compared to 62.5 per cent and 37.5 per cent respectively in 1981 (Directorate of Economics and Statistics, 2006).

Improved agricultural practices are a priority for tackling poverty today, and for meeting future generations' needs. It is estimated that an increase of 70 per cent in agricultural productivity is required by 2050 to feed the 9 billion people expected in the world (FAO, 2009). Greater agricultural productivity requires improvements in agricultural production, agro-processing, post-harvest and storage facilities, and distribution and retail – and this requires energy inputs at each stage of the agro-food production chain (see Figure 2.1).

Figure 2.1 Energy inputs to enable activities in the agricultural value chain

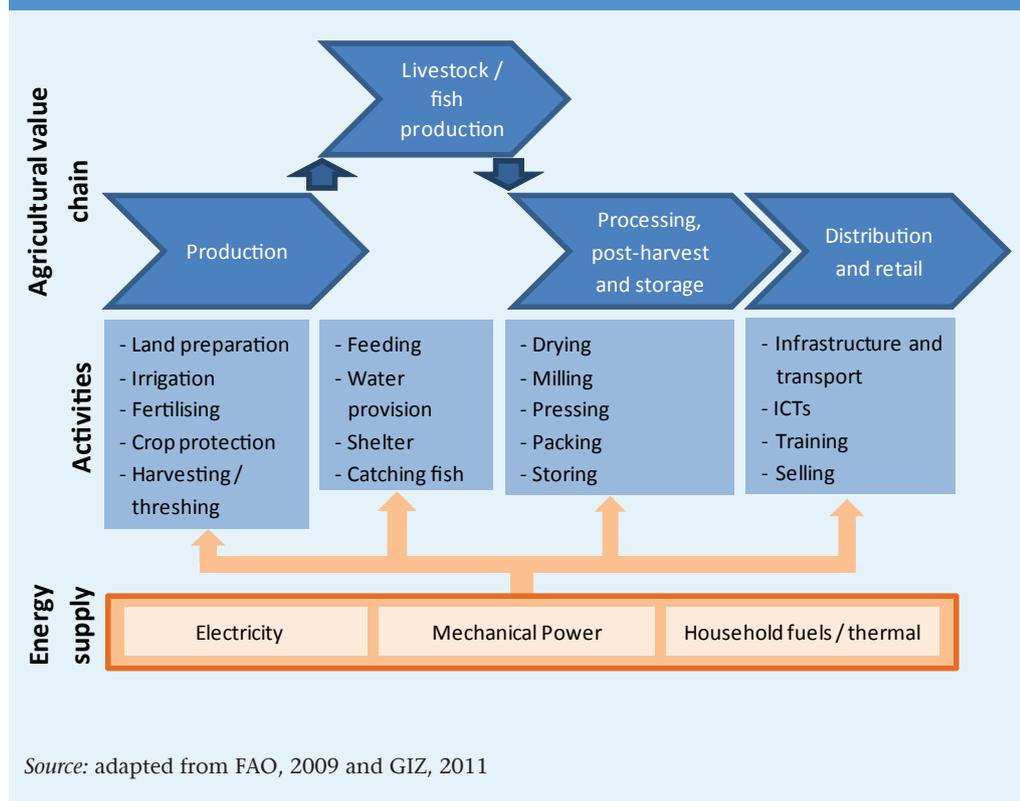


Figure 2.1 outlines the wide variety of activities that require energy in the agricultural value chain. A number of energy services available in poor households, including lighting, cooking, and ICTs, enable some of these activities. Many of the activities however require specific energy services accessible only with an increased level and quality of supply, and specific equipment, appliances or knowledge. Whilst the energy supply is an important component, clearly many other resources and assets are required – including land, water, seeds, and equipment.

Improved agricultural practices can enable poor farmers to:

- **increase productivity** and yields;
- **provide better quality and quantity** products at less time, effort, and wastage, through better processing and storage;
- **earn more from produce** through new market opportunities and access to information and networks.

For poor farmers to achieve this and realize higher incomes as a result requires an improved quality of energy supplies, an increase in the amount of energy used, and access to a wider range of energy services.

Increasing productivity

For poor farmers, agricultural production activities are still 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 levels of farm-power systems can be identified according to the relative contribution of humans, draught animals, and machinery (GIZ, 2011):

1. Basic **human work** for tilling, harvesting and processing, together with rain-fed irrigation.
2. Use of **animal work** to provide various energy inputs. (Neither level 1 or 2 involves direct energy input from an external fuel source, although indirect energy input is needed for the production of food for human consumption, animal feed, and cultivation inputs like fertilizers and herbicides/pesticides where used).
3. The application of **renewable energy technologies** (e.g. wind pumps, solar dryers, water wheels, biomass conversion technologies), **fossil fuel-based technologies** (e.g. diesel engines and pumps) or **hybrid systems** (a combination of both) for motive and stationary power applications and for processing agricultural products.

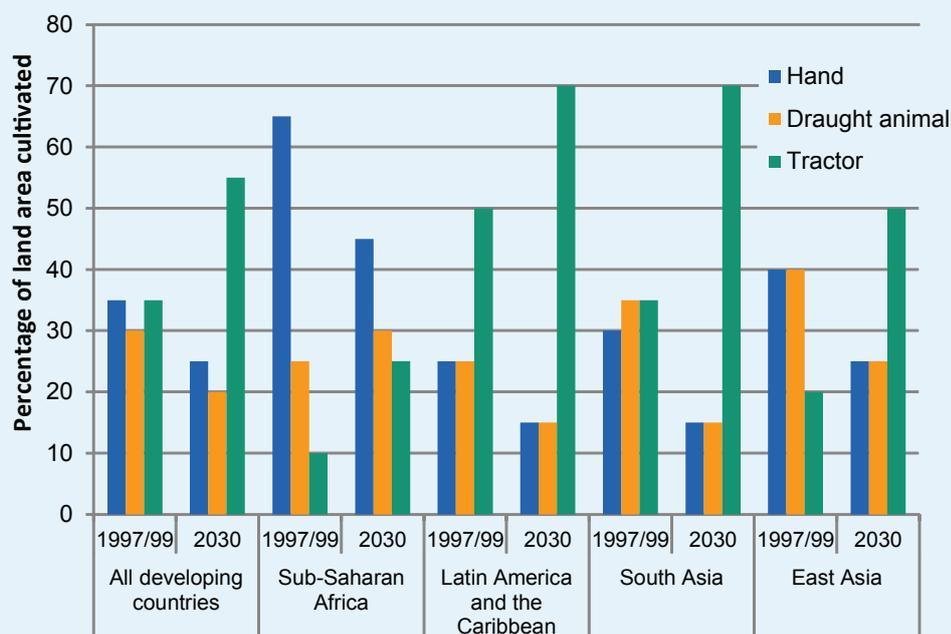
Box 2.1 Farming in Sudan

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 bought ten goats for her family and can send two of her children to school.

Source: Practical Action.

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, draught animal hirers cultivate 2 ha, farmers owning draught animals cultivate 3-4 ha, tractor hirers cultivate about 8 ha, and farmers owning tractors cultivate more than 20 ha (FAO, 2006).

Figure 2.2 Proportion of land cultivated by different power sources, 1997/99 and estimated for 2030



Source: FAO, 2003

Figure 2.2 shows how the proportion of land cultivated in all developing countries by the three different power sources in 1997/99 was broadly similar: 35 per cent was prepared by hand, 30 per cent by draught animals, and 35 per cent by tractors. The proportions however vary between regions with sub-Saharan Africa in particular characterized by high rates of human and animal cultivation, and only 10 per cent of farm area served by tractors (FAO, 2003).

Projections to 2030 show an important expected shift in cultivation practices in developing countries (FAO, 2003). The proportion of land cultivated by hand, and animal will decrease to 25 per cent and 20 per cent respectively, and the proportion by tractor will rise to 55 per cent. This offers the opportunity for increased productivity and reduced drudgery for farmers, but expensive tractors, animals, and equipment are often not available to poor people. Innovative business and community models are required to ensure smallholder farmers are able to access improved technologies, through rental schemes or cooperatives for example. This shift to mechanized farm systems is likely to reduce the labour requirements of cultivating land and result in fewer employment opportunities in rural areas. Well-designed policies and programmes are required to encourage alternative opportunities along the agricultural value chain and with other rural livelihoods during this shift.

Comparing the productivity of different farm-power systems ('modern', 'transitional', and 'traditional' in Table 2.1) highlights how little energy is used in human-powered farming and how relatively unproductive the land is (Table 2.1). 'Traditional' production methods yield only one-fifth as much per hectare compared with modern commercial practices, but can be significantly more energy efficient in terms of the yield per unit of energy input.

Table 2.1 Rice and maize production by ‘modern’, ‘transitional’, and ‘traditional’ methods

	Rice production			Maize production	
	Modern (United States)	Transitional (Philippines)	Traditional (Philippines)	Modern (United States)	Traditional (Mexico)
Energy input (MJ/ha)	64,885	6,386	170	30,034	170
Productive yield (kg/ha)	5,800	2,700	1,250	5,083	950
Energy input yield (MJ/kg)	11.19	2.37	0.14	5.91	0.18
Yield per energy input (kg/MJ)	0.09	0.42	7.35	0.17	5.59

Source: FAO, 2000a

The typical energy content of chemical fertilizers and crop protectors (two of the production activities defined in Figure 2.1) used to cultivate a commercial hectare amounts to 13,834 mega joules (MJ) (FAO, 2000a) – about 20 per cent of the ‘modern’ total and already twice that of the total ‘transitional’ method. The energy content is made up of the embedded energy in the raw materials, the manufacturing of the products, and the transportation of the products to the farm.

The relationship between energy inputs and productive yield is not linear. There is a point after which additional energy inputs have only marginal impacts on yields, and in fact reduce employment requirements, and impact negatively on the environment and climate. Agriculture is a significant contributor to global greenhouse gas emissions, accounting for 15 per cent of carbon dioxide, 49 per cent of methane, and 66 per cent of nitrous oxide (FAO, 2003) equivalent to about 20 per cent of global GHG emissions (excluding land use change). This shows the importance of decisions about the type and levels of external energy inputs into agricultural production on both local and global matters.

Following the path of fully industrialized agricultural systems based on increasing external energy inputs is not considered a feasible option for increasing agricultural productivity for smallholder farmers. Leapfrogging to more efficient systems such as Integrated Food Energy Systems (IFES) offer alternatives. IFES aim to address these issues by simultaneously producing food and energy, as a possible way to achieve the energy component of sustainable crop intensification (FAO, 2011).

However, it remains clear that an increase in the energy inputs in a number of key dimensions, alongside improved and environmentally responsive practices, is required in order for poor farmers to escape low yielding, climatically vulnerable, subsistence agriculture.

Irrigation is of utmost importance in agricultural production – access to water is a major determinant of land productivity and active water management through irrigation offers an important opportunity to improve and stabilize yields. Irrigated land productivity is more than double that of rain-fed land (World Bank, 2008).

Irrigation increases farm productivity by:

“Irrigated land productivity is more than double that of rain-fed land

”

- Allowing additional crops to be grown in a year – in some instances extending the growing season into dry months can allow an additional one or two crops per year.
- Increasing the yield of crops – cereals and vegetables have significantly higher yields when provided with ample water.
- Reducing the risk of crop failure caused by erratic rainfall and drought – one of the expected impacts of climate change, and many anecdotes say it is already happening in some communities, is that rain patterns will change and become more erratic, making it increasingly difficult for farmers to produce enough.

Box 2.2 Practitioner's perspective – potential for Integrated Food and Energy Systems (IFES)

Experience with integrated farming (IFAD, 2010) has demonstrated that (a) adopting sustainable management practices can improve production while preserving the environment; (b) residues, wastes, and by-products of each component serve as resources for the others; and (c) poor farmers have the traditional knowledge needed to integrate livestock and crop production, but because of their limited access to knowledge, assets, and inputs, relatively few adopt an integrated system. This approach is truly integrative and can improve profit and help to reduce poverty.

The practice of IFES showed that on the small scale it is possible to combine food and biomass production for energy generation on the same land with multiple-cropping systems, or systems mixing annual and perennial crop species (IFES Type 1); or maximizing production combining food crops, livestock, fish production, and sources of renewable energy (IFES Type 2). This could be possible with agro-industrial technology (e.g. gasification or anaerobic digestion) and incorporating alternative energy (e.g. solar and wind). Therefore, similarities with IFAD or integrated farms are obvious with the added factor of alternative energy. The constraints in applying IFES are diverse at farm and ex-farm level, and they include: technical aspects, political will, access to markets, financing systems, and, importantly, transfer of skills. One constraint that is particularly important refers to the development and implementation of policies. If developing countries are willing to focus their goals on the main topics listed above, integrated systems can provide a good stimulus to drive forward production. The scale can be defined according to region, and the approach is valid at farm and community level.

Some challenges still remain for decision-makers and practitioners, and one of them is the need to include small farmers in order to increase the productivity of traditional farming systems, adopting an effective integrated system that produces usable biomass while conserving natural resources, and thus making it a sustainable system.

Rocio Diaz-Chavez, Research Fellow, Imperial College, London

In sub-Saharan Africa, only 4 per cent of the area in production is under irrigation, compared with 39 per cent in South Asia and 29 per cent in East Asia (World Bank, 2008). So despite significantly less land being irrigated than rain-fed, 59 per cent of cereal yields produced in developing countries in 1997 came from irrigated land. This proportion is expected to increase to 64 per cent by 2030 as a result of increased irrigation (FAO, 2003).

Many poor farmers rely on rain-fed land, and whilst not all areas are suitable for irrigation, the potential for increased irrigation to many farms is substantial. Table 2.2 outlines common methods of irrigation. Water availability is the main determinant of irrigation potential, however the contribution of energy and pumping technologies remains critical in many cases. A range of pumping

Table 2.2 Comparative analysis of irrigation methods

Irrigation method	Irrigated area	Water requirements	Energy requirements	Capital cost	Operating cost
Manual	<0.5 ha	Low to High	Low (Manual only)	Low	Low to Medium***
Surface/ Gravity fed	Unlimited	High	Low (Manual only)**	Medium	Low
Sprinkler	Unlimited	Medium	High	High	High
Drip/Micro- irrigation	Unlimited	Low	Medium	High	Medium

* the amount of water used in a manual system will depend on the technology used for distribution.

** in some systems, pumping may be required at certain points in the system.

*** operating costs will depend on local labour costs and the type of manual irrigation technology used.

Source: GIZ, 2011; Winrock International, 2009

technologies exists that employ a variety of power sources, including electricity, diesel, wind power, and human power. In general, the scale of production, costs of the technology, and organizational capacity of the farmers will drive decisions about which irrigation approach to use.

For poor farmers, mechanically assisted manual irrigation methods are often the most appropriate technology due to the low capital costs of the pumping technology (if any is used), the typically small areas of land to be irrigated, being human-powered so not reliant on an externally sourced supply, and suitable for village-level maintenance. Studies of smallholder farmers in southern Africa showed that by using a treadle pump to irrigate small plots of land it is typical to increase crop yields by 50-80 per cent and double their income (UNDP/PAC, 2009).

The treadle pump has proliferated in many places across South Asia and sub-Saharan Africa, with hundreds of thousands of units sold. In some instances pumps have produced a crop cycle sales income of US\$606, which means that, subtracting \$79 spent on production costs, a treadle pump can 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, 2000b). These technologies are capable of very low running costs since they are powered by local renewable resources. The high capital cost, challenges of village-level maintenance, and availability and awareness of the technologies remain barriers to increased uptake.

With growing water scarcity and costs of large-scale irrigation schemes rising, there is a need to enhance productivity by improving existing schemes, expanding small-scale schemes, and developing water harvesting.

ICTs also have the potential to contribute to increased farm productivity through improved communications and knowledge sharing. Mobile phones can help to 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 the increases in farm productivity in Asia. Weather forecasts via TV and radio have an important economic significance in regions such as Mongolia where 80 per cent of adult community members listen to weather forecasts for productive uses. Forecasts have a positive impact also on herd productivity because it reduces the risks in herd management (van Campen et al., 2000).

Improved agro-processing

Agro-processing transforms products originating from agriculture into both food and non-food commodities, 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 services are often provided by a specialist in that service, a small-enterprise or co-operative miller or smokehouse for example. This is an energy-based service enterprise for that person (see next section on MSEs), but also provides an important energy service for those farmers who retain the product to sell on or use themselves.

Processing allows agricultural products to be conveniently:

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

This extends the markets in which they can be sold and permits sales at higher prices and in larger quantities (FAO, 2009).

For many poor rural households who rely on their own farm produce for the basic staple of their diet, processing crops in the home – de-husking rice, shelling maize, grinding wheat – using hand tools is the only option. As well as producing low quality goods compared to high-speed machinery, hand processing is extremely energy and time intensive. In many cultures it is considered the task of women and children – studies from Mali show that women typically spend three hours every day milling, grinding or de-husking – although this is only a portion of their workday that typically lasts 17 hours 30 minutes (UNDP, 2004). Other households carry or transport heavy produce long distances to be processed by powered machinery, and may have to pay high prices for the privilege.

The wasted time and drudgery of traditional agro-processing can be significantly reduced with access to modern energy services. In the case of the multifunctional platform (MFP) project in Mali that is widely used for agro-processing, women customers saved on average 2-6 hours per day, and four of the 12 studies reported that the time saved was being used for income generating and entrepreneurial activities (UNDP, 2004).

Introducing agro-processing services can improve incomes for smallholder farmers since farmers selling unprocessed crops only receive a proportion of the price of finished products. Processing can be done at the farm level, however economies of scale and specialization can often be achieved by semi-centralizing processing at community level (e.g. community watermills) or wider. Processing at farm or cooperative level can create more reliable markets for farmers to increase their income and save time and resources, as the energy service is available in the village. Major opportunities for diversification are also possible through the processing and use of agricultural residues and by-products such as molasses and rice husks.

Earning more from produce

Getting agricultural produce from the farm to the consumer involves numerous interconnected post-harvest and even post-processing activities including grading,

Box 2.3 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. In order to power a traditional mill, water is led from a fast-flowing stream along a canal, and then down a steep chute or penstock into the mill house. Improvements to the rudimentary design increase the power, efficiency, and durability of the mill.

Watermill owners who have improved their grinding mills have a higher throughput so can serve more customers, and produce higher quality products. The waiting time for customers has been reduced from 3-4 hours to 1-2 hours, which also frees up the time of the customer who may have walked a long distance and has to wait. Owners of improved watermills have seen an average of 25 per cent increased income with their new technology

'It's much easier with a watermill here in the village. It was hard before because we had to go far away to the mill but now it's nearby. 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.

packing, transport, storage, distribution, marketing, and sale. A range of modern energy services is required for these activities. Such activities cannot take place without exchange of information and are facilitated by the use of ICTs, based on electricity in particular.

In addition to utilizing energy services to increase productivity and improve quality, farmers must also understand and interact with markets in order to secure the best returns for their produce. Poor farmers are often working in situations where they have limited knowledge about the wider markets in which they are operating. In addition to extension and other support services, they can benefit from electronic information about pricing and market requirements. This can reduce time wasted in travel to markets where prices are low, and being forced to sell then or have wasted a trip. It can also alter the informational power balance with middlemen, in the cases that these operators do not add additional value.

Improved information availability via ICTs, either at household or community/co-operative levels (e.g. through joint-bargaining), can play an important role in helping farmers secure the best prices for their products, thereby strengthening participation in rural agricultural markets and improving earnings from the land.

Summary

Agriculture contributes significantly to the economic and social makeup of the majority of developing countries. Increased agricultural productivity is a primary driver for food security, income generation, development of rural areas, and therefore global poverty reduction.

For smallholder farmers, increased incomes and development requires a range of energy services at each step of the agricultural value chain from production, processing, and post-harvest, to distribution and retail.

Access to energy services can enable a smallholder farmer to:

- **increase productivity** and yields via improved efficiency of land preparation, planting, cultivation, irrigation, and harvesting;
- **improve processing, providing better quality and quantity** of products at less time and effort via energy supported cooking/heating, storage, preservation, or transformation into higher quality/added-value forms;
- **earn more from produce** through new market opportunities and access to information about pricing.

For poor farmers to achieve these goals and realize higher incomes as a result requires improved quality and affordability of energy supplies, an increase in the amount of energy used, and access to a wider range of appliances providing energy services. These outcomes are also however interlinked with non-energy factors including access to land, water, seeds, knowledge, and markets for produce. The style of agriculture and the organizational structure (co-operatives etc.) also have important implications for the risks and returns on earning from the land, which in turn impacts back on people's ability to afford the energy supplies and services required.

Energy and earning in micro and small-scale enterprises (MSEs)

Many poor people living in the developing world earn their living from 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, despite the fact that in many cases the home may actually be the location of the business. 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.

The *PPEO* analyses the necessary steps between poor people having access to an energy supply and realizing increased incomes from MSEs, and highlights additional factors, such as access to markets and business skills, that are required alongside energy access for the positive potential to be achieved.

Defining micro and small enterprises

Despite the International Labour Organization supporting the development of definitions of MSEs (Allal, 1999) to enable comparison across countries, there is as yet no agreed international definition. Countries vary in their choice of indicators used to define the scales of enterprise, however the most common are employment, turnover, and assets.



The Government of India for instance uses several systems based both on the number of employees and the level of investment (Government of India, 2006), while the definition used for categorization of small industries includes both the number of employees and the use of electric power (MOSPI, 2010). Categories of investments are defined separately for service and manufacturing enterprises in India. For instance, micro enterprises in manufacture have investments in plant and machinery up to US\$50,000, while in micro-scale service enterprises investments are up to \$20,000 (Government of India, 2006).

Energy activities in MSEs – manufacture and service sectors

The distinction made between the manufacture and service sector is also relevant from an energy needs perspective. 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). Enterprises involved in manufacture tend to have different types and generally high energy demands related to needs for mechanical power, heat for processing, or special electricity demands such as for welding. As a special and large category that operates between manufacture and services, the food production sector has energy demands in the form of heat, and the level of the demand even in micro-scale enterprises ranges from household level to manufacturing level.

To fully understand the energy demands in enterprises it is necessary to look at the range of ways energy services are used. Table 2.3 shows the diverse range of urban poor enterprise activities present in Kibera, a large slum in Nairobi, Kenya.

Table 2.3 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 and 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 planning 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

Source: Karekezi et al., 2008

Also shown in Table 2.3 are the main energy supplies and appliances used to enable each activity. Whilst many of these enterprises are also found in rural towns and villages, such as shops, grain milling, or small bakeries, the variety and quantity of enterprises is significantly less. Service-based enterprises in particular are more prolific in urban areas, in part due to the high density of customers.

Common energy services in enterprises

Total Energy Access defines the energy services required by households to meet their basic needs (see Chapter 3). These same energy services are required for people involved in enterprises, although they are not necessarily the main activity requiring energy in the enterprise.

Lighting for work after dark improves productivity and incomes, particularly in areas where customers have a demand for evening services. Even in areas without evening customers, lighting increases flexibility of operating hours, allowing other activities to be performed during the day.

Box 2.4 Lighting up a small business in Yanacancha, Peru

Mrs 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.'

Other examples of energy services that are used across sectors are those providing comfort and entertainment for the customers or for the entrepreneurs and workers, or both, such as **cooling** from electric fans, **heating**, and **ICT** applications including TV and radio. Energy can improve the attractiveness of bars, restaurants and shops. A bar can attract more clients when it has a television showing movies, news or sports, while a restaurant that sells cold drinks has a more attractive product. **Cooking and water heating** is also present in many instances to cater for employees' meals and drinks.

Where the energy service requires a relatively small amount of energy, such as with lighting, powering a radio, or cooking a single meal, this can typically be met with existing household supply methods and appliances. In enterprises where these energy services contribute to the main activity, such as cooking for a food vendor, or refrigeration for a bar, an alternative supply and appliance that can provide a greater amount of energy service more conveniently or efficiently is often necessary.

Enterprise-specific energy services

MSEs also have energy service needs that are specific to the particular enterprise activity. Within each category of energy service the required amount of power, and in some cases the required form of energy supply, vary depending on activities, scales of operation, and also on tradition. Important categories of energy services that can be distinguished in MSEs are as follows:

Process heating and cooking: The energy services for heating are diverse. Some can be met by the household minimum standards for Total Energy Access in the category ‘cooking and water heating’, however there is a distinction in the energy carriers and volumes appropriate for heating depending on the energy service and sector.

For cooking food, the scale of operation is influential for preferred energy supplies. For cooking in restaurants the demands of speed, flexibility, taste, and cleanliness result in demands for LPG, kerosene, and fuelwood. Cooking on a larger scale typically is based on cost of fuel, so the cheaper fuelwood and coal are often preferred.

Process heating can involve using boilers, ovens or kilns (e.g. for rubber production, ceramics, brick making), which, depending on heat requirements, and local fuel prices and availability, may use firewood, charcoal, coal or a fuel oil. Residues such as coconut husks and rice husks may also be used where available with appropriate boilers as a lower-cost fuel source, which also has less impact on natural bio-resources.

Ironing is a common energy service among tailoring enterprises, and social expectations often define which energy carriers are used. Kooijman-van Dijk (2008) found that in more wealthy areas tailors use either an electric iron or none, while in poorer areas coal irons are still used. In metal works, welding requires electricity, while traditional blacksmiths make use of coal and bark for heating.

Box 2.5 Haji – charcoal ironer in Mukuru

Mukuru is a slum nearby the industrial area in Nairobi where many rural people came to find employment. Here Haji runs a small business of washing and ironing. Due to limited space at the premises, he has to find a space where he can hang clothes and have someone watch them dry.

He hand washes the clothes and uses a charcoal iron to press them. Haji aspires to get an electrical power supply and invest in modern laundry machines for washing, drying, and ironing clothes. He says that there is potential for such improved services as there is adequate customer base. He explains that:

‘Getting power here is a difficult exercise but I want to try and obtain a regular connection.’

Mechanical processing: Milling of grains is one of the most common and most widespread non-farm enterprise sectors (see section on ‘Energy and earning off the land’ for more details). Power demands are met by diesel engines or electric motors, or by direct mechanical power supply from hydro. Other processing of agricultural products can include oil expelling, removing husks or shells, producing fibres, and many more.

Cooling: Cooling is used extensively in food production value chains (see section on ‘Energy and earning off the land’ for more details), in transporting

from primary producers to processors, as well as in storing at retailers before sale to customers. Cooling is important to maintain the freshness of food products, particularly dairy and meat products, as well as fresh vegetables. This maintains their value and enables them to be sold over longer periods, i.e. avoiding waste and lost revenue. In addition, selling cold drinks in hot climates adds value from energy services.

Manufacturing and repair: Transforming raw materials into end or intermediate products such as timber planks, or wooden furniture is an example of a manufacturing activity which can be done by hand, but is speeded up and made more efficient through the use of energy services. Sawmills and carpentry enterprises also set high demands on energy supply even for the machines used in micro-scale enterprises.

Manufacturers of goods more widely, including from plastic or metal also require energy services in the form of 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: Using appliances such as television, radio, and hi-fi is a way to attract more clients to the shop, bar or restaurant. Internet service is an enterprise which usually quite quickly starts up when electricity and a phone line becomes available in a rural town. In addition shops can charge mobile phones as a service for the clients. These services are sometimes clustered in kiosks providing a range of charging and ICT related services.

Deriving services – what matters to enterprises

“ A wide range of energy services are required in enterprises, with some requiring multiple energy services at different stages of production and processing ”

A wide range of energy services are required in enterprises, with some requiring 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 (UNDP, forthcoming). The amount of energy required is also variable, based on the scale of the enterprise.

Aspects of energy access which appear most important to enterprises and entrepreneurs are the following:

- **Reliability of the supply:** in terms of the number of hours of supply or availability throughout the year, the predictability of outages or lack of supply, and the availability during the hours of the day it is required.
- **Quality of the supply:** not only for electricity in terms of voltage, but also for solid fuels such as for fuelwood in terms of moisture content.
- **Affordability of supply:** as a proportion of running costs and as a proportion of the price that people are willing to pay for the end product or service.
- **Adequacy of supply:** in having the capacity to meet the needs of the enterprise in terms of peak power or duration of operation.

Access to energy services requires more than just an energy supply of course; an appliance is needed to convert the supply into a useful form. In the case of welders, they require both the electricity and the welding machine – and the combined performance of both elements determines the quality of welding service available. The four characteristics that define energy supply are also applicable to the appliance.

Box 2.6 Power outages bring down incomes in Nepal

Gagan's grocery shop sells food and other small items such as bread, sweets, and cold drinks. The grocer 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 dry season when the hydro-generation is less effective. During this period, which is also the hottest time of year, the refrigerator mainly remains turned off due to the lengthy power cuts. However, for general-purpose lighting, his house and the shop, different types of lighting devices such as cell-based torchlight, candles and water-based battery, and CFL bulbs are in use.

The income from the shop has been severely affected due to the ongoing energy crisis. The gradual decrease is both due to shorter operation hours and due to lack of power for refrigeration. He says, *'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 from the national grid.'*

Subash runs a small carpentry workshop from his house in the same rural village. He uses electricity for lighting, running a fan, watching television, and to power carpentry tools. He says, *'My profession needs electricity. However, power cuts due to load shedding disturb my regular working hours and capabilities and bring down my income. I cannot earn enough for my family: my wife and children have to rear cattle and find firewood to support the family.'*

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. There are several steps between improved access and greater returns which are often overlooked when taking a purely energy supply perspective. An adequate supply of energy means that the required energy services can be delivered at the time and cost that is appropriate to the entrepreneur.

Even if energy supply and the appropriate appliances are in place, the actual changes in enterprise (including farming) activities and their impacts on incomes, is to a very large extent, dependent on the **markets for the products and services provided**. Most micro-scale enterprises sell to local markets. In rural areas with high occurrence of poverty, the local customer base is limited and customers have low expenditure 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 fast emerging competition in case of successful introductions of new products or services is a widespread phenomenon.

For **improvements in efficiency of production** through modern energy services to lead to higher returns for MSEs, it is necessary that costs of operation are reduced, or for the number of products/services sold to increase, or the sale price of each product/service to 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. However, if the local customer base is insufficient, links to new groups of customers outside of the local community need to be established (Aterido and Hallward-Driemeier, 2010).

Markets for enterprise products – location and social networks

So what determines the scale and demand of the markets on which MSEs depend to sell their goods or services?

“Improved energy access, while an important enabler, is no guarantee of an increase in viability of MSEs”

”

Box 2.7 Practitioner's perspective – the development linkages of agriculture, enterprise, and energy

Taking East African countries as a case, their economies are largely driven by agriculture and small enterprises, characterized by infrequent use of motive energy, and consequently, low levels of energy consumption. This makes it less attractive for private enterprises to offer services in this sector, which compounds the problem of having limited infrastructure available. Without infrastructure (including clean energy services), it remains very difficult to persuade skilled people to move back into rural areas, leading to a shortage of trained teachers, nurses, engineers etc. in rural areas.

Albert Butare, Former Minister of State for Infrastructure of Rwanda

At the local level the building of a new road to a market village, the end of conflicts, or the establishment of new large scale enterprise or organizations that bring jobs and people with higher incomes into rural areas (Davis et al., 2002) are all factors that would help an economy grow. In such situations, creating access to energy can unleash a pending development of enterprises, as was seen in the Southern Sudanese town of Yei after electrification (UNDP, forthcoming).

However in areas which are not positioned for growth, poor entrepreneurs need to extend 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. Accessing such markets is a major barrier to rural development (Reardon et al, 1998). For poor entrepreneurs without social networks based in larger markets in towns or with middle or high-income customers, it is practically impossible to understand and serve external market demands, including trends and keeping up with latest developments and standards.

For this reason programmes supporting energy access to rural MSEs should always integrate a market demand-side element based on an assessment of the overall market system, and in particular demand volume and characteristics. This is important since connecting with or stimulating such market demand may require additional non-energy measures (including marketing, or end-user finance for example) in order to make the MSE activity, and so the energy supply provided to it, viable. Without support for enterprises to expand their markets, the potential benefits of energy access on incomes may not reach poor people.

“ Programmes supporting energy access to rural MSEs should always integrate a market demand-side element ”

Gendered impacts within MSEs and customers

When looking at the impacts of energy on MSEs, it is important to recognize that males and females may experience different impacts, particularly when recognizing that women are disproportionately represented among the poorest segment of society. There are gender divisions according to the sectors and scales of enterprises, as well as in locations, be it in the household or in a separate establishment. There appears to be relatively more women in home-based enterprises, and in enterprises in sectors closely related to traditional female roles such as cooking, hairdressing, clothes washing, and tailoring, although this differs per country. Related to activities in food processing, women are often involved in enterprises using heating as an energy service. Where clean-cooking practices take the place of traditional cooking, women may then benefit disproportionately, although not necessarily in income, but in health and wellbeing. The distribution of benefits of high power electricity

supply is also typically influenced by gender roles as men tend to work with heavy electric appliances such as welding and carpentry. Milling in many countries, especially if home based, is done by both men and women.

An analysis of working conditions integrating the wellbeing of people at work would value the improved conditions for workers caused by cleaner fuels or the substitution of hard manual labour by machines. However, where such mechanization or fuel switching removes the need for labour, then this can create tensions in removing working opportunities for women in the short term.

Impacts on customers of energy service use with MSEs can also be gendered. For example in the case of milling, the energy service may replace manual labour by the would-be customers, or reduce walking distance. Increased opening hours of shops increases flexibility of daytime activities. Such impacts are often especially relevant for women, as in many countries women are responsible for tasks such as fuelwood collection and have so many daytime tasks that evening hours are highly valued. However, where they are not in control of household incomes, then they may be unable to express that demand.

Summary

Adequate and affordable energy access has a strong bearing on the viability of MSEs. A wide range of energy services are required in the numerous types of enterprises, such that a categorization by energy services is not considered useful in defining energy access by enterprises. The quality, reliability, affordability, and adequacy of the energy supplies and appliances combined is a better determinant of the energy access enjoyed and its impact on enterprise viability and growth potential.

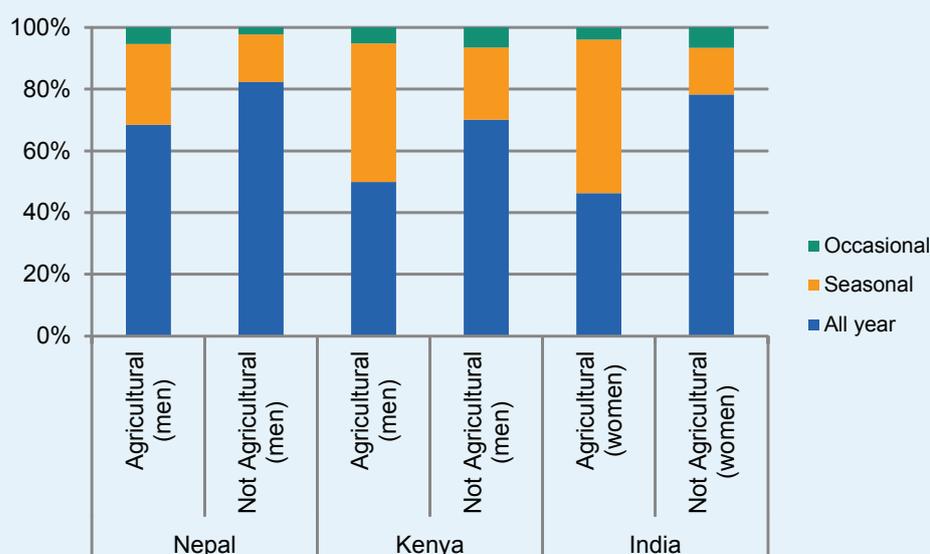
There are important steps between the potential and real impacts of energy supply on earning a living from MSEs. Although improved supplies can be important, accessing appropriate appliances, perhaps via end-user finance and training can also be important. Increased incomes often depend on the entrepreneurs' ability to identify, access, and maintain new markets for the new or improved opportunities that energy services can provide. In this respect business support can be important in developing and maintaining market links for poor entrepreneurs. Forms in which this can take place include through cooperatives, but also through the extension of commercial value chain links that take into account the producers.

Energy and getting a job

In sections 'Energy and earning off the land' and 'Energy and earning in a micro or small-enterprise', poor people are, under the International Labour Organization's (ILO) definition of employment, 'self-employed'. The other way people can earn a living is 'paid employment' and, getting a job working for someone else, whether a public or private organization, is the other main way in which income can be earned. Increasing energy use in employing enterprises, usually larger firms, has a complex effect on the opportunities for poor people to earn a living, with both positive and negative dimensions depending on the sectors and firms in question, and the national regulations with regards to worker rights and organization.

Paid employment can be on either a full or part-time basis. In some sectors, particularly the agricultural sector (as illustrated in Figure 2.3), seasonality of employment is an important factor as people can be in full-time employment, but only for a portion of the year.

Figure 2.3 Percentage of people working on different time basis in Nepal, Kenya, and India



Source: Ministry for Health and Population et al., 2007; KNBS and ICF Macro, 2010; IIPS and Macro International, 2007

Employment can be formal or informal, depending on whether it is recognized by the state (and generally taxed) or operating outside of official markets and accounting systems. For poor people, informal employment makes up the largest proportion of employment, accounting for 72 per cent of non-agriculture related employment in sub-Saharan Africa (ILO, 2002). However, enterprises at a scale where they have a substantial number of employees are more likely to be in the formal sector, and most informal employment is within the self-employed category.

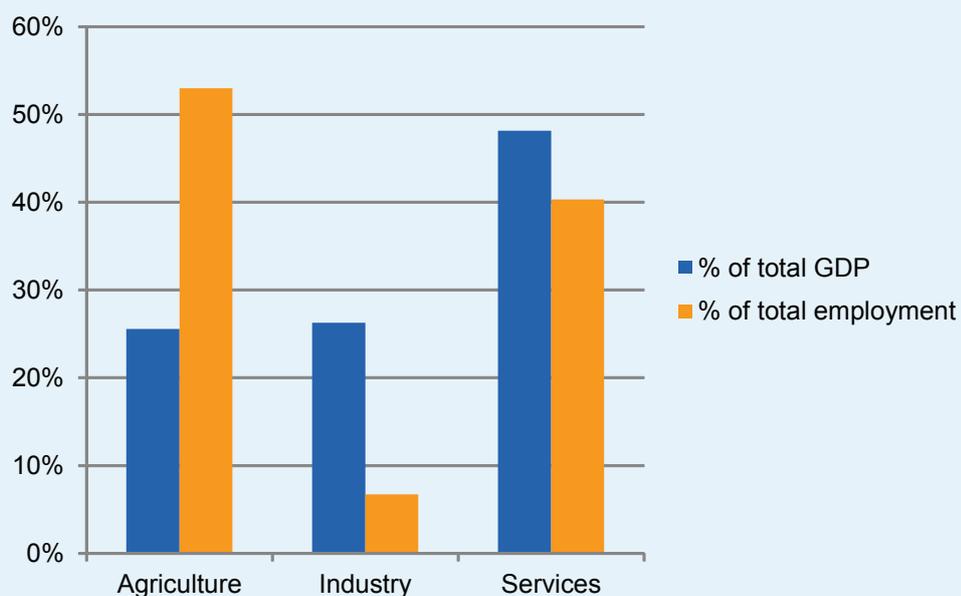
It is important to differentiate between a job and decent work, which is defined by ILO (2002) as ‘work that gives people the opportunity to earn enough for themselves and their families to escape poverty, not just temporarily but permanently’. Care is required to differentiate between those self-employed but operating at margins which leave them in poverty, compared with those with a job at a wage which leaves people below the poverty line, either because there are not enough hours available, or because the wage is too low.

Where can decent jobs be found?

Data availability on informal employment is scarce, and even information on formal employment in poor countries is often incomplete. However, what information is available gives an indication of the proportions of people in employment. For the 11 countries in sub-Saharan Africa who have reported to the ILO on employment statistics in the last 10 years, Figure 2.4 shows employment sectors as a proportion of total employment, and as a proportion of GDP.

The orange bars in Figure 2.4 highlight the importance of agriculture (including hunting and forestry) as the major employer overall, followed by services. Very important informal sectors, including production of biomass energy (see next section) are however not captured in these statistics, even though they are important in considering overall trends in the availability of jobs (PPEO 2010).

Figure 2.4 Average employment percentage per sector versus average GDP percentage in 11 sub-Saharan African countries



Source: ILO statistics on Africa and CIA World Factbook, Practical Action analysis.

Comparison with the blue bars, which indicate the sector's share of GDP, highlights that the availability of jobs in a sector is not necessarily in direct proportion to the scale of the industry in terms of turnover. Agriculture can be seen to employ a disproportionate number of people compared with industry, in contrast to their contributions to GDP. Services employ a similar proportion of the workforce to GDP, because of the inherent human factor in service provision. This should be considered in targeting of support for energy access with the intention of creating employment.

Within these sectors, the establishments which are in a position to pay employees for their services include enterprises of small, medium and large scale (where micro are considered owner-operator enterprises with no employees), as well as public services and institutions such as the civil service, public schools, hospitals, as well as other private but non-profit institutions such as universities and NGOs.

In the Indian rural agricultural sector for example, most employment is owner-operators earning off the land, while a lower proportion are farms with hired workers. Manufacturing by contrast is mainly conducted via enterprises with hired workers in both rural and urban contexts. The retail trade has more owner-operators in rural areas, however in urban areas most retail trade is done by enterprises with hired workers. In urban areas there are generally more establishments providing employment, with almost four times the number as owner-operator establishments (MOSPI, 2010). This reflects the pull for people to go to urban areas to 'find work'.



The role of energy in creating job opportunities

Increasing use of energy services can have both positive and negative effects on the accessibility of employment for poor people in the sectors above. In some cases it can reduce the need for unskilled labour, often provided by poor people excluded from education and skills training systems. However, in the employment sectors of agriculture, industry, and services – all are seen to be improved in their efficiency or quality through the application of energy services (e.g. improved productivity of agriculture, lighting, ICTs in education, and energy services for increased comfort in hotels and restaurants).

In general, increases in energy access are correlated with increases in economic growth which, mediated by factors such as labour intensity, increase the availability of jobs – however the relationship is complex and increased employment is not guaranteed (UNDP, forthcoming). As clearly illustrated in Figure 2.4 for sub-Saharan Africa, the dominant employment sector is agriculture, and this is also the sector often most accessible to poor people. In rural areas of India nearly 63 per cent of the male workers are engaged in the agricultural sector with an even higher percentage of women in this sector at 79 per cent (MOSPI, 2010). The relationship between energy and the availability of decent work in the agricultural sector is a complex one and involves both agricultural sectors which require energy in order to exist (e.g. tea sector) and also, with the emergence of biofuels, energy crops themselves are being produced (see next section on ‘Earning from supplying energy’).

The previous section on ‘Earning from your own micro small-enterprise’ addressed the various ways in which energy supports different types of enterprise activities. The types of energy services used in larger enterprises and activities which

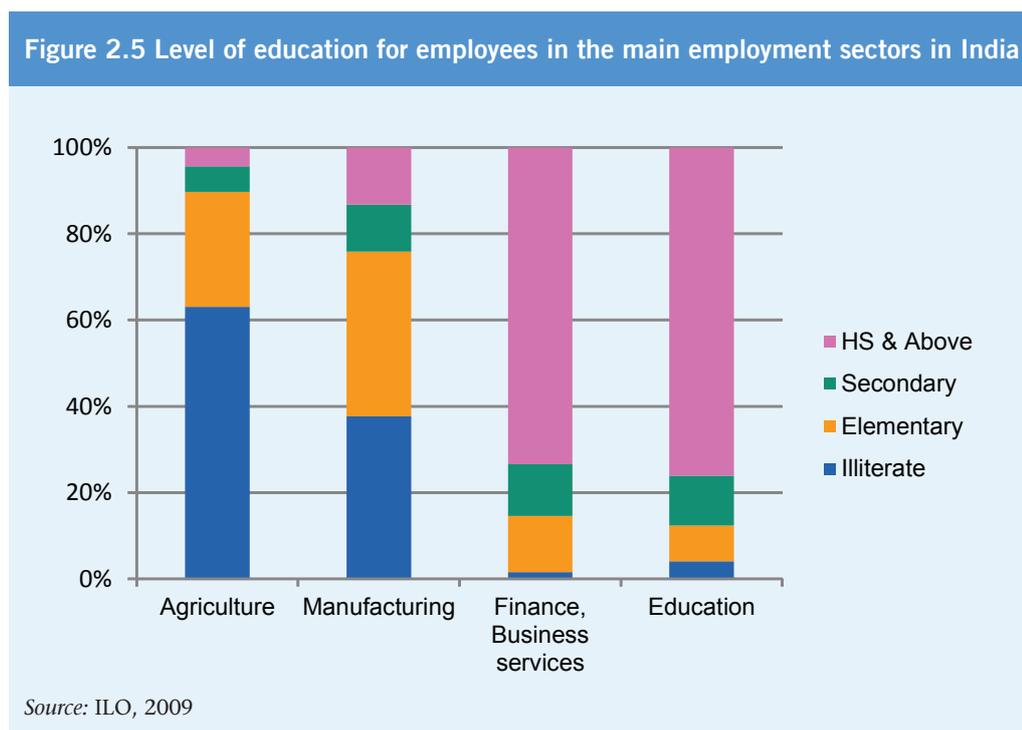
provide paid employment are not so dissimilar as to warrant separate analysis, other than to point out the larger scale and more multidimensional nature of energy inputs into larger and integrated enterprises.

In practice the connection between energy access and the availability of jobs connects largely with the growth of the enterprises, and employment intensity of that growth. There are many factors that contribute to this growth, including availability of finance, market access, availability of skills, access to resources, conducive regulatory environments, management capacity, and others. Not least amongst these factors however, is access to adequate, affordable, and reliable energy.

In an enterprise survey in sub-Saharan Africa (CGDEV, 2009) electricity was cited as the top elemental constraint on enterprise growth in 11 of the 30 countries surveyed, and second in nine 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.

What is of most interest from poor people's perspective is the extent to which energy access affects the number and accessibility of jobs that poor people can access. 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 that labour is preferred less to automated solutions in some cases. Enterprises using greater levels of automation and energy services in the form of ICTs, for example, also require personnel with increasing levels of education and skills. Unless support or training is provided, this excludes 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.

The educational profile of workers in different employment sectors in India is



illustrated in Figure 2.5.

Skills requirements however also go beyond academic education and in developing employment practical training and skills development also has an important role. This is particularly true in the provision of technical products and services, including energy – as discussed in the practitioner perspective in Box 2.8.

Box 2.8 Practitioner's perspective – appropriate technology training

Experience has shown that education and skills development in their conventional forms may not necessarily respond to the actual needs on the ground be it in energy supply, processing of the agricultural produce, or even in water supply. The main problem is that the training institutions tend to maintain uniform, standard curricula most of which are borrowed from developed economies and the academic world, and may not necessarily address the nature of the problems affecting developing countries.

At the technical level, attention must be paid to the use of local materials and the ability to maintain and repair technologies. To this effect, one needs to come up with innovative ways of combining the general conventional 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

Summary

As with MSEs, adequate, affordable, and reliable energy access has the potential to improve the productivity and efficiency of enterprises, and in this way improves their viability and growth potential. In general, economic growth is linked with increased use of energy, and economic growth can be expected to create jobs overall.

However, whether enterprise success or growth is translated into increased opportunities for employment to poor people it depends on the employment intensity of growth and the accessibility of employment opportunities created.

Improved returns on employment (higher wages or improved benefits) depend on the extent to which improvements in enterprise viability are passed through to employees. Where progressive taxation policies are in place, labour organization is possible and protections such as minimum wage legislation are available, then such energy-linked improvements can lead to more and better opportunities for earning a living.



Earning from supplying energy

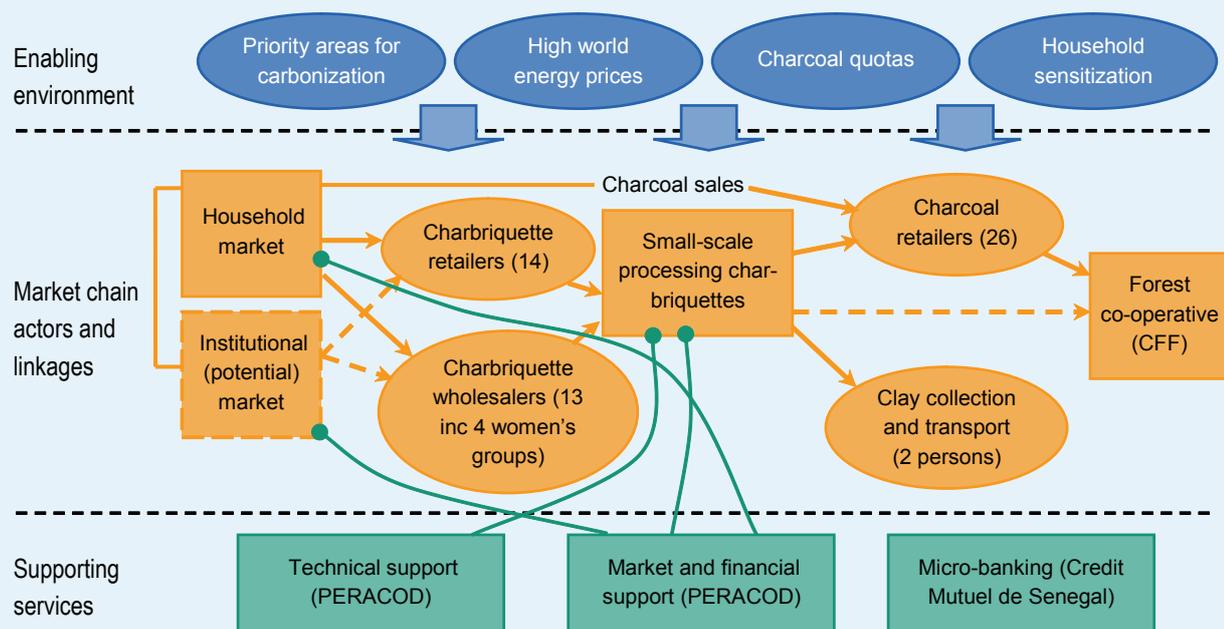
The previous sections outline the role that productive uses of energy play in enabling poor people to earn a better living, however the supply of energy itself represents an important employment sector with great potential for growth if access to energy supplies and services are increased.

To gain a deeper understanding of this potential it is useful to separate the supply of energy into three elements:

- **Fuel** – the energy source. All fossil-fuelled energy supplies and services, as well as bioenergy supplies including fuelwood, charcoal and biofuels. However this is not applicable to many other renewables.
- **Conversion equipment** – how the energy source is transformed into an energy supply. This is very important for renewables and includes solar panels, wind turbines, hydro schemes, and charcoal kilns, but is also important for fossil-fuelled systems including generators for producing electricity for a household or enterprise.
- **Appliances** – the way energy produces the energy 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.

Figure 2.6 Market system for charbriquettes in St Louis, Senegal



Source: FAO/PISCES, 2009

The significance of bioenergy

Currently the most important energy supply sector providing earnings for poor people is the bioenergy sector. The market map in Figure 2.6 illustrates the value chain for charcoal and charbriquettes, a principal form of bioenergy, in a town in Senegal.

Figure 2.6 illustrates the diversity of steps and corresponding livelihoods activities associated with the charcoal sector, as well as the additional opportunities when the charcoal dust is used to create additional value in the form of charbriquettes. Bioenergy has particularly long and pervasive value chains through rural areas, including agri-forestry, processing (e.g. carbonization), and distribution. Improved cookstoves to use the fuels are a linked manufacturing value chain providing the appliance for use of the fuel. Fuelwood and charcoal are today important existing sources of earnings for poor people, often second only to agriculture in rural areas of developing countries (*PPEO 2010*). Improved efficiency technologies in production and use, and formalization of these sub-sectors (currently often grey markets and so heavily affected by corruption) would improve, and make more sustainable, returns for the millions of poor people working in this sector (*GIZ, 2010*).

Biofuels are emerging as another earning opportunity in rural areas, which effectively creates a new valued product alongside existing cash crops, primarily food and fibres. However it is challenging for poor farmers to understand how, and if, to engage with this emerging market, which is driven by export promotion and external priorities, and there are uncertainties associated with switching or integrating biofuel crops. But for those farmers for whom producing current crops is no longer competitive, biofuels provide new earning opportunities if governance and legal protections around the sector are in place (*FAO, 2011*).

The earning opportunities of improving energy access

Creating TEA and improving energy supplies will entail widespread change in the existing energy sectors of poor countries. This will create many opportunities for earning in underdeveloped sub-sectors, but this change will also affect existing employment sectors such as the currently dominant fuelwood and charcoal markets.

Box 2.9 Kenya – sustainable charcoal production

Kenya's forest resources cover only 1.7 per cent of the country's 58.2 million hectares and are estimated to be decreasing by 2 per cent annually. Firewood is mainly a rural fuel with over 90 per cent of Kenya's rural population dependent on it. Charcoal made from wood, on the other hand, is produced by rural people as a source of income. Charcoal is mainly an urban fuel, with 82 per cent of the urban population using it, mostly with improved stoves. In 2002, the Youth to Youth Action Group, with financial support from Thuiya Enterprises Ltd, initiated the community-driven commercial afforestation project, using two types of Acacia tree to make charcoal, in order to enhance the livelihoods of the local communities. Charcoal has previously been thought of as only semi-legal, so those involved in this initiative have to overcome social barriers to manufacture it. There is a high level of collaboration between several groups of actors, with legal contracts ensuring that each party gets paid for their efforts.

Source: FAO/PISCES, 2009.

Table 2.4 overleaf 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 described in the *PPEO 2010*.

It is important to note that whenever a switch is made from essentially no supply/service to creation of a service – as in the case of creating an electrical connection, providing refrigeration or heating – earning opportunities are created, but few put at risk. In the examples where a new supply is created which displaces labour, e.g. mechanical power, then reduced labour is needed, which can reduce employment, but also act positively in improving efficiency and returns while reducing drudgery and opportunity costs. In cases where another fuel, equipment or appliance is being used already (e.g. for cooking and lighting), then a switch would change the employment profile, depending on the change.

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 in China, primarily for cost reasons. This makes the product more affordable in poor country contexts, and although local manufacture would create more local jobs than distributing imported lanterns, at present, this is not as viable from an end cost point of view. And in this case, if there is no product, then there is no distribution chain either – so no jobs at all. This does depend on the nature of the energy product, particularly its complexity, the degree to which costs can be saved by mass production, transport costs, and trade restrictions.

Table 2.4 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 courier 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)

Nonetheless, the benefits in terms of local job creation and reducing fossil fuel consumption can also be important factors in terms of directing energy policy – which generally seeks to internalize these otherwise externalized benefits. This is the approach which Brazil has taken for example in creating the ethanol sector as described in Box 2.10 and this model is being exported to other countries, including in sub-Saharan Africa.

Box 2.10 The Brazilian ethanol sector

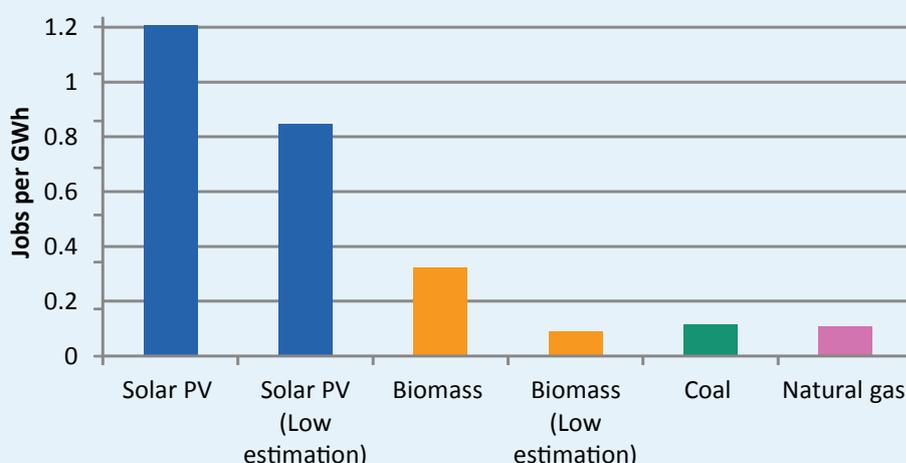
Brazil's ProAlcool programme has created the world's foremost ethanol economy and made it the second largest producer globally. Rural job creation has been a major benefit of ProAlcool because alcohol production in Brazil is labour intensive. Around 700,000 direct jobs, plus three to four times this number of indirect jobs have been created. It has cost between US\$12,000 and 22,000 to create each job, which is around 20 times less than in the chemical industry by comparison. Of the 700,000 total jobs, around 300,000 are cane cutters earning \$300-400 per month, on a piece rate. Cane cutting is seasonal however with cutters earning \$1.35 per hour each day for six days a week during the growing season of six to seven months (APEC, 2010).

Source: UNDP, forthcoming.

Employment intensity of energy sub-sectors

Future estimates of the requirements for universal energy access by 2030 suggest that of the 952 TWh of electricity generation required annually, 400 TWh will come via mini-grids and 172 TWh from isolated systems (IEA, 2010). If this transition is to occur then a huge number of jobs would be created in the decentralized energy sector. Expansion of grid power would also create jobs, although potentially less per GWh as described in Figure 2.7. The relative employment intensity of renewables is a key argument in support of low carbon energy access.

Figure 2.7 Estimated jobs created per GWh



Source: Kammen et al., 2004; Huntington, 2009

Demand-side earning implications of improved energy use

Although this chapter focuses on the use of improved energy services in earning and enterprise scenarios, the earning implications of a lack of energy access in the household also have to be considered. Supplying improved fuels, equipment, and appliances to households also generates potential impacts on earning now and in the future. For example, when children cannot study at night due to a lack of light, their educational attainment reduces (*PPEO 2010*) with implications on their future employability. Drudgery in the household due to lack of energy access is also connected with 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 health impacts that both restrict family member's ability to earn a living due to illness, as well as draining family finances on costly medical treatment.

A 2006 WHO publication evaluated the costs and benefits of household energy and health interventions. The analysis included both a shift from solid to gas and liquid fuels, as well as the use of cleaner burning stoves.

Economic benefits were calculated to include reduced health-related expenditure as a result of less illness, the value of assumed productivity gains resulting from less illness and fewer deaths, time savings due to the shorter time spent on fuel collection and cooking, and environmental impacts at the local and global levels.

Studies show that the most significant contribution to economic benefits switching from cooking with biomass to LPG was time saved that was invested in other productive activities. Other economic benefits include mitigated health costs, and environmental impacts. Further, when these benefits are offset against the costs of switching, a return of almost US\$7 is realized for every \$1 spent, suggesting that the opportunity cost of time savings and other benefits will yield 7 times the gain as compared with the cost. Given that the vast majority of this benefit is time savings, this benefit would largely be realized at the household level.

Summary

The supply of energy is today a vital sector of employment for millions of poor people living in the developing world. The production of bioenergy continues to be an important source of income for poor people and often encompasses long and job-intensive rural value chains.

This energy-sector employment would become far more important if the target of universal energy access by 2030 was achieved in the multiple dimensions of energy access. New job opportunities would be created by appliance, equipment, and fuel provision, although fuel switching would also displace a proportion of traditional energy sources.

Although both centralized and decentralized sources of energy supply have an important role, in general decentralized systems have a more direct impact on the ability of local people to earn a living through the supply and maintenance chain.

Summarizing energy for earning a living

Energy has been shown to have important connections with earning a living for poor people in the four key earning opportunities of earning from the land, earning from running an MSE, getting a job, and earning from supplying energy. In each case, new earning opportunities, improvements in existing earning activities, and reduced opportunity cost benefits are indicated from increased energy access.

Access to energy creates **new earning opportunities** as some SME opportunities are only possible with improved energy access, while increasing access is correlated with enterprise growth and new job creation. There are also significant new employment opportunities in the energy supply chain required to meet universal energy access and to reach the targets in rural areas, markets for decentralized renewable energy will need to expand. Figure 2.7 shows that these sources of energy, such as solar and biomass are relatively employment intensive and therefore likely to significantly expand job opportunities.

Agriculture is one of the most significant contributors to the ability of poor people to earn a living and is also one of the areas where energy can have the greatest impact in terms of **improving existing earnings** – energy has a key role along the entire agricultural production chain, improving productivity, producing better quality, and earning more from produce. Mechanical power enables more land to be cultivated and the productivity of irrigated land (often requiring pumping) is more than double that of rain-fed land. Improved agricultural processing and storage/cooling are energy services expanding incomes for farmers, while creating employment in the MSEs sector. Many MSEs can lower costs, improve efficiency, broaden service offering, and improve returns via more affordable, reliable, and quality energy supplies.

There are also a number of **opportunity costs** associated with not having access to energy that have been seen to greatly impact on earning potential. This includes reduced drudgery in enterprise activities such as grinding, milling and aspects of farming. However, it also includes lack of light to study in the evening affecting educational attainment and future earning potential, as well as time spent collecting firewood or cleaning pots from a smoky fire, and time spent in ill health due to indoor smoke inhalation. Key factors that keep people locked in a cycle of poverty.

Although positive benefits of energy access on earning a living have been shown, some potentially negative impacts have also been identified in labour displacement and skills lock-out for poor people, in particular via transitions towards automation and between fuel types. Additionally, the non-automatic nature of the realization of the benefits of energy access in earning a living have been explored highlighting key disconnects, and the steps that can help overcome these.

Improved energy access, while an important enabler, is not a guarantee in itself of an increase in the viability of MSEs, or the incomes of the people running them. There are several steps between improved access and greater incomes which are often overlooked when taking a purely energy supply perspective. Figure 2.8 summarizes the steps along the way to realizing the potential of energy access to improve incomes and achieve development objectives. It also shows some of the tools available to policymakers and practitioners in order to overcome the barriers to progress.

The *PPEO 2010* proposed a set of 12 minimum standards for access to energy services in the home – referred to as Total Energy Access. These standards define the level of energy services required for poor people to meet their basic needs. The

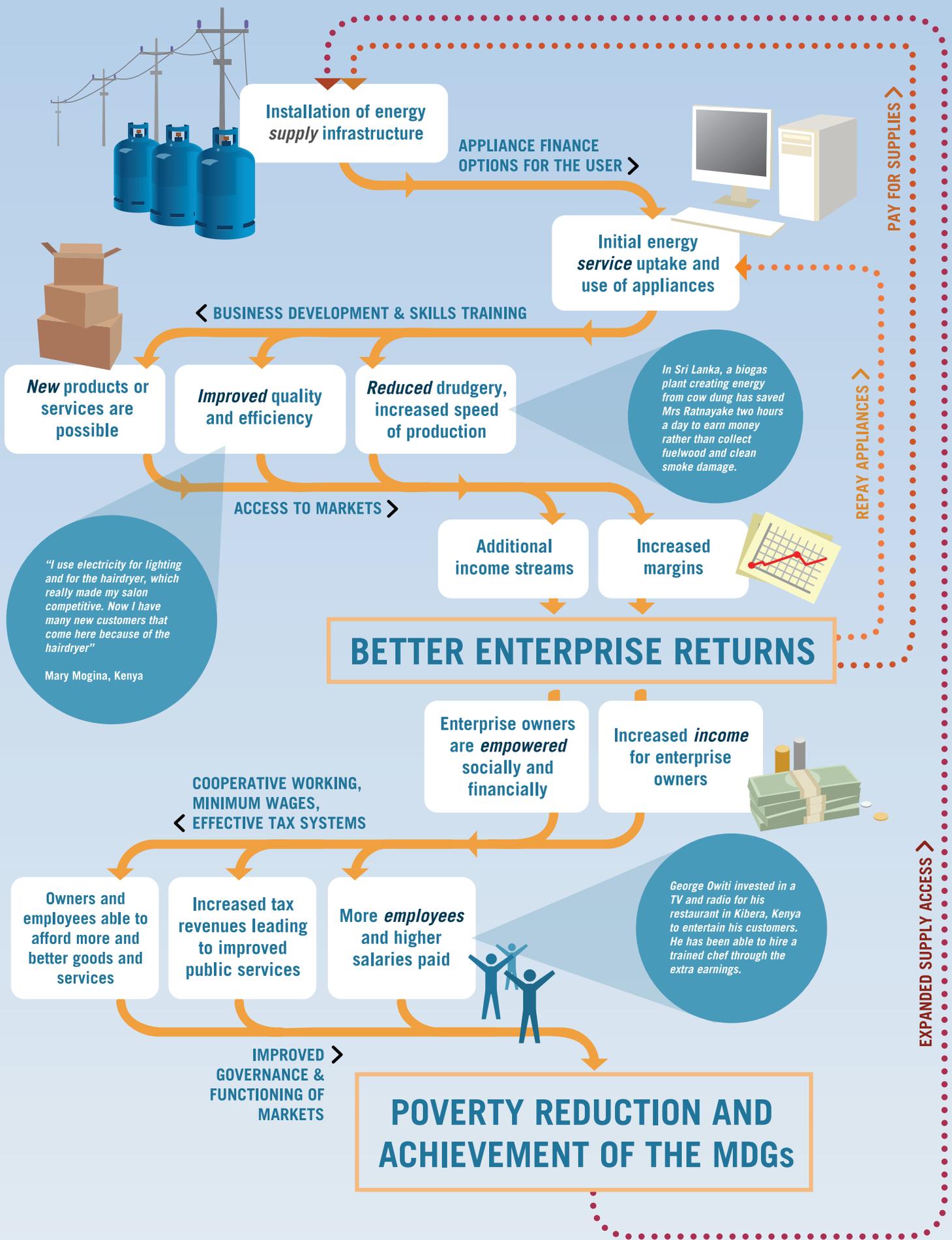


Figure 2.8 Steps from energy supply to earning a living

Source: adapted from Kooijman, 2008

Energy Supply Index outlined the qualitative dimensions of the three main supply dimensions that can deliver these services when appliances are in place.

However, the wide range of energy services required in enterprises and variable energy consumption requirements, based on the scale of the enterprise not on physiological or health factors – make defining a similar set of minimum service standards for enterprises less useful and representative.

Whilst it is the energy services that are employed in the enterprise activities, an access indicator that considers the reliability, quality, affordability and adequacy of energy supplies is considered more useful as a measure of enterprise energy access. Given that the appliances used are an integral part of that supply system, the PPEO would propose to include an indicator of each of these parameters for the appliances used also.

Table 2.5 Enterprise energy access matrix

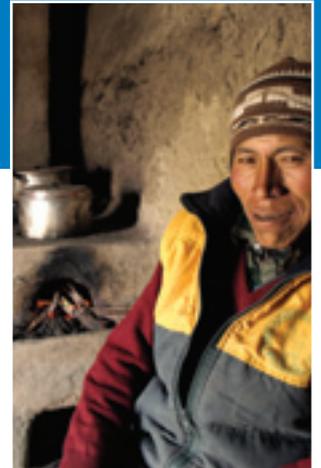
Energy supply				
	Electricity	Fuels	Mechanical power	Appliance
Reliability	Availability (hours per day) Predictability (timetabled or intermittent)	Availability (days per year)	Availability (days per year)	Downtime (%), linked to ease of maintenance and availability of spare parts
Quality	Voltage and 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)

Table 2.5 then develops the Energy Supply Index (ESI) further, with a particular focus on enterprises. The ESI for households (see Chapter 3) is more focused on the cleanliness, health, and convenience of the energy supplies, matched with household and human needs. Human physiological needs and rights are the main measure of adequacy for a household, but these are reflected in the TEA minimum service standards rather than a minimum supply level. In the case of an enterprise the adequate level of energy supply will depend on growth, and may increase over time.

While reliability and quality are part of the household ESI metric, although in less detail, affordability was not, since it was argued that this was less relevant than what people are actually accessing. This is on the basis that if a supply level was more expensive than people could afford, people would move to a lower level, with impacts visible on reduced service standards. With respect to the viability of enterprises however, energy costs can be a critical portion of operating costs, making affordability a critical dimension of people’s ability to earn a living from energy.



3. People's experience of energy



While energy for earning a living is the focus of this year's *PPEO*, it is still important to set this in the context of the energy needs of people at the household level. These needs are not directly 'productive' but they must be met for people to remain healthy and ensure that the tasks of staying alive do not impede opportunities and aspirations, including education and earning. This was the focus of the first *PPEO* and it is a theme that will continue in Chapter 3.

Poor people's true experience of energy poverty is often hidden because there is no internationally agreed definition of 'energy access'. And yet how we define energy access is critical in determining how we tackle energy poverty.

The *PPEO 2010* defined Total Energy Access through a series of minimum standards for access to the key energy services, which all people need, want, and have a right to. This approach, based on energy services at point of use, has since been refined through international consultations, and piloting in communities in three countries in Latin America, Africa, and Asia. It is updated in this chapter as a practical tool for measuring the status and progress of energy access at household level.

The TEA approach has connected with the viewpoints of others working on this issue: UNIDO et al., (2011) for example states that 'current supply side approaches that focus on the provision of modern energy carriers are not sufficient for reaping the full potential of social, economic improvements which follow from improved energy access'. The UN Secretary-General's Advisory Group on Climate Change (AGECC, 2010) goes beyond this, defining energy access as 'access to clean, reliable, and affordable energy services for cooking and heating, lighting, communications, and productive uses'.

However, the most widely cited definitions of energy access continue to focus on energy supply in terms of connection to grid electricity and use of 'modern' fuels. Such definitions imply a binary, which does not exist in most people's real experience of energy access. They disguise a continuum of reliability, affordability, convenience, and health impacts associated with different energy supply realities. This continuum was recognized in the *PPEO 2010* in the Energy Supply Index of progress on the quality of energy supply an update of which, again based on consultations and piloting, is presented in this chapter.

To present people's experience of energy it is not sufficient just to look at averages of sparse national data and extrapolate down. Instead it is necessary to talk to people and understand real needs, preferences, and constraints, and then

“ How we define energy access is critical in determining how we tackle energy poverty ”

also extrapolate up. When this reality is considered in definitions of energy access alongside technical considerations, and people’s voices are integrated alongside national data – then there is a basis for real progress.

Total Energy Access – an integrated set of minimum service standards

The original TEA categories – lighting, cooking and water heating, space heating, cooling, and ICTs – each with minimum standards, were proposed for debate after research and consultation in the preparation of the *PPEO 2010*. These have since been refined and improved via international consultation and piloting in three countries: Kenya, Peru, and Nepal. The results of these pilots are analysed later in this chapter.

The main refinement is that the TEA standards now focus exclusively on the level of the household, while enterprise and community service energy needs are recognized as separate and complimentary levels as highlighted in the introduction (Figure 1.3). Chapter 2 has proposed a framework for measuring levels of energy access for earning a living and the level of the enterprise. Next year’s report will focus on energy for community services and will develop a framework accordingly.

Other than refinement of the details in the standards, the other main development is that the TEA minimum standards have been turned into a practical survey tool in the form of a standardized questionnaire with 14 yes/no questions relating to proxy indicators of the standards having been met. This means that anyone with an interest and minimum level of training is able to quickly develop a clear but textured and comparable picture of the energy access status of a household. The updated TEA service categories and minimum standards are provided below, and the corresponding questionnaire is provided in Annex 1.

A household that meets all of the nine minimum standards is judged to have ‘total energy access’ and a lack of energy services no longer holds them in darkness, drudgery, and ill health. Where energy services are not required due to climatic conditions, such as space heating in hot climates, these services are considered met.

Table 3.1 Total Energy Access minimum standards – revised for 2012

Energy service	Minimum standard
Lighting	1.1 300 lumens 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 or 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 (PM2.5) < 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°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°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

Where a household meets some but not all of the minimum standards, a basis for action is created by the clear identification of service gaps. This enables possible interventions to be prioritized and the mapping of supply and appliance solutions onto the remaining needs. The progress of households on the transition towards TEA can also be tracked.

Box 3.1 TEA comparison with linked energy service indicator systems

The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) also considers energy services as key to measuring energy access and has also proposed minimum indicators. The TEA minimum standards and GIZ indicators share the same approach and some indicators are common, but there are also some differences. The GIZ indicators prioritize lighting, cooking, and ICTs (and so do not include space heating and cooling), and include additional criteria for safety, affordability, and accessibility, asserting that:

- all energy sources and technologies (lamp, stove) are not hazardous to health, do not emit high amounts of particulate matter and fulfill basic safety standards
- expenditures for energy do not exceed 10 per cent of the household income or not require more than 10 per cent of the working hours of a household member

While safety is a critical issue and the TEA standards cannot be met with inherently unsafe technologies such as polluting stoves or kerosene lamps, no specific criteria are included relating to varying product and national safety standards, other than indoor air pollution as in the GIZ proposal.

For energy to enable poverty reduction and development, access should be available without an excessive burden on the income of a household, or consume inordinate amounts of people's time. However measuring affordability as a percentage is challenging since household incomes are often seasonal, men and women may split the household's income and certain costs including energy, and expenditures include appliance purchase and fluctuating fuel prices. In the TEA standards it is preferred to maintain the service as accessed or not, rather than integrate measures of perceived affordability.

Measuring time spent collecting fuel as a percentage is also difficult as fuel use and collection times vary between seasons, family groups often collect wood together, collection and purchase may happen alongside activities such as animal grazing, shopping or returning from school. In the TEA an absolute number of 30 minutes per day is preferred as minimum standard.

The Multidimensional Poverty Index (MEPI), (Nussbaumer et al, 2011), is another international measure in development that recognizes the variety of energy services required to measure energy poverty, cooking, lighting, refrigeration, entertainment/education, and communications. The MEPI is a composite index, generating an energy poverty score between 0 and 1 based upon access to the above five dimensions. It uses existing data to determine access to energy services, for example, a household with access to electricity is judged to have lighting, or owning a mobile phone equates to meeting telecommunication needs. The MEPI provides a useful insight into the macro energy situation in a country and allows comparison between countries or regions, but the aggregation of data is less relevant at community or project level.



Energy supplies – carriers for energy services

While Total Energy Access defines the energy services people need to escape poverty – the ultimate yardstick of energy ‘access’ – it is also important that the *PPEO* consider the supplies from which these services are derived. The quality of supplies has important implications on which energy services can be achieved, and at what levels of health impacts and convenience.

The *PPEO 2010* proposed the Energy Supply Index (ESI) as a means of measuring the quality of energy supply. The ESI measures the three main supply dimensions of energy access – household fuels, electricity, and mechanical power – by assigning discrete levels to the qualitative dimensions of people’s experience of accessing them.

This index has also been updated in response to feedback and comments on the *PPEO 2010*. Specifically an additional level 0 has been added and the levels have been clarified and refined to capture some additional cases, which were highlighted as ambiguous in the original index.

Of the energy supply dimensions relevant to a household, household fuels and electricity are now widely recognized as two key supplies for people living in poverty. The ESI however also recognizes the contribution of mechanical power in increasing the efficiency and effectiveness of productive activities (see Chapter 2), as well as physical processes fundamental to meeting basic human needs, especially pumped water and processed food, which are of particular relevance to reducing the burden of household tasks which often fall on women. In spite of the importance of mechanical power in meeting everyday energy needs, its role is generally under recognized since it can also be derived from electricity or liquid-

Table 3.2 Energy Supply Index 2012 – revised quality levels

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.

fuelled engines (UNDP/PAC, 2009). This is by no means automatic however, and so the ESI maintains a separate measure of supply of mechanical power reflective of its important role in the lives of women in particular.

Critically, the ESI also recognizes that access to energy supplies cannot usefully be divided into those with ‘modern’ supply and those without, given the reality of the mixtures of fuels, equipment, appliances, and practices which people use. The ESI levels instead indicate possible transition pathways towards cleaner, healthier, and more convenient supplies, by defining a series of incremental qualitative improvements. These improvements are interlinked with broader socio-economic development, which is also in turn enabled through improved access to energy.

An understanding of the full range of energy supply transition pathways is important as we plan for increased energy access and the target of universal energy access by 2030. It is not realistic, or perhaps even preferred, that all of the 2.7 billion people cooking on traditional biomass (IEA, 2010) switch to cooking with a liquid or gas fuel, nor to suppose the 1.4 billion people without electricity will receive a reliable grid connection. Grid reliability and quality is variable, and strongly influences the extent to which people can use it for the energy services they need. Substantial improvements in supply quality are also possible in all dimensions using decentralized technologies including solar home systems and improved biomass cooking facilities. Such variations and improvements can be tracked and valued in the ESI in a way not possible in other binary supply side metrics.



Total Energy Access in practice

To practically measure status and progress on TEA, a standardized questionnaire has been developed from the practitioner e-consultation held early in 2011 in collaboration with GIZ on the HEDON platform. Practical Action then trialed the use of the updated TEA minimum standards and ESI index in households in a total of six communities in Peru, Kenya, and Nepal. Feedback from this trial was used both to validate the questionnaire and tool, as well as to identify initial common and differentiated trends in service and supply access, which are typically not picked up in other access indicator systems.

The TEA questionnaire, provided in Annex 1, comprises of 14 yes/no questions to be completed through an interview with a household member. The questions use proxy indicators of service and appliance use in the same way as the MEPI approach to avoid extensive household monitoring, although this can also be done if resources allow. Discussing the energy supply situation with a household and identifying the appropriate levels can determine the ESI score. In this trial phase, a series of additional contextual and preference questions were also asked in order to establish why people did or did not have access to particular services and supplies.

Pilot communities were selected representing different regions, including both urban and rural areas, and in diverse agro-climatic zones. In each country two communities were selected in close proximity, one with an improved and the other with a generally poor energy supply. In each community 50 households were asked about their access to energy services using the TEA questionnaire, and about the quality of their energy supply based upon the Energy Supply Index (ESI).

Box 3.2 TEA pilot community profiles

Kenya – the research was conducted in Nairobi in the urban slum areas of Kibera and Mukuru. The households surveyed in **Kibera** were close to a main road and many had illegal connections to the grid, whilst in **Mukuru** the households surveyed were further away from a connection so were without electricity.

Nepal – the communities of Hatiya and Handikhola in the rural district of Makwanpur participated. Makwanpur is in the central region of Nepal in the low hills bordering the plains extending from northern India. **Hatiya** is located next to the district capital with year-round road access and most houses connected to the grid. **Handikhola** is some distance further from the district capital and only accessible by road during the dry season, restricting the availability of imported modern fuels during the monsoon.

Peru – the Andean communities of Yanacancha Baja and Chaupirume-Chaupiloma, located at over 3,300 m above sea level, in the Northern Region of Cajamarca were surveyed. **Yanacancha** has benefitted from a decentralized micro-hydro scheme connecting 57 per cent of households, while the rest are connected to the national electric grid, installed in 2010. In contrast, **Chaupirume-Chaupiloma** currently has no form of modern energy supply, although plans to build a micro-hydro plant are in process.

Of all 300 households and nearly 1,400 people surveyed, it is stark to note that zero achieved Total Energy Access. The highest average score out of nine was achieved in Hatiya in Nepal with an average of 5.70, followed by the less well-connected Handikhola with 5.18. Kibera in Kenya had the third highest average with 4.84 while the nearby Mukuru area had the lowest score overall with 3.22. The Peruvian communities both also had an average of less than 50 per cent of TEA services with similar average scores in the hydro-connected Yanacancha at 3.36, with the non-connected Chaupiloma actually slightly higher at 3.48.

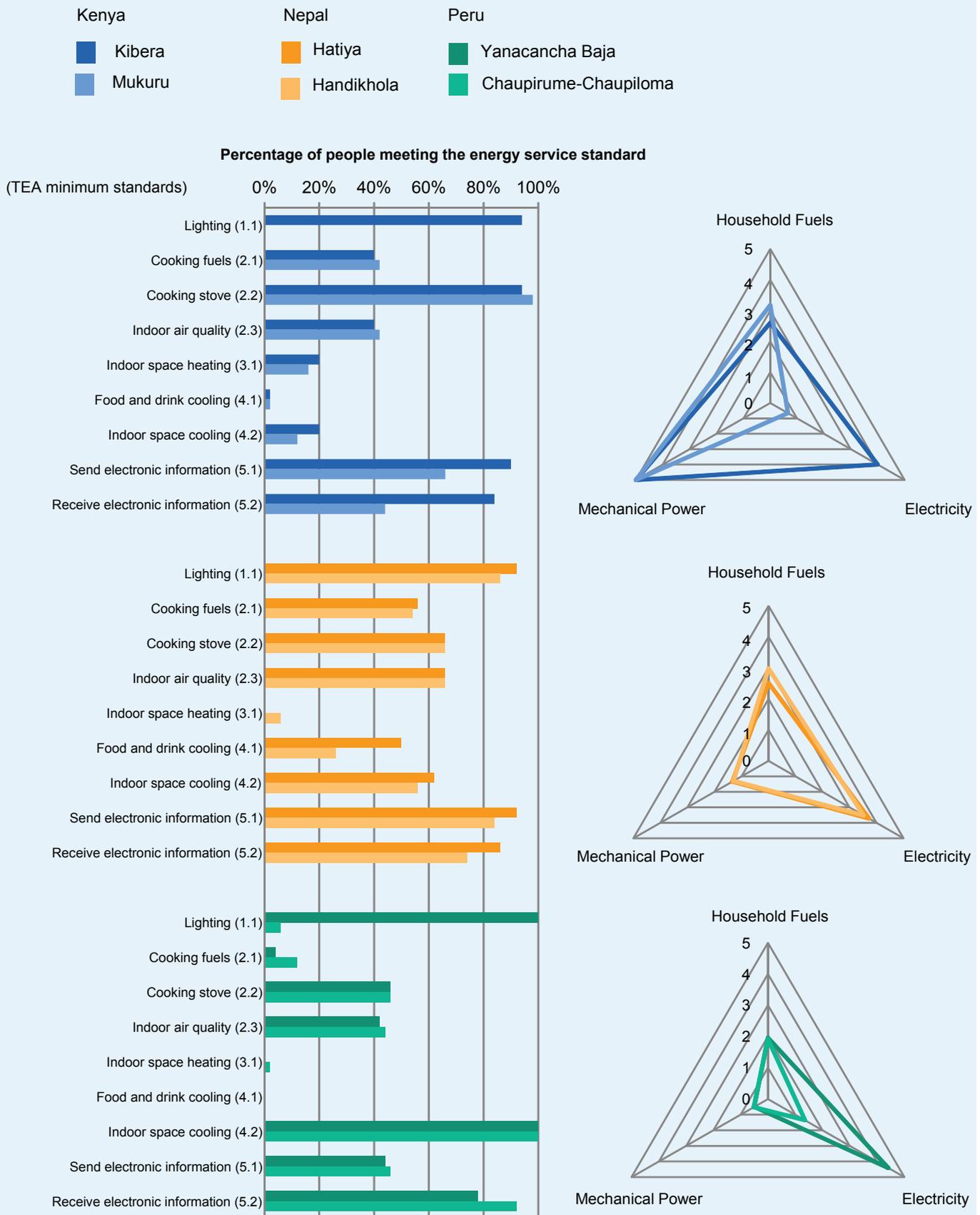
While averages can be a useful overall indicator, as the apparent discrepancy between the electrically connected Yanacancha and the non-connected Chaupiloma shows, the reasons behind these average access levels can only be understood when looking individually at the respective energy services and supplies which people can actually access.

Figure 3.1 presents the TEA survey results from the six communities. It shows the percentage of households achieving the TEA minimum standards according to each of the nine energy services for the six communities.

Although the sample sizes (and survey budgets) were relatively small, the results of this survey still provide a rich basis for analysis and comparison of the energy access status of households and communities. The results also point to potentially important insights in terms of people's preferences and priorities for energy services and supplies, which could be further explored and validated as larger and more representative samples are built up.

In this edition, locally collected data from the six communities is placed in the context of what national and international data is available, to explore the latest status of poor people's experience of total energy access. This reveals both the common human experiences of energy poverty, as well as people's varying approaches to overcoming its different dimensions.

Figure 3.1 TEA and ESI scores in the six communities of Kenya, Nepal, and Peru



Note: In some cases, e.g. Indoor space cooling in Peru, 100% achievement means that the households achieve the minimum standard in normal ambient conditions, without an energy service being needed.

Lighting

Household lighting is a fundamental need, required in the home to extend work and study hours, and allow household tasks and social gatherings. People without any form of electricity supply must resort to technologies such as kerosene lamps and candles that give off polluting fumes, pose a fire hazard, and are more expensive and of lower brightness than an electric light equivalent (PPEO, 2010).

To meet the TEA minimum standard for lighting, a household must have at least 300 lumens (a measure of light energy radiated by a light source) of light for a minimum of four hours per day. This level of illumination can only practically and safely be met with electric lights since kerosene wick lamps and candles are not strong enough to provide this level of light, while kerosene pressure lamps are notoriously dangerous. A total of 300 lumens is the equivalent of a 25 W incandescent bulb that can allow sufficient lighting for reading and study, and task lighting in the home.

In the three communities with electricity available from the national grid, Hatiya, Handikhola, and Kibera, four out of five households, representing more than 600 people, met the lighting standard. Of these households, many had more than one light and felt that their lighting was adequate. The houses that did not meet the standard were not connected to the grid, reportedly because they couldn't afford the connection fees and regular bills. These houses are mainly still using kerosene lamps, and many people expressed a desire for electric lighting in line with the TEA standard.

Of those that met the standard for lighting, many were still often deprived of lighting due to the unreliability of the supply from the national grid. Their scores on the Energy Supply Index indicate that their electricity supply is poor quality and intermittent. Research teams found that completing the ESI with people led to a good discussion about people's supply situation, and helped get a better understanding of how the quality of this supply affects the energy services they receive.

In Kibera, all of the households surveyed had electricity supplied by illegal connections tapped from the grid's transmission lines. However, not all people in the slum use this for lighting with another study showing that overall 55 per cent of Kibera's residents use kerosene, 42 per cent electricity, and 1 per cent candles (Karekezi et al., 2008). Compared to the option of illegal grid connection, many people still choose kerosene for lighting. Households can be without power for long periods if the authorities disconnect the illegal connections. Many people are also concerned about safety, due to the high number of electricity related fires and deaths linked to illegal sub-standard wiring.

In Kenya as a whole, as illustrated in Table 3.3, fewer than one-fifth of households meet the lighting minimum standard, with most people relying on kerosene and other low-quality fuels (KNBS, 2007). There is a significant divide between urban and rural areas, with 51.7 per cent of urban households using electric lighting compared to only 5.9 per cent of rural households. The disparity is mainly due to the low electrification rates in rural areas. The percentage of people using solar energy in rural areas is higher than in urban, but far from enough to provide comparable levels of electric lighting with urban areas.

In Hatiya and Handikhola (Nepal), the majority of houses surveyed had formal connections to the grid. People use the electricity for lighting, radios and televisions, charging mobile phones, and some houses have electric fans and fridges. Of the houses surveyed, it is common for people to have a few electric lights in their

“ Of those that met the standard for lighting from grid electricity, many were still often deprived due to the unreliability of supply ”

Table 3.3 Percentage distribution of households by main source of lighting fuel

	Firewood	Grass	Kerosene	Electricity	Solar	Gas	Dry Cells (Torch)	Candles
Kenya	4.5	0.1	76.4	15.6	1.6	0.2	1.1	0.3
Rural	5.8	0.2	86.4	3.9	2.0	0.2	1.4	0.1
Urban	0.5	0.1	46.4	51.0	0.7	0.2	0.1	1.0

Source: KNBS, 2007

house and most people responded that their lighting needs were adequately met, but felt it would be improved if they had a solar panel to provide power during the long periods of power outages in the country. People without grid electricity said they would like electric lights but couldn't afford the costs.

All of the houses surveyed in Yanacancha (Peru) meet the lighting standard with electricity supplied from either the community operated micro-hydro system or the national electricity grid. Despite having a 24 hour supply, only a quarter of the houses surveyed used the lights for more than four hours per day since most people leave their homes very early to travel to their distant farms and don't return home until late. Four-fifths of the households use more than two bulbs and 70 per cent expressed that their lighting needs were adequately met. A few people expressed dissatisfaction at recent technical problems with the system that had led to varying brightness of lights and even damaged bulbs. The community uses energy efficient, incandescent, and fluorescent bulbs, although the energy efficient bulbs are less common because they are more expensive and some people fear that they will break because of the fluctuations in the electricity supply. Factors in the quality, reliability, and cost of the supply will be key in determining whether people will switch over to the grid, or stay with the community micro-hydro scheme.

In the two communities without grid electricity available, Chaupiloma and Mukuru, only 4 per cent of the households surveyed met the lighting standard. In Chaupiloma 24 per cent of the interviewees had an electric light but only 4 per cent were able to be used for more than four hours a day, meaning only 4 per cent of households met the lighting standard. Solar PV panels were used to power their electric lights since they are a long way from the grid. The community also combine solar use with batteries, torches, oil lamps, and candles for lighting – although not kerosene since the Peruvian government has recently banned this fuel (Peruvian Times, 2009). The solar panels only allowed users to get one or two light bulbs in their house; most felt this was adequate but would like more bulbs and to be able to use them for longer. Every one of the houses without electric lights said they would like to change, but were unable to because there was no grid access and they couldn't afford higher capacity solar PV systems.

In Mukuru, Kenya, none of the households surveyed used any form of electric lighting, instead using kerosene lamps and candles. Solar PV products are available in Nairobi close to Mukuru but they have not been widely accepted by the people here as an alternative to grid electricity. There are several reasons why people choose their lighting fuel, principle amongst them are affordability, availability, quality, and convenience (Karekezi et al., 2008).

The survey results reiterate the connection between quality electricity access and adequate lighting. It is notable though that even in communities that are served with electricity, around a fifth of households were still left behind by the cost of connection, bills, or appliances and wiring. Closing equity gaps such as

“ Even in communities that are served with electricity, around a fifth of households were still left behind by the cost of connection, bills, or appliances and wiring

”

these must remain an important element of strategies for universal energy access, along with expansion of more reliable grid access, mini-grids, and standalone systems, including solar lanterns.

Cooking and water heating

Energy for cooking consumes more energy than any other single activity in most developing countries. Nearly 3 billion people cook using biomass and coal. There is a wide range of socio-economic effects of cooking in circumstances of energy poverty and the *PPEO* last year identified improved cooking practices as contributing to every single one of the MDGs. Women and children are the worst affected by traditional practices, with impacts on health, time spent in drudgery, and opportunities lost in terms of time that could be spent earning a living (see Chapter 2) or children missing education to help in the home.

“ Energy for cooking consumes more energy than any other single activity in most developing countries ”

Box 3.3 Practitioner’s perspective – cooking and children’s health, and education

There are a number of health impacts associated with smoke, respiratory illness, eye disease, lung cancer, and low birth weight. New-borns and infants are often carried on their mothers’ backs while they are cooking, or kept close to the warm hearth. As a result, they spend many hours breathing polluted air during their first year of life – just when their developing airways and immune systems are most vulnerable.

A lack of access to household energy interferes with a child’s access to education, especially for girls, who traditionally need to fetch firewood or other fuels for cooking and heating. This perpetuates gender inequality into adulthood where women are less able to find time for employment or further education. Research in rural Tanzania found that women in some areas walk 5-10 km a day collecting and carrying firewood with loads of between 20 and 38 kg. And in rural India, the amount of time spent collecting firewood is over three hours a day on average.

Lucy Stone, Climate Change Advisor to UNICEF UK

To achieve clean and convenient cooking, and reap the full range of socio-economic benefits from improved cooking practices, requires consideration of both the stove and the fuel, and how they combine in practice. Whilst the *PPEO* recognizes that designing minimum standards for cooking is extremely challenging, not least because cooking practices are so complex, varied, and changeable, the TEA standards attempt to determine what improved access looks like and promote an understanding of the factors that contribute to it.

The TEA outlines three minimum standards for cooking, relating to the type and amount of cooking fuel used, the type of stove, and the indoor air pollution (IAP) present in the house. Meeting all three indicates the household has a cooking practice that means they no longer suffer the hardships associated with traditional cooking methods. For a household to meet the fuel standard, they must have access to sufficient fuel to cook enough meals every day without expending more than 30 minutes per day collecting firewood. To meet the stove standard a household must be using a fuel-efficient stove that allows a 40 per cent reduction in fuel use compared to a three stone fire. A clean environment in which the family can cook

and live without suffering from a range of smoke-related health problems will meet the indoor air pollution standard.

Of the 300 households surveyed, 105 were cooking in a way that met all three cooking TEA minimum standards. The two communities in Nepal had the highest proportion of the three cooking and water heating standards met by more than half of households, followed by the Kenyan communities with around two-fifths of households, and fewer than one in ten households meeting all three in Peru. Considering all developing countries as a whole, access to 'modern' fuels is much greater in urban rather than rural areas, 70 per cent compared to only 19 per cent respectively. In sub-Saharan Africa this percentage drops to 42 per cent and 5 per cent respectively (UNDP/WHO, 2009).

It is important again to note that the standards were met using a variety of fuels and that each country had a different predominant fuel, with kerosene being prevalent in the Kenyan communities surveyed, biogas and LPG in the Nepali ones, and wood on an improved cookstove with extraction in the two Peruvian communities. Table 3.4 shows which fuels were used by the households meeting all three standards in the six communities.

Table 3.4 Fuels used by TEA pilot survey households meeting all three cooking minimum standards

	Kenya		Nepal		Peru		Total using fuel
	Kibera	Mukuru	Hatiya	Handikhola	Yanacancha Baja	Chaupiloma	
Biogas			15	25			40
Electricity	3						3
Kerosene	11	22					37
LPG	2		11	4	2		19
Wood (with ICS and extraction)						6	6
Total meeting 3 TEA standards	16	22	26	29	2	6	105
% of survey HHs meeting 3 TEA standards	32%	44%	52%	58%	4%	12%	35%
Energy Supply Index (ESI) – HH fuel community average	2.6	3.18	2.52	2.98	1.96	1.92	

Kenya was the only country with households using kerosene for cooking, using kerosene wick stoves in all cases. Kerosene is more widely used in Africa than other developing regions with 7 per cent of households in Africa using kerosene, compared to 4 per cent of all households in all developing countries. Kerosene is typically considered under the definition of a 'modern fuel' (UNDP/WHO, 2009), although a lot of the rudimentary wick stoves people fuel with kerosene are in practice inefficient and unsafe. The limited evidence available suggests that only the highest interim goal for pollutant levels (35 µg/m³) is likely to be met with kerosene stoves (Leaderer et al., 1999). Of the 33 households using kerosene, one felt it was very clean, 15 would like improvement, 12 felt it was polluting, and five said very polluting. The safety of the stove was also considered an issue with

14 households saying the stove was ‘rather’ or ‘very dangerous’. The TEA considers kerosene as meeting the standard but recognizes that further research is required to quantify the emissions from common kerosene stoves, and that unsafe stove variants cannot be considered compliant.

Kibera was the only community with households using electricity for cooking, and here only three houses were using it. Another study in Kibera reported that households used electricity for cooking as it is convenient, fast, and easy, although found it was commonly used for preparing quick meals or making tea rather than as the main fuel for cooking (Karekezi et al., 2008).

The 62 households from the Kenyan communities that didn’t meet the cooking and water heating standards were using charcoal and wood (58 per cent and 4 per cent respectively), on a range of stoves: three-stone fire (4 per cent), traditional metal charcoal stove (8 per cent), and an improved charcoal stove with ceramic liner (50 per cent). The Nepali communities surveyed were the only ones with biogas. A total of 40 per cent of the Nepali survey households met the standard via use of biogas, produced in a domestic biogas plant using animal waste. The remaining 15 per cent of households that met the three minimum standards use LPG. In Hatiya, where 11 houses use LPG, they have year-round road access and are close to the district capital. Handikhola has four houses using LPG and the access road is cut off in the wet season, potentially explaining why household biogas plants are more common than in Handikhola. The remaining 45 per cent of households that didn’t meet the standards all cooked using wood, and only 40 per cent of this group used some form of improved cookstove.

Box 3.4 Cooking with biogas stoves in Nepal

Mahesh’s family lives in Chapagaun, just outside Nepal’s capital Kathmandu. They have been using biogas stoves to cook two meals every day for the last three years. Mahesh says:

‘I used to spend all day looking for firewood and cleaning pots and pans. Those days are now gone! Now it’s cheap and easy to cook rice, lentils, and vegetables for my seven people family. When my neighbours saw that I had more time for other chores, they decided to install their own biogas plant too!’

Today there are 140,000 rural Nepali households who cook with biogas. In addition to providing a cost efficient energy source, biogas provides other benefits, such as:

- improved sanitation, as some digesters are connected to toilets;
- reduced time required to collect firewood, which was 2-3 hours a day;
- reduction of indoor air pollution;
- use of the by-product, digested slurry, as fertilizer.

The two communities in Peru had the fewest number of households meeting the three TEA cooking standards. Just two households in Yanacancha were using LPG and six households in Chaupiloma used wood on an improved cookstove with a chimney and spend fewer than 30 minutes per day collecting fuel. The TEA indoor air pollution standard judges chimneys sufficient to reduce IAP levels to meet the standard, however the PPEO recognizes that where chimneys are poorly designed and badly maintained they can actually be worse for IAP than a stove without a chimney, as discussed in Box 3.5 overleaf.

Box 3.5 Practitioner's perspective – What makes a good chimney stove?

Various key issues need to be addressed for chimney stoves to be effective:

- Chimney stoves need to be cleaned very regularly, or they block with soot very soon, so a lot of follow up is needed if the users are to learn to maintain them. The flue should be easily dismantled to facilitate cleaning.
- Where stoves are introduced, there needs to be people trained to repair them.
- The combustion chamber should be made of lightweight insulating material that reflects heat back into the stove. Early stoves used mud, and this absorbs heat, so the stoves took a long time to get hot, and during this time, a lot of smoke was produced, blocking the chimney.
- A good chimney stove will have the opening for inserting fuel exactly the right size, with a small bar across this opening close to its base to ensure that air can pass underneath the fuel so that the fuel burns completely.
- If there is insufficient space between the pot and the combustion chamber, the particles of smoke will move past the pot and go into the flue before they are burnt. This creates more smoke and reduces efficiency. Good design to optimize the hot flames brushing against the pot sides improves energy efficiency.

Elizabeth Bates, independent smoke and stove expert

Apart from the two households in Yanacancha using LPG, all others participating in the Peruvian surveys cooked with wood, with around 95 per cent of households gathering all of their fuel. Of the 54 per cent of all households using this woodfuel in three-stone fires, 98 per cent described this as 'rather', or 'very polluting'. Of the 44 per cent using chimney stoves or improved stoves with smoke-hoods, 73 per cent found the fuel very clean to use. Chimney stoves were relatively recently installed by the government JUNTOS programme that began in 2005, and an NGO project which began in May 2010.

In Latin America and the Caribbean overall, only 15 per cent of households cook using wood, compared to 69 per cent in sub-Saharan Africa, and 42 per cent in all developing countries (UNDP/WHO, 2009). However, as the TEA survey shows, this number can be much greater in poor communities than the average. It also shows that the stoves and smoke extraction with which people use woodfuel has an important bearing on how healthy and convenient the cooking experience is in practice.

Another important factor, which challenges the usefulness of the 'modern' versus 'traditional' fuel definition, is the way in which people use more than one fuel and more than one stove for cooking on a regular basis. This is discussed further in the section on 'Household Fuels'.

The TEA's three minimum standards for cooking do not include an assessment of the safety of the cooking practices. Households were however asked about their perceptions of the technologies they used. Very few people felt that their cooking practice was safe, with most people responding that it was okay but wanted to improve, which is not surprising in itself. The results from Kenya showed a very wide range of responses about perceived safety for all types of stoves. In the two Nepali communities, the dangers associated with three-stone fires seem to be poorly recognized given all households that cook on an open fire felt that safety was okay, but would like to improve. In Peru however 24 of the 54 households cooking on an

“ People use more than one fuel and more than one stove for cooking on a regular basis

”

open fire felt it was ‘very dangerous’ and a further 17 thought it ‘rather dangerous’.

These factors of perceived cleanliness and safety, along with seasonal affordability, multiple fuel use, and cooking preferences are not peripheral concerns. Instead they combine to play the defining role in which fuel and stove combinations poor people choose. While average percentages of people using ‘modern’ fuels may be discussed at international levels, people are meanwhile making more complex decisions at the household and village level about how best to meet their cooking and water heating needs. Understanding of this perspective is necessary in the pursuit of universal energy access in order to help people move towards more convenient, efficient, and healthy cooking practices in line with the TEA minimum standard, whatever fuel they are using.

“ While percentage ‘modern’ fuel use is discussed at international levels, people are making more complex decisions ”

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Indoor space heating

Space heating is an important energy service for many people living in temperate regions and at high altitudes in tropical countries, particularly during their cold seasons. It is estimated that half a billion people in South and South-east Asia alone use stoves for space heating, whether as an absolute daily necessity in the coldest climates or for comfort during cooler seasons or at night (Hulscher, 1997). Prolonged exposure to cold temperatures can lead to a number of health issues, including acute respiratory infections (ARI). These very same illnesses are compounded by indoor air pollution inhaled while spending long hours trying to stay warm near open fires (*PPEO 2010*).

The TEA minimum standard requires that the minimum daytime indoor air temperature of a household is 18°C, which is the recommended minimum bedroom temperature below which longer-term health issues can be experienced (Keating, 2010). This can be met automatically if the people feel their house is warm enough all year round without heating, which is the case for many people in sub-Saharan Africa, South/South-east Asia and the Caribbean who live in countries with average daytime temperatures above 18°C. The standard can also be met by households that use passive means of keeping temperatures up, or use a purpose-built heating device or heating stove in their home.

Box 3.6 Getting more energy services out of wood

The Aga Khan Planning and Building Service works in Pakistan to implement infrastructure and technology-related development initiatives. Their Building and Construction Improvement Programme (BACIP) provides families in remote mountain villages with access to affordable, energy efficient technologies, which insulate their homes, heat their water, and reduce their consumption of fuel wood. The programme has installed over 15,000 energy efficient and living condition improvement products in various households. Some of BACIP’s standard products include:

- roof hatch windows, double glazed windows which allow for more light while conserving heat;
- fuel-efficient stoves with water warming facilities attached that use the same fuel;
- floor insulation, wall insulation, and roof treatment techniques for thermal efficiency;
- solar cookers and solar water heaters for fuel conservation.

Source: Aga Khan Development Network http://www.akdn.org/akpbs_pakistan.asp

“ Improved efficiency stoves and modern fuel-burning stoves that focus heat on the pot are less good at providing heating

Of the 300 households surveyed, fewer houses met the indoor space heating standard than any of the other standards. In Kibera and Mukuru, 20 per cent and 16 per cent of people respectively, said that their house was warm enough without a heater. None of the households had a purpose-built heating stove while many used their everyday cooking stoves to provide heat and others said they didn't use anything specifically to heat their homes. Whilst some cookstoves are good at heating rooms by dissipating heat to the room, improved efficiency stoves and modern fuel-burning stoves that focus heat on the pot are less good at providing heating.

” In Hatiya and Handikhola, the hottest region of Nepal bordering northern India, none of the households met the standard. None felt their house was warm enough all year without heating, around half heated their rooms using an open fire or their normal cooking stove and the remaining didn't have any special form of heating. Of the households using some heating device, they were only used for between one and three months of the year.

In Yanacancha and Chaupiloma, in the high Andean region of Cajamarca, only one household felt their house was warm enough all year round. The region receives extreme cold spells or *friajes* with temperatures dropping to -20°C and accompanied by snow and frost. The people interviewed commented that the *friajes* are becoming more frequent, with more extreme temperatures and extending outside of the usual season. Despite this none of the people heated their homes, instead relying on passive measures including thick adobe walls and roofs and warm winter clothing made from Alpaca wool.

Space heating is a complex issue which relates to energy, but also relates to the quality of the house and its insulation and passive solar properties. It is also a seasonal concern in many places, while for many poor families relying on a single heat source – the requirement for space heating and the cookstove is linked. However, with maximum efficiency and utility of cookstoves and heating stoves being fundamentally different, creative approaches to buildings and appliances are needed in order to maintain healthy and liveable temperatures in cold climates.

Food cooling

“ For the hundreds of millions of undernourished people in developing countries, the capacity to preserve food is an important component in tackling hunger

” For the hundreds of millions of undernourished people in developing countries, the capacity to preserve food is an important component in tackling hunger. Without preservation facilities and the ability to lengthen the time that produce remains fit for consumption, it is a challenge for poor families to manage variable food supplies. In hot climates, farm, fish, and animal produce does not stay fresh for long. The rapid perishing of products can be overcome by a number of methods including, cooling, drying, and curing. Cooling is often the preferred method for preservation since the produce is not significantly changed by the process.

” The TEA minimum standard for food cooling requires that households be able to extend the life of perishable products by a minimum of 50 per cent over that allowed by ambient storage. The indicator of achievement of this standard is that a household must own and use a cooling appliance that can keep food cool. The appliance may be an electric, solar or gas fridge, or passive cooling device such as a *zeer* pot or cold box.

Of the 300 households surveyed, only 13 per cent met the food cooling standard. None of the 100 houses surveyed in Kenya had a refrigerator (even in Kibera where 47 of the 50 households used grid electricity) and only two houses used any kind

of cooling device – a clay pot. The people in Kibera and Mukuru purchase most of their foodstuffs at a nearby market, allowing them to buy food as required in amounts they can consume without requiring storage. Given the unreliability of the grid and the insecurity of supply due to the illegal connections, the high cost of fridges makes them a risky purchase. In urban areas, cold storage facilities at the enterprise level are critical to households obtaining a reliable supply of fresh food.

The communities surveyed in Nepal have the highest proportions meeting the food cooling standard with half of the households questioned in Hatiya having a cooling device (17 have a fridge and eight have a clay pot), and a quarter of houses questioned in Handikhola (one has an electric fridge, one a gas fridge, and 11 have a clay pot). Households in these hot rural areas produce a lot of their own food, which arrives in gluts so needs to be preserved. There are peak times when fruit and vegetables are ready, animals are slaughtered, and dairy products are produced in bulk. The clay pots people use are called *ghainta* and they are usually buried underground or in water with food in to keep it cool.

In Peru, none of the households surveyed met the food cooling standard and nobody used a cooling appliance to keep food cold. The communities' diet is based on cereals and potatoes, which are kept in storage houses that can preserve for a long time in the cool dry mountain climate. People complement this with meat from smaller animals such as chicken and guinea pigs that are consumed quickly and usually raised close to the household. The little other meat people have is dried and salted for preservation. The sale of alpaca milk to large companies constitutes the main income of many agricultural families. There is not however a habit of storing and consuming milk for the family, although some families produce other dairy products such as cheeses and butter for local use. Even though households haven't met the food cooling standard, the people practice a variety of methods that enable them to extend the life of products – these methods are enabled by the cool mountain climate found at high altitudes.

With low levels of access to food cooling facilities, many people surveyed can be seen to be working around this gap with the use of other preservation techniques, or by narrowing their diets in line with the lack of cooling. Others rely on the cooling facilities which local shops may be able to secure (see Chapter 2) to effectively outsource cooling requirements. Although these adaptation strategies can be effective, particularly in colder climates, food cooling is maintained within the TEA standard since to ignore it would be to exclude an energy service, which is fundamentally important to a secure and nutritious diet.

Indoor space cooling

Many poor areas of the world are subject to soaring temperatures that can affect people's health, productivity, and comfort. Household space cooling is a significant priority in hot and humid areas, even though many low-income households cannot afford this service (PPEO 2010).

The TEA minimum standard for indoor air cooling proposes that the maximum apparent indoor air temperature of a household should not exceed 30°C. Houses that don't require cooling to meet this temperature are considered to have met the standard. For areas that do require cooling, the standard can be met by using an appliance such as an electric fan or through passive means such as building features that reduce heat absorption and give good ventilation.

“ Many poor areas of the world are subject to soaring temperatures that can affect people's health, productivity, and comfort

”

Box 3.7 The importance of cooling

Food cooling is safer and more efficient than traditional food preservation methods. Betserai has been living with his family in Epworth, Zimbabwe, for more than nine years. He says ***'We preserve our meat by salting and we then hang the meat to dry. Many people regard it as a traditional method but we have no option because that is the only way we can store meat for more than two days, as we have no electricity in the house.'*** However, Epworth is often affected by cholera outbreaks. Betserai says ***'In such times our method of refrigeration is compromised. We fear that our food will get contaminated without a fridge, so we only buy food that we can consume in that day.'***

The proportion of people meeting this standard varied significantly between the communities surveyed, although the two nearby communities from each country had similar levels of access, despite having different supply options. People's indoor space cooling requirements are strongly linked to the climate. For some communities in hot areas, cooling appliances are a real priority, but others in cooler climates don't need any form of cooling. Very few people met the standard in Kenya, nearly half met it in Nepal, and all met it in Peru.

Situated at 1,600 m above sea level, Nairobi has a cooler climate than some of the surrounding hot and dry regions. Even so average temperatures during the hottest months can be uncomfortably hot, especially in the tight-packed slums with houses made of rudimentary building materials. In Nairobi, only 16 per cent of households surveyed met the indoor space cooling standard; one household had an electric fan and 15 responded that their house was cool enough all year without requiring further cooling. Nearly all the houses surveyed said they left windows and doors open for cooling, some for all 12 months of the year.

The two communities surveyed in Nepal are situated in the Terai, a region that experiences daytime temperatures in excess of 30°C for most of the year and as expected all of the people surveyed said that their houses required cooling. In Hatiya and Handikhola 62 per cent and 56 per cent respectively of households met the standard. All of these houses used an electric fan, except one house that had air conditioning.

Yanacancha and Chaupiloma in Peru are high mountain communities with a cool climate and an average temperature in the hottest month of around 16°C. Each of the 100 households surveyed responded that their house was cool enough all year round without further cooling.

The requirement for space cooling is highly dependent on the local climatic zone, of which the same country can have multiple. Countries like Nepal and Peru are particularly illustrative examples with three distinct climatic zones, each with totally different requirements for space cooling and conversely, space heating. However, seasonal shifts also have important impacts on requirements for both. These factors have practical implications on people's productivity and comfort, and where increased levels of energy supply are available, they can become dominant energy consumers, as is witnessed in air conditioning daytime peak loading in industrialized countries. Lower energy and cost alternatives such as fans and locally adapted building design features, including traditional buildings of high thermal mass, can also play an important role in keeping spaces feeling comfortable year round.

Send and receive electronic information

Information and communication technologies (ICTs) have been established as important tools for alleviating poverty because they enable the widening of relationships beyond people's immediate surroundings (*PPEO 2010*).

The updated TEA proposes two minimum standards relating to ICTs: that people can both send and receive electronic information from their houses. Sending electronic information allows people to communicate with others beyond their locality – this standard can be met with access to a fixed or mobile phone, or internet connection in the home. Receiving electronic media allows people to access information relevant to their lives and livelihoods – this standard can be met with access to a television or radio, internet connection in the home, or just with a mobile phone.

More households met the two standards for ICTs than any of the other energy service standards. A total of 70 per cent of all households surveyed can send electronic information from their household using a mobile phone, 76 per cent can receive it through a radio, television or mobile phones, and 37 per cent only through a mobile phone. The relatively high rate of people meeting the ICT standard is true of each community, even those with a low quality supply of electricity such as Mukuru and Chaupiloma. This reflects national statistics such as in Kenya where only 15 per cent of the population has access to electricity and yet the penetration of mobile phones is over 50 per cent (*PPEO 2010*). Since ICTs are commonly low power devices with a built in battery they can also be used by households without a grid connection, powered by decentralized supplies such as solar panels or diesel generators.

ICT ownership is also dependent on other factors such as affordability and availability of devices, and network infrastructure. In Kenya and Nepal, the community with the better quality of supply has more people meeting the ICT standards – likely as a result of higher incomes or being in closer proximity to retailers and repair centres, as well as having electricity in the home.

Interestingly this is not the case in Peru where despite having no grid electricity Chaupiloma's people have slightly greater access to ICTs than in Yanacancha. The people in Chaupiloma charge their mobile phones from solar panels and use dry cell batteries for radios. In the mountainous area of Yanacancha the mobile signal is very weak, it is rarely available in the village unless the people climb a nearby hill. Despite this 44 per cent of people still have a mobile phone (compared to 46 per cent in Chaupiloma). Yanacancha also has a community satellite phone and internet café (although the internet connection is not always reliable).

In Kibera, the 10 per cent of households that don't meet the standard for sending information from their home all reported having regular access to a fixed or mobile phone outside of their house, either in a neighbour's house or at a local shop. Of the 16 per cent of households that don't meet the standard for receiving information in their home, all reported having access in a neighbour's house. In Kibera, six houses were surveyed that had internet connection and Mukuru had one, but none did in the households surveyed in Nepal and Peru.

ICTs are a fast expanding sector illustrating the potential strength of the 'base of the pyramid' market, even where energy access constraints are severe. The inherently decentralized nature of the mobile phone supply and infrastructure, as well as strong demand and well understood technology has accelerated uptake. Radios, TV, and the internet are in high demand with entertainment and information valued highly. Decentralized energy technologies have underpinned the expansion (UNDP, forthcoming) and the sector also offers potential to widen access to additional energy services.

“ Since ICTs are commonly low power devices with a built in battery they can also be used by households without a grid connection ”

“ The inherently decentralized nature of the mobile phone supply and infrastructure, as well as strong demand and well understood technology has accelerated uptake ”



Energy supplies in practice

While the previous analysis has focused on the TEA minimum service standards, mapping these on to supplies as relevant, it is also valuable to consider the supply side independently of the services derived. The Energy Supply Index (ESI) levels indicate incremental improvements towards a higher quality and more reliable supply in the three dimensions of electricity, household fuels, and mechanical power.

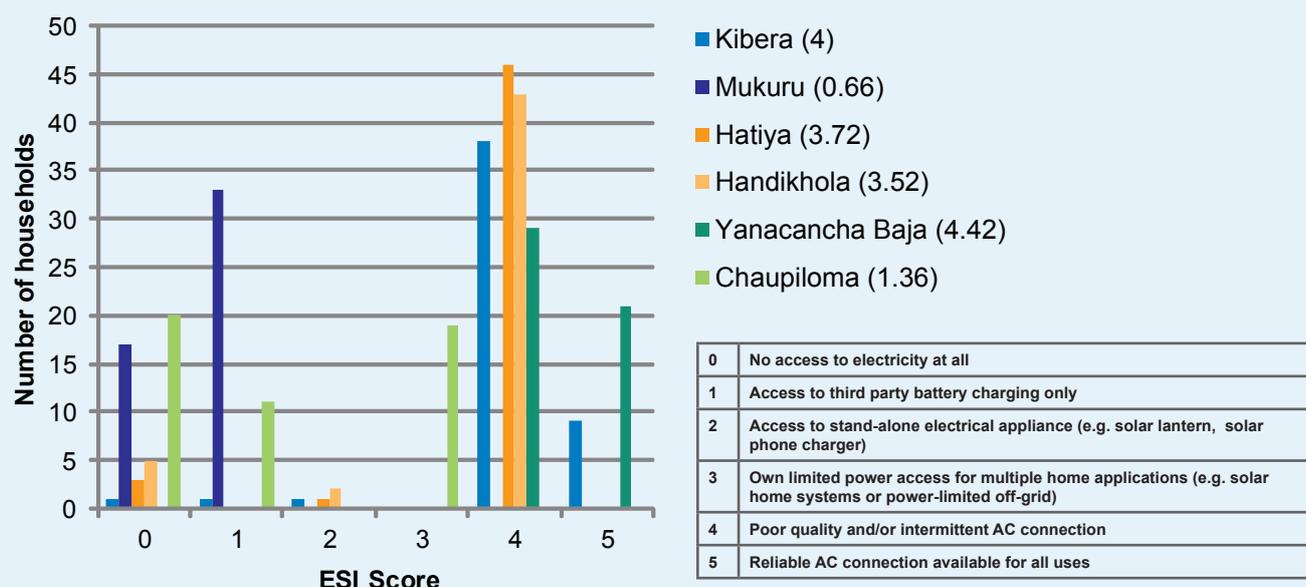
This section analyses the responses of those surveyed in terms of their levels on the ESI. The analysis also compares these responses with international data and highlights models and technologies that have been particularly successful at progressing people up the index to improved quality of energy supply.

Electricity

Electricity access is hugely useful to households due to its versatility and, if reliably available at low enough cost and high enough capacity, it can serve all TEA needs. It is the preferred supply in terms of efficiency and convenience for lighting and cooling services, and is the only possible supply to ICTs. Methods of supplying it are diverse in terms of fuel source (coal, diesel, solar, hydro, wind etc.) and delivery systems (including grid connection, decentralized mini-grids and standalone electrical systems such as solar home systems, and charged batteries).

Figure 3.2 shows the distribution of ESI scores for electricity for the 300 households surveyed in Kenya, Peru and Nepal:

Figure 3.2 ESI scores for electricity amongst survey households (average scores in brackets)



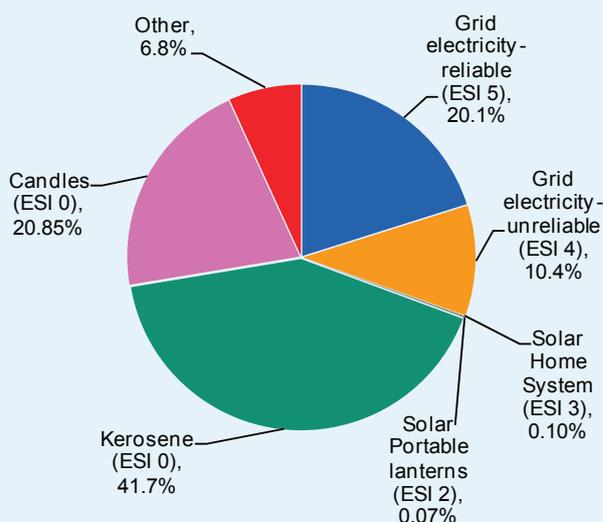
Of the 50 surveyed households in Kibera, 47 were connected to the grid, the great majority of which were illegal connections. Despite efforts by the main utility, the Kenya Lighting and Power Company (KPLC), to electrify the slum area, studies have shown that most households paid for electricity as part of their monthly rent rather than sourced from KPLC (Karekezi et al., 2008). Illegal connections to the grid are extremely common – between 20-40 per cent of all grid connections in India are thought to be through illegal methods (GNESD, 2007). This suggests that many more households have electricity access than currently reported, as official statistics don't measure illegal connections. If 40 per cent more people were connected to the grid than reported, this would infer an additional 254 million people in South Asia alone based upon 2009 data (UNDP, 2009). Whilst providing electricity to millions, illegal connections are reported to increase the frequency of blackouts. In Africa as many as one third of grid users are considered 'under-electrified' due to blackouts (Lighting Africa, 2010).

In Mukuru, none of the households surveyed had electricity connections in spite of their houses being relatively near electricity transformers and power lines. However, they have access to third party battery charging for their mobile phones. Studies have shown that reasons for not connecting include the high upfront costs of connecting to the grid and on-going bills, and many people being wary of the use of electricity owing to the safety issues after numerous incidences of electrocution and electrical-based fires (Karekezi et al., 2008).

The households in Mukuru are among the 69.5 per cent of households in sub-Saharan Africa that are without electricity. Africans without electricity typically rely on kerosene and candles as their primary fuel for lighting. However, getting a connection is only part of the story. Figure 3.3 illustrates the breakdown of electricity supply, and primary lighting fuels for households without electricity, for the 836 million people in sub-Saharan Africa. The graph illustrates the high proportion of those connected to the grid in sub-Saharan Africa who still receive unreliable and intermittent supply.

“ Whilst providing electricity to millions, illegal connections are reported to increase the frequency of blackouts ”

Figure 3.3 Electricity supply quality and primary lighting fuels for sub-Saharan Africa (Total population = 850 million)



Source: IEA, 2010; GNESD, 2009; Lighting Africa, 2010, Practical Action analysis

It should be noted that much of the data is based upon estimations and drawn from disparate sources. This reflects the lack of detailed and accurate information on the quality of people's energy supplies, which must be addressed if such information is to provide the basis for effective policies, strategies, and investment plans to tackle energy poverty.

The Nepali cases of Hatiya and Handikhola are illustrative examples of the issue of grid reliability where, although more than 80 per cent of surveyed households have a connection, all are in ESI category 4 – receiving intermittent or poor quality grid-equivalent power. Nepal generates most of its grid electricity from hydro schemes and suffers long power cuts during the dry season. A load shedding timetable dictates the times when people have electricity, at its worst available for only eight hours a day, and not during the hours when it is needed most.

Wider factors behind unreliable grid power more generally include technical issues, which can include insufficient generation capacity and aging equipment, as well as socio-economic and institutional issues such as insufficient management and maintenance capacity. Illegal connections as noted above have impacts on absorbing generation capacity, as well as not covering costs creating economic issues in maintaining supply. Such realities can often mean that people with grid connections enjoy far fewer energy services than they need, on a reliable and affordable basis.

Box 3.8 Illegal connections and lighting in Nairobi, Kenya

Otieno Kamili, a resident of Kibera, says *'I think I am one of the many lucky slum dwellers who enjoy "stolen" electricity. To get it, a gang of generally four to six men usually in the dead of the night climb up the electricity pole lines and attach a thick cable to the live wire. They then descend the cable to the ground below, where it transports the electricity to the nearby Kibera slum. Anyone who wants electricity has only then to contact one of these gangs and they join you using thin wires plus an earth connection. I use the electricity for lighting and to power a radio and television and charge my mobile phone.'*

Despite these issues with grid power, many continue to consider the national grid as the only method of supplying electricity. Meanwhile, the costs of extending the grid to rural and sparsely populated areas can be very high due to the transmission distances, poor household's low electricity use, and the losses incurred in long distance transmission. Such limitations on the potential of the grid to reliably and affordably reach the 1.4 billion without electricity access are increasingly being recognized. The IEA estimates that to achieve universal energy access by 2030, 100 per cent of urban, but only 30 per cent of rural, households will be connected to grid electricity (IEA, 2010). The remainder are expected to be connected with mini-grid or isolated systems.

Although good examples exist, currently decentralized mini-grid schemes only make up a small percentage of electricity connections. Yanacancha is one example of a town receiving electricity from a decentralized mini-grid source, in this case supplied by hydropower. However, recently the grid has finally arrived in the town on a pilot basis and now 57 per cent of the households are connected to the locally managed mini-grid and the remainder to grid power. It will be interesting to witness whether the decentralized system will stay in operation over the longer term, go out of operation, or be connected to the grid as an independent power producer. Although there are important effects regarding sense of ownership and investment in the local scheme (as well as inertia), it is likely that in the long run the respective reliability, cost, and quality of supply will be critical factors in people's selection. In the current period, with two electricity supply options available, it has comfortably the highest ESI average for the six communities surveyed at 4.42, with all households surveyed at levels 4 or 5.

Although the grid provides a new option in Yanacancha, the decentralized village mini-grid was previously successfully providing electricity service, and such a system is also foreseen for Chaupiloma which remains distant from the main grid. Chaupiloma is currently the only one of the six settlements surveyed which uses a substantial percentage of isolated electricity supplies at ESI level 3, in the form of household solar PV systems. For such communities without access to mini-grids, standalone appliances can provide the next best solution. The most common of these are solar home systems (SHSs), which integrate a solar panel with battery storage and a number of lights and appliances depending on the size of the system. Although the set up costs are high, operating and maintenance costs are low, and they can power multiple lights and devices. Currently 850,000 have been sold in Africa of 2.5 million worldwide. This is expected to rise to three million in Africa by 2015. Due to the high costs of the system – on average US\$150 for a 20 Wp system, Lighting Africa estimates that SHSs are unlikely to be accessible to more than 50 per cent of the African population in the near to medium term, even given projected price declines and access to finance innovations.

For such poorer households, solar portable lanterns, equivalent to ESI level 2, are thought to provide the answer. These are much cheaper – around \$30-80 per lantern in Africa, and yet bright enough to meet TEA standards for lighting. Although they usually only address lighting demands (sometimes phone charging), Lighting Africa expects the lanterns to replace kerosene as a key light source, increasing from 2009 levels of 650,000 units (0.6 per cent of the market) to 6-13 million by 2015 – 0.6-1.3 per cent of the total African market.

The households with least access to electricity, on ESI levels 1 or 0, use a variety of methods to gain what access they can. Some charge car or phone batteries on a pay per charge basis and then use the car batteries to power lighting. Lighting Africa suggests 200 million in Africa currently have a phone but no grid connection

“ The IEA estimates that to achieve universal energy access by 2030, 100% of urban, but only 30% of rural, households will be connected to grid electricity ”

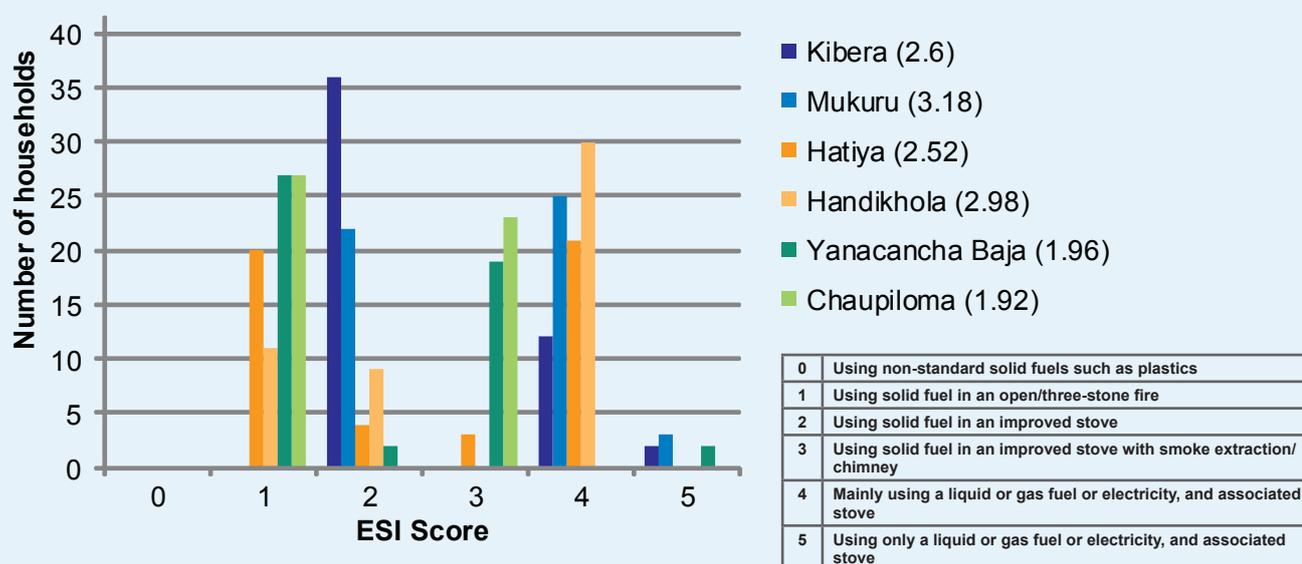
to charge it. Rarely a cheaper option overall – an average off-grid phone user can pay between US\$2-15 per month on phone charging, and in Kenya alone it is estimated that off-grid phone users spend US\$155million annually on phone charging (Lighting Africa, 2010).

Household fuels

Household fuels serve the essential energy needs for people’s life, particularly cooking and water heating. The quality of supply of household fuels is characterized by different factors including the type of fuel (firewood, charcoal, LPG, kerosene, biogas, briquettes, etc.), the appliance used (traditional stove, improved stove, gas stove, ethanol stove, etc.), and delivery system (gathering, purchasing, self-production, etc). These elements have several health and socio-economic effects on people in developing countries, which have been described in this report.

Figure 3.4 below illustrates the levels of ESI of the 300 surveyed households.

Figure 3.4 ESI scores for household fuel amongst survey households (average scores in brackets)



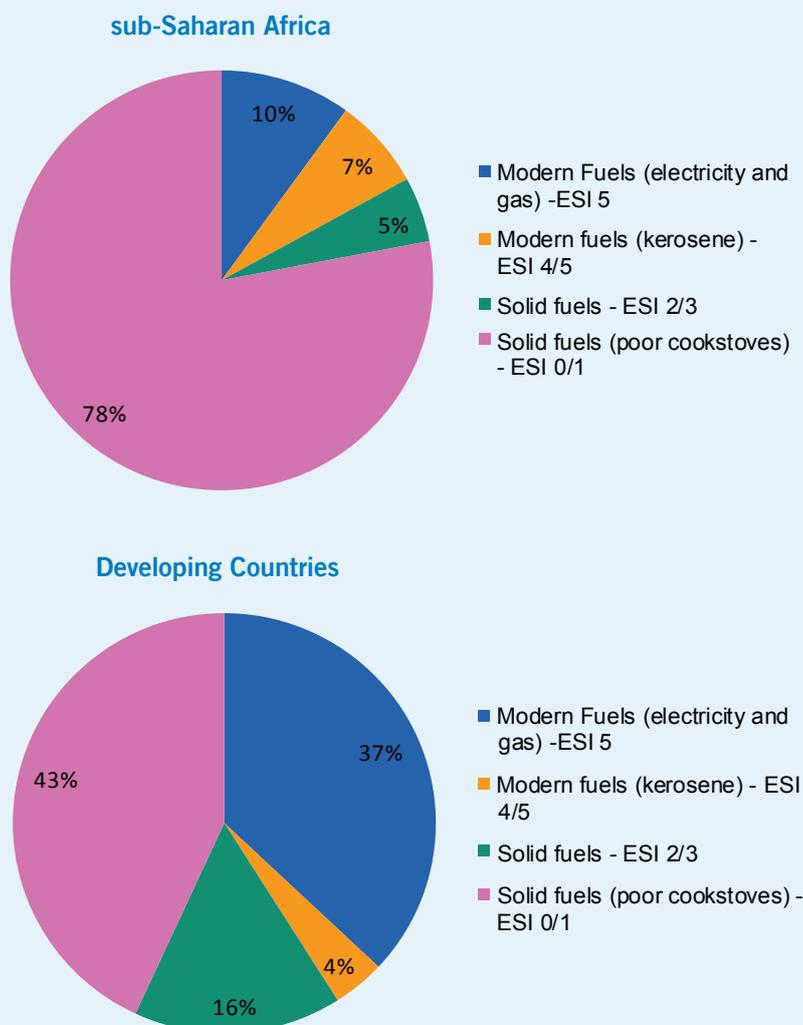
Of all surveyed households, only seven achieved an ESI score 5, that means they use a liquid or gas fuel with a modern stove as their sole household fuel. In fact, LPG, electricity, kerosene, and biogas are rarely the sole cooking fuel used by households. In the surveyed households in Kenya and Nepal, 73 per cent and 61 per cent of households respectively, stated they used a secondary fuel on a regular basis. In Kenya, many households using kerosene as their primary fuel used charcoal as a secondary option, and vice-versa.

In Nepal it is significant that 50 of the 55 users of biogas and LPG as a primary fuel also often use wood. Most of these households are beneficiaries of a nationwide biogas programme. Biogas is a clean energy, which requires the installation of a bio-digester, which can be very cost effective, but does not always produce enough fuel for all the household needs. In addition, in cold regions, open fires are often used in the evening to provide heat to the household and act as a social focus. LPG use is increasing in many cities in developing countries, but its price remains inaccessible for most.

This makes analysis problematic, as biogas, LPG, and also kerosene tend to be used as complementary fuels to firewood and charcoal, although this is not represented by international statistics on ‘modern fuel’ use (see the graph shown as Figure 3.5), which describes access to fuels without considering that most people use more than one fuel.

Figure 3.5 shows that more than half of people in developing countries cook with solid fuels, with more than three-quarters doing so in sub-Saharan Africa. While in developing countries as a whole, around a quarter use some kind of improved cookstove, less than 10 per cent of those using biomass in sub-Saharan Africa use an improved stove. In total, 37 per cent of people in developing countries have access to ‘modern fuels’, such as electricity, liquid, and gas, but only 17 per cent in sub-Saharan Africa.

Figure 3.5 Access to fuels in sub-Saharan Africa and developing countries



Source: IEA, 2007, Practical Action analysis

However, these figures do not tell the full story, because they do not represent the reality, which is that a high proportion of people use more than one fuel. Table 3.5 shows the patterns of primary and secondary fuel use in the Kenyan and Nepali surveys. This shows that most of the people using biogas and kerosene as their main fuel also use firewood or charcoal as secondary fuel. This depends on several factors, such as the availability of modern fuels, affordability, social and cultural aspects, access to appropriate appliances, etc. This reality is a critical factor to be considered both in interpreting international statistics and targets, as well as designing programmes or promoting products.

Table 3.5 Main and secondary fuels used in Kenya and Nepal

Kibera and Mukuru (Kenya)		Secondary fuel			Total
		Charcoal	Biogas	Kerosene	
Main fuel	Wood	2	0	1	3
	Charcoal	0	2	41	43
	Kerosene	23	0	0	23
	LPG	1	0	1	2
	Electricity	2	0	0	2
Total		28	2	43	73

Hatiya and Handikhola (Nepal)		Secondary fuel				Total
		Wood	Dung/residues	Biogas	LPG	
Main fuel	Wood	0	1	6	1	8
	Biogas	40	0	0	0	40
	LPG	10	0	3	0	13
Total		50	1	9	1	61

Note: remaining survey households not featured here used only one fuel

For those without access to any liquid, gaseous or electrical supplies, there are a series of levels of improved use of solid fuels, essentially biomass and coal. Coal is more widely used in Asia with associated environmental and health impacts, and is more expensive, but generally takes less time to collect, and causes less deforestation. Biomass in the form of wood or charcoal is more commonly used globally by those without access to liquid or gaseous fuels. Other solid fuels in use include dung and peat.

The key differentiators between levels 1 and 3 are the way the fuel is used. In order to achieve level 3, which enables the TEA standard to be met, both improved efficiency stoves and smoke extraction/ventilation are required. Ventilation is essential if improved stoves are to bring emissions in kitchens from biomass down to levels acceptable to the TEA standard 2.3. However, even without ventilation, validated improved stoves offer improvements in efficiency and fuelwood use and so reduce drudgery in collecting firewood relevant to TEA standards 2.1 and 2.2.

In Yanacancha Baja and Chaupiloma in Peru, the survey showed that people use either traditional cooking stoves, such as a three-stone fire, or an improved stove

Table 3.6 Type of stoves used, and perceptions of stove cleanliness, for households in Yanacancha and Chaupiloma, Peru

	ESI Level	Total number of households	Very clean	Rather polluting	Very polluting
Traditional three-stone fire	1	54	1	26	27
Improved biomass stove without chimney	2	2	2	0	0
Improved biomass chimney stove	3	19	15	3	0
Biomass stove with smoke hood	3	23	19	2	1
LPG stove	5	2	2	0	0
Total		100	39	31	28

with chimney. This is due to the improved chimney stove programmes in these communities and it is also illustrative of the split Peruvian situation where in most of the country TEA is significantly improving, yet the most remote communities cannot benefit from such improvements.

As Figure 3.5 shows, of the 3 billion people worldwide without access to modern fuels in 2007, over 27 per cent of these, or 828 million people, used improved cookstoves. However, 70 per cent of these were in China – and in sub-Saharan Africa, where 80 per cent still use solid fuels, only 4 per cent used improved cookstoves. As the available data is not broken down further than this, differences in the efficiency of stoves cannot be measured, and questions such as the type of fuel used, whether waste materials are burned or whether the stove has a chimney cannot be answered, despite the impact that these differences will make on a household.

Those with worst access to household fuels, ESI level 0, often have to resort to waste materials such as plastics and rubbish. This has the worst health impacts due to the toxic gases produced from burning these. No data exists for the extent of this.

Mechanical power

Although mechanical power is most closely associated with enterprise and earning activities, its contributions to pumped water supply to households and processing of foodstuffs in the house make it an important energy service to consider at the household level.

We can only estimate the number of people with access to mechanical power technologies internationally. The data is scarce – only five developing countries collect mechanical power data and only three have set targets for more – compared to 147 countries setting national targets for improved cooking, and 100 having targets for electricity access (UNDP/WHO, 2009).

Figure 3.6 ESI scores for mechanical power amongst survey households (average scores in brackets)

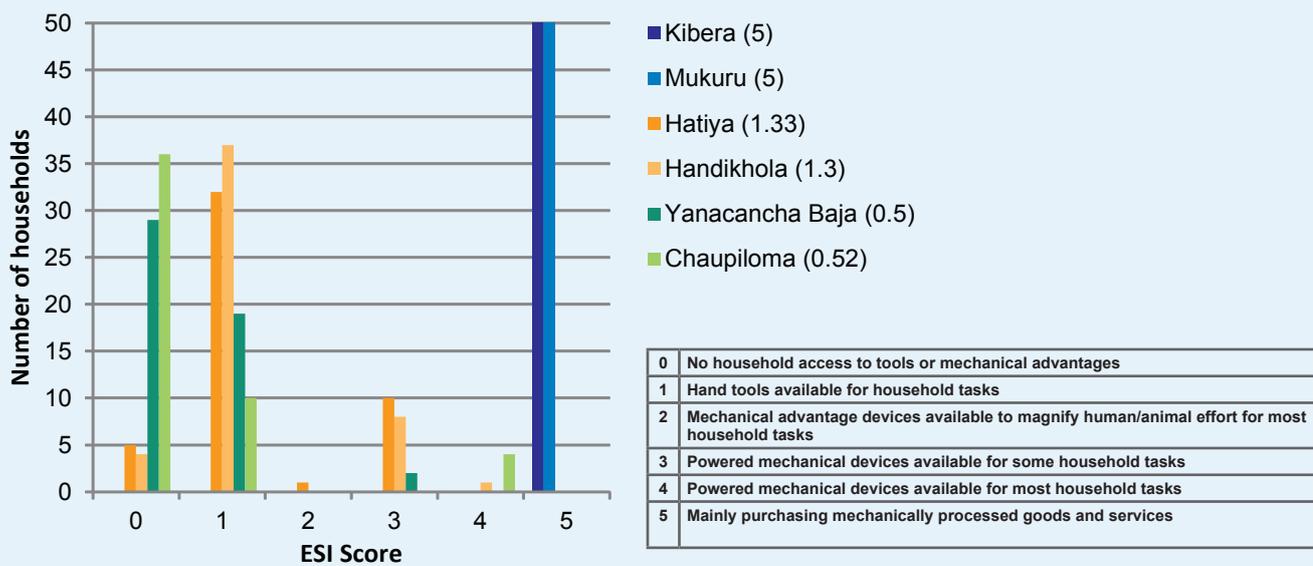


Figure 3.6 illustrates the mechanical power supply quality results for the 300 households surveyed for the PPEO.

The results are in line with the general acknowledgement that mechanical power is much more needed in rural households than urban ones.

On one hand, all the households that have been surveyed in the urban slums of Mukuru and Kibera present ESI level 5. They do not need to own mechanical devices for their household tasks, as they can buy water and foodstuff that has already been processed.

On the other hand, people from rural communities, such as Hatiya and Handikhola in Nepal, often cultivate their own staple food, which they need to process for their own consumption or for sale and they need to extract water from a well.

Therefore, different levels of mechanical power supply can have a strong impact on household lives. At the bottom level, the water is pumped manually and the flour ground using hand tools. Many hours are spent on tasks, which could be done in minutes with access to mechanical power. This limits the ability of people to have time for other household or earning activities (see Chapter 2).

A striking situation is illustrated by the data in Yanacancha Baja in Peru. While the village has almost full access to electricity, these communities have no access to tools or mechanical advantage devices (ESI 0). One reason might be that they produce and sell the food unprocessed to a bigger reseller. This also shows that energy access for households cannot be achieved only with the connection to electricity, but it requires other kinds of energy supplies, such as mechanical power. For instance, a household using a TV and an electric light, but which then manually collects water from the well, has not achieved TEA.

At ESI level 2 are tools and machinery that reduce the amount of human power required to do tasks – from animal drawn ploughs to water pumps that avoid having to hand-draw water from wells.

In Nepal, watermills are a typical example of a powered mechanical device which is an appropriate technology powered by a reliable and clean fuel, such as

river water and people with access to this kind of mechanical power are presented at ESI level 3.

ESI level 4 is achieved by households that use powered mechanical devices for most of their activities. An example are the multi-functional platforms, which consist of a small diesel engine mounted on a chassis, to which a variety of food-processing equipment is attached, including grinding mills, vegetable or nut oil presses, and dehuskers. By reducing the time taken to carry out household food processing such as rice dehusking, the women in the village have more time (on average 2.5 hours), for other activities such as education or income-generating activities (UNDP, forthcoming).

Summarizing people's experience of energy

The research in Kenya, Nepal, and Peru has demonstrated that measuring energy services in combination with energy supplies can provide important insights into the energy access situation in a household and community. Although the sample sizes are small, this real experience and preference data can be reflected up into national and international understanding of energy poverty and access. The analyses typically used in policymaking are averages of averages, based on weak national statistics data, and ignore the informal factors which dominate poor people's reality.

Through TEA, this report proposes an approach to the data problem from the other perspective, the poor people's perspective, and solicits and presents people's experiences and preferences. In comparing across the communities on three continents the *PPEO* finds many similarities indicating the universality of energy poverty as an issue, as well as real diversity in approaches to achieving as many energy services as possible.

For efforts towards universal energy access to deliver real benefits to the hundreds of millions of people in the world with inadequate energy access, we must include energy services in how we define and measure energy access.

Furthermore, to design and monitor the progressive policies, strategies, and investment plans needed to tackle energy poverty, more detailed and accurate information on people's access to energy services and the quality of supply must be available.

While the *PPEO* encourages international institutions and national statistics systems to take this perspective on board in their work, and such processes are ongoing, the *PPEO* is also keen to enable a more decentralized approach to filling the energy access data gap. The Total Energy Wiki is being developed by Energypedia and Practical Action to allow anyone with access to the internet, anywhere in the world to upload energy access data they have collected using the TEA and ESI questionnaire. Everyone – from community mobilizers and local government employees, to travelling volunteers and students – will be able to gain in their shared understanding of energy poverty, improve their practice to help achieve energy access, and share with others around the world to do the same. Standardized household level data, tagged where possible for GPS co-ordinates and time collected, will enable a complimentary dataset to be built up, viewed, and analysed. If enough people participate, this could start to crowd-source part of the answer to the energy access data gap. The *PPEO* welcomes you to participate in the Total Energy Wiki pilot on Energypedia – go to www.energypedia.info/totalenergywiki to get involved.

“ The similarities of experience across three continents point to the universality of energy poverty ”



4. Framework for action



The UN Secretary General's goal of universal energy access by 2030 is a rallying cry to the international community to tackle an injustice, which traps billions of people in poverty. But as Kandeh Yumkellah, chair of UN Energy, said in his foreword to this report – this goal needs an action agenda to become a reality.

Global change on the scale implied by achievement of universal energy access is difficult to imagine while the number of people without access to energy continues to grow in absolute terms, as described in the Introduction. In the *PPEO 2010*, three key areas – policy, capacity, and financing – were identified as issues on which change is required at local, national, and international levels if energy access is to be accelerated. The concept of an energy access ecosystem was proposed to describe the system conditions which could enable rapid growth in access to the range of energy services and supplies defined by the TEA minimum standards and the ESI.

This chapter describes what a healthy energy access ecosystem looks like in more detail, and with it, the policy, financing, and capacity approaches required to create it. In the final section the outline of a movement for change is proposed which could ultimately help lift billions of people out of poverty for good.

As documented in the previous chapters, neither governments, nor the private sector, nor NGOs, have to date delivered sufficient modern energy services to meet the needs of poor people globally. Although there has been progress, a new model is required to reach beyond the boundaries of what appears possible today.

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A new model
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possible today

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Energy access ecosystems

If universal energy access is to be achieved, covering the full range of energy service and supply dimensions defined by the TEA and ESI metrics, it will inevitably be via an energy mix of resources, fuels, equipment, and appliances. To deliver the various elements of this mix, clearly more people and organizations will have to be in the business of providing energy access to more poor people, operating at far greater levels of activity, than there are today.

All human organizations – whether they are private firms, government departments, international NGOs, community-based organizations, or utilities – are working within an environment that both enables and constrains their existence and ability to fulfil their function. Organizations that are trying to provide energy products and services for example, are also connected within the ‘energy access sector’. Some compete, offering similar products like different lanterns, or offering

alternative products such as kerosene versus ethanol stoves. Some also collaborate, perhaps selling products for multiple firms, or by employing specialist support services. Others perform complementary functions within supply chains, without even necessarily realizing the others are there.

Collaborations can be conscious, for example in a strategic partnership, or pressing for the lifting of shared regulatory restrictions via a sector association, or perhaps just adhering to common standards to avoid souring the market. But sometimes collaboration is less conscious, perhaps through skilled staff moving between organizations as they build their careers, success by one institution creating confidence amongst financiers to support another doing something similar, multiple firms operating within a country creating the critical mass needed for a centralized importer to reduce costs of a key component because organizations are also part of a wider market system.

Few organizations fulfil the same role, or set of roles, in a market system in the same way. Some provide just one product or service, some only do marketing and distribution, some only provide financing – but could do that for multiple products, some provide transport – and would be more viable if they transported more, some integrate two or more of these functions. These different players, roles, and strategies are essential if market systems are to develop, become more efficient, and deliver more energy products and services at the range of price points which different people can afford, including poor people. This applies to energy sub-sectors such as solar PV systems, small-hydro, and biogas, but it also applies across the energy access sector, where any value chain serving poor people's energy needs must confront and overcome many similar barriers in terms of low and dispersed returns, thin supply chains, and institutional and capacity constraints.

The *PPEO* proposes the term energy access ecosystem to describe this reality. The ecosystem analogy recognizes that the energy sector comprises multiple inter-related systems, which collectively deliver energy supplies and appliances, using a mix of energy sources and a range of technologies.

The natural ecosystem analogy describes the interdependence of organisms, the symbioses and the competition, the evolution and niche exploitation, as well as the disruptive leaps as environments and behaviours change. The application of the term business ecosystem has been developed in management theory in recent years (Peltoniemi and Vuori, 2004), while innovation systems use similar ideas in describing technological change (Douthwaite, 2002).

An ecosystems perspective should both enable an understanding of the dynamics of energy access ecosystems, as well as identification of entry points and strategies for change.

Building on the recommendations of last year's *PPEO*, it is proposed that the critical dimensions driving change in an energy access ecosystem are in terms of policy, financing, and capacity. Figure 4.1 illustrates the concept of an energy access ecosystem, building on representations of market maps and dynamic network systems.

What is a healthy energy access ecosystem?

In a business ecosystem, for an enterprise to be successful, the wider ecosystem needs to be successful. Each member of the ecosystem shares the fate of the network as a whole (Iansiti and Levien, 2004), in the same way that a restaurant in a failed neighbourhood is likely to go bankrupt (Moore, 1996). The ecosystem

“ The energy sector comprises multiple inter-related systems, which collectively deliver energy supplies and appliances, using a mix of energy sources and a range of technologies ”

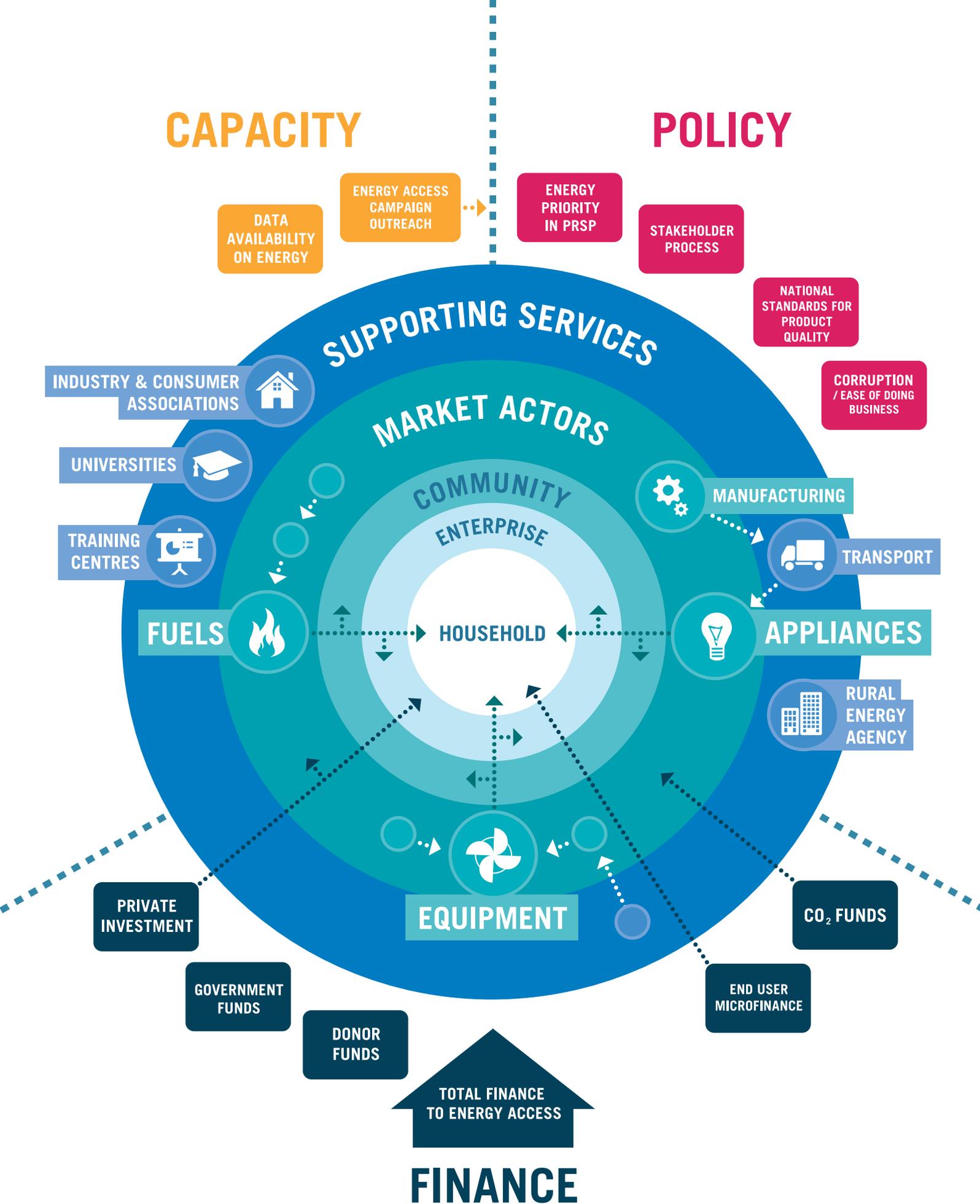


Figure 4.1 The energy access ecosystem

analogy therefore recognizes co-evolution and collaboration as well as competition (Hackney et al., 2004) as means to achieve healthy ecosystems providing products and services. It also recognizes the importance of the systems of governance on which providers rely, as well as the flows of money supporting creation and regeneration of the system, as well as the skills of those creating and maintaining that system. This does not imply that competition would be absent, as there will most certainly be competition between players with the same speciality. One player may drive out another, or competition may foster innovation leading to the players evolving into distinct non-competitive niches (Hackney et al., 2004).

Critically, from the perspective of creating energy access, a healthy access ecosystem must be one in which expanding access to more and poorer people is an evolutionary outcome valued within the system, and in this, policy and associated incentive structures play a crucial role. The 'fittest' must be the one who reaches the most people with services that they want, in the form they want, when they want it, and at a price they are willing and able to pay. Where policy serves to reduce inequality, the poorest will also be served in such a way that they can escape poverty.

However, the reality is that the energy markets serving poor communities are often very 'thin', with few players, little competition, little innovation, and little activity. At the heart of this weakness is lack of effective demand, i.e. the consumer population are poor. The reasons they are poor, as described in Chapter 2, are related to, and reinforced by, people's lack of energy access.

This situation then both describes and reinforces a 'weak' energy access ecosystem within a vicious circle. There is a lack of finance at all levels: purchasing power within the consumer base, working and other capital for enterprises, affordable loans, equity and debt, grant funding for research. Policies and legal frameworks are not prioritized, not incentivised, or positively discourage energy access activity via permit bureaucracy or tariff barriers on energy equipment import. There is a lack of relevant capacity, skills and awareness amongst would-be market players, consumers, financiers and governance systems regarding energy access, unable to break the cycle of no experience no progress, no progress no experience.

If energy access is to be accelerated, these ecosystem factors must change in order to create vibrant, inclusive, and sustainable market systems, in which more and stronger organizations are delivering a range of energy services and supplies to more and poorer people. In order to guide the changes in policy, capacity and financing that are needed, the *PPEO* proposes a framework for mapping what an ultimately 'healthy' ecosystem would look like.

There are many definitions used to describe the health of a natural ecosystem, with this perhaps summarizing most dimensions: a healthy ecosystem is one that maintains the sustainability of its vigour, organization, and resilience. In this context vigour is a measure of the system's activity or production; organization is a measure of the number and diversity of interactions between the components of the system; and resilience is the system's ability to maintain its structure and function in the presence of stress (Mageau et al., 1995). The requirements for healthy business ecosystems proposed by Iansiti and Levien (2004) are extremely similar: productivity, niche creation, and robustness.

Building on these definitions, Table 4.1 proposes an initial framework for the evaluation of the health of energy access ecosystems. This is set up to address the national-level energy access ecosystem, which remains a critical unit of human organization in terms of laws and policies, national budgets, institutions, and capacity systems. It is however recognized that local and provincial ecosystems

Table 4.1 Indicators for a healthy energy access ecosystem

	Ecosystem health indicator	Unit	Data source
Financing			
1.1	Total annual investment in energy access infrastructure per capita	\$\$	Available: IEA
1.2	Volume of private sector investment in energy access infrastructure per capita	\$\$	Available: IEA
1.3	Availability of microfinance for energy end user and enterprise financing per capita	\$\$	Unavailable: consultation workshop needed
1.4	Volume of national government/donor financing targeting energy access per capita	\$\$	Unavailable: consultation workshop
1.5	Volume of carbon funding for energy access projects (not industrial efficiency) per capita	\$\$	Unavailable: consultation workshop
Policy			
2.1	Energy access prioritized in PRSP and national budget/capita	Yes/No, \$\$	Available: IMF, World Bank
2.2	Existence of a rural energy agency or equivalent	Yes/No	Available: IEA
2.3	Ease of doing business index	World ranking or score	Available: World Bank
2.4	Corruption perceptions index	World ranking or score	Available: Transparency International
2.5	Transparent and accountable multi-stakeholder processes used in energy policy formulation	Yes/No	Unavailable: consultation required
2.6	Availability of national standards on technical quality in energy access products and services	% products/ services covered	Unavailable, consultation required
Capacity			
3.1	Number and growth in ecosystem members (number of firms and NGOs active on energy access)	#, growth rate	Unavailable: consultation workshop (or from sector association)
3.2	Proportion of ecosystem members displaying innovative businesses and technologies	%	Unavailable: consultation workshop (or from sector association)
3.3	Number and strength of energy access sector and consumer associations	# active, # of members	Unavailable: consultation workshop
3.4	Courses run in educational institutions relating to energy access, including vocational	# of courses, # of graduates	Possibly available: Department of education, skills etc.
3.5	Availability of data on energy access and energy resources within the country	Yes/No	Possibly available: Ministry of Energy
3.6	Existence of widespread campaigning and awareness-raising programmes on energy access	Yes/No	Unavailable: consultation workshops

will have their own characteristics, strengths, and weaknesses, in each of these dimensions.

It is recognized that in practice some indicators will be more important than others, however at this stage the evidence for application of weightings is not strong enough to propose. Weightings may also depend on national or organization-specific contexts. Several of the proposed indicators do not have data available and so rely on consultations that introduce potential variation. With varying units, it is also necessary to normalize answers against a uniform scale for each index. The *PPEO* has translated values into scores out of 1, although this also introduces potential variation, as scales are not absolute on each index.

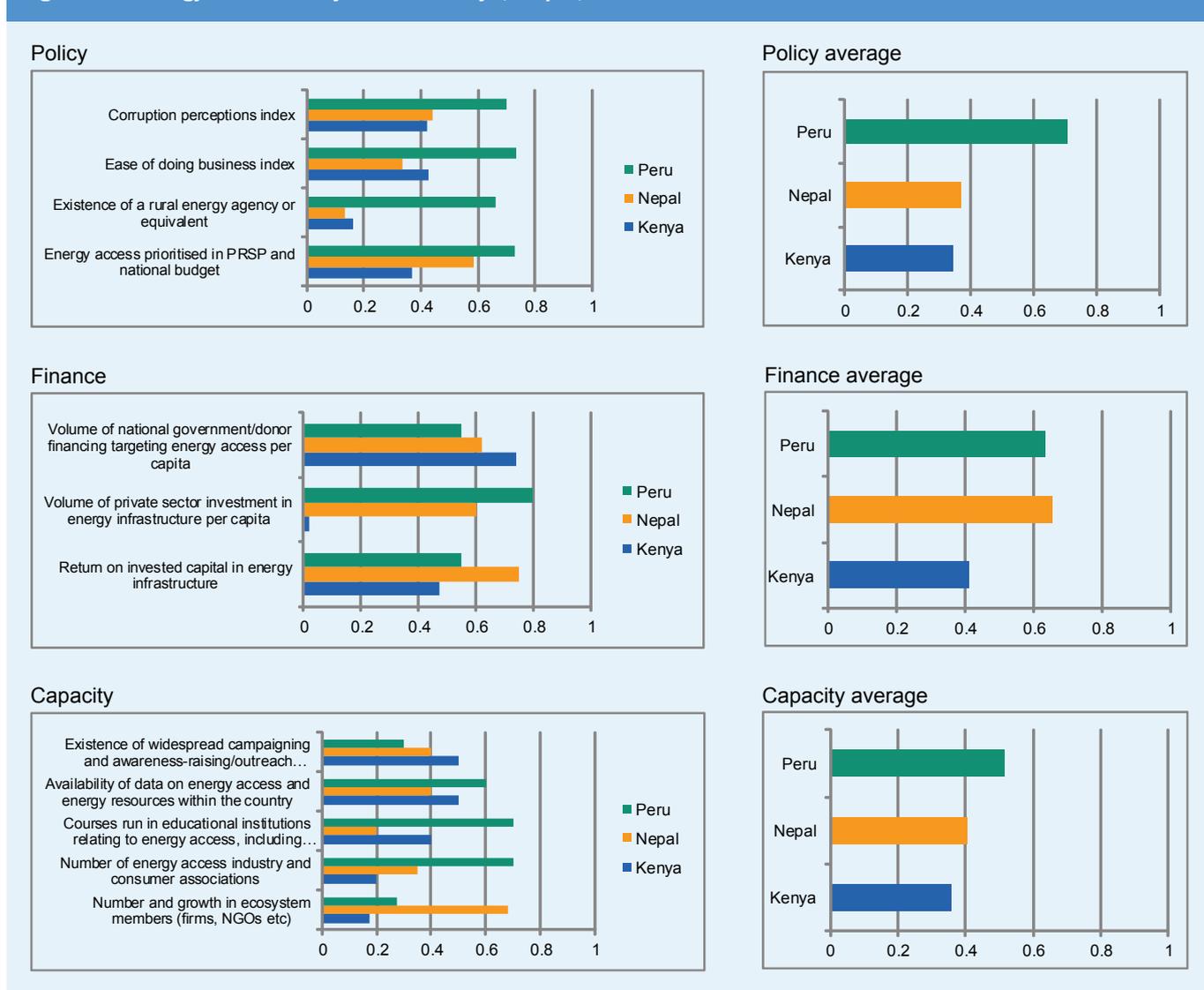
However, it is proposed that the above contains some of the essential policy, capacity, and financing elements of a healthy energy access ecosystem, and can therefore indicate a national ecosystem's health. The better a country scores on the indicators of health in the energy access ecosystem, then the better that country would be expected to do on the basket of overall results on energy access and development illustrated in Table 4.2, including ultimately the MDGs.

Table 4.2 Overall results of a healthy energy access ecosystem

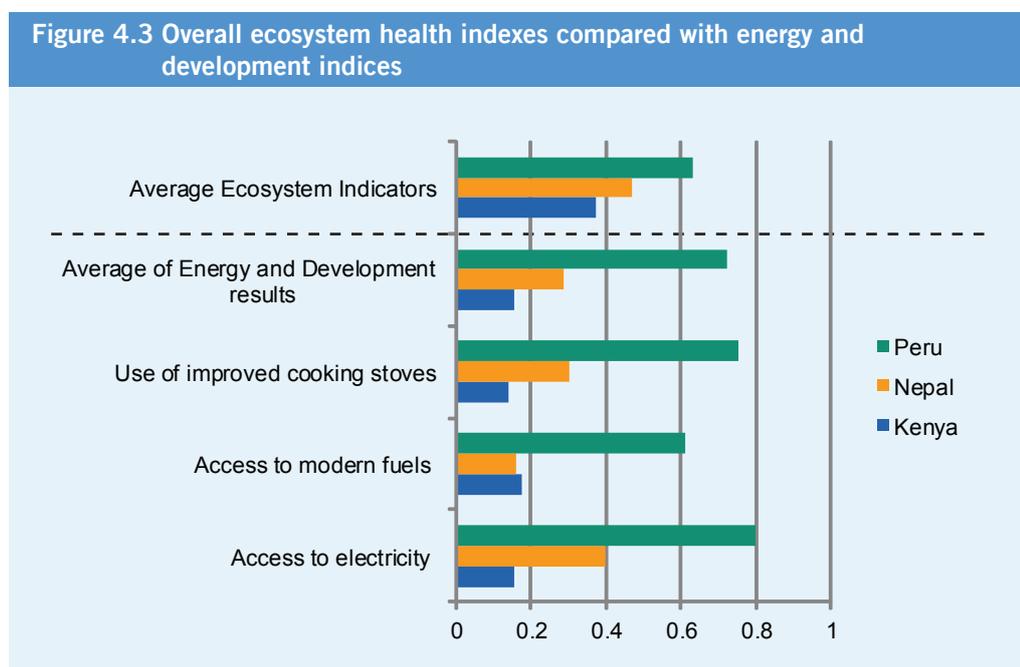
	Energy and development indicators	Unit	Data source
4.1	Total Energy Access (TEA) and Energy Supply Indices (ESI)	Score, Score	Soon available: Total Energy Wiki
4.2	Percentage of households with access to electricity and rate of change	%, rate	Available: IEA
4.3	Percentage of households with access to modern fuels and/or modern cooking devices and rate of change	%, rate	Available: IEA
4.4	Percentage of households with access to mechanical power and rate of change	%, rate	Unavailable: consultation required
4.5	Value and rate of change of Multidimensional Energy Poverty Index (MEPI)	%, rate	Available: UNIDO
4.6	Overall rate of change of MDG monitoring indices	%, rate	Available: UNDP

These indices were applied on a pilot basis in Kenya, Peru, and Nepal, drawing on available data, as well as consultations with actors in the energy access sector, and the results were as shown in Figure 4.2. Scores for each country are presented for each of the policy, capacity, and financing indicators for which data could be gathered, as well as the average scores for each country on policy, capacity, and financing indicators.

Figure 4.2 Energy access ecosystems in Kenya, Nepal, and Peru



The results illustrate the health of national energy access ecosystems in each of the three countries. Comparison with the overall energy and development results available today provides an initial indication of correlation between ecosystem health and energy access outcomes.



In piloting the indicators some challenges were encountered, including that not all indicators could be addressed within available resources and data consistency was an issue. This suggests room for refinement of the indicators, and reiterates the call for improved energy access data collection and publishing. In addition, while capacity and policy indicators show a trajectory of some years, finance indicators tend to show a snapshot of the last year of budget information, when in practice investments change over the years. A degree of weighting of the results was necessary in order to present per capita values out of 1 – although weightings do not necessarily represent the respective influence of each indicator.

Although the small sample of three countries and early generation of the ecosystem health metric mean caution is required, interim conclusions pointed to by the breakdown of pilot results illustrated in Figure 4.2 include the following:

- Policy indicators of national enabling environment factors, corruption, and ease of doing business, appear to broadly correlate with energy access outcomes, however they require broader processes of reform outside of ‘energy’ policy. This re-emphasizes the integrated nature of energy access with progress on broader societal and policy issues. Corruption is likely to be a drag on the system as a whole, while ease of doing business will affect market-oriented solutions particularly, as well as earning a living potential from the energy access created.
- Existence of a rural energy agency or equivalent is an indicator of intent in policy, however correlation with results is likely to depend more on institutional capacity, mandate, and integration with other ministries – and indeed it appears a weak predictor for outcomes as currently formulated. The prioritization of energy access in national policy and budgets however appears a much stronger predictor, emphasizing the need for clear and expressed commitment to energy access at government level.

- Finance indicators overall do not appear to reflect energy access outcomes as much as policy outcomes do overall. This is possibly in part because finance indicators reflect only the latest national budgets and investments, while longer-term trends in investment have cumulated in the results visible today. A country such as Peru with relatively high energy access could be expected, as it does, to have relatively lower government and donor levels of financing than those with lower access (if that is being actively addressed).
- Private investment however appears to show stronger correlation with the overall results. In this respect, private investment may to some extent be considered a bellwether for the energy access ecosystem. As energy access ecosystems strengthen and mature, in terms of their policy conditions and capacity, so risks should reduce. In this context private sector investment can be expected to form a larger portion of total energy access investment.
- Capacity health indicators as a whole reflect overall results reasonably well, but with some significant deviations between sub-indicators. Capacity indicators present mostly quantitative data, showing for example the number of courses in educational institutions, but not their quality or skill outcomes. The existence of widespread campaigning and awareness on the issue is the only ecosystem health indicator that appears to run in opposite correlation to the energy access outcomes. This is possibly since the country with the most widespread problem could be expected to have the most campaigning and awareness, to create, over time, the policy and financing shifts needed to create access.
- Of all the capacity indicators the number of energy access consumer and industry associations appear the most linear with the results, perhaps indicating that the establishment and consolidation of these collective institutions is a good indicator of ecosystem evolution and strength in terms of interconnections and collaboration. The total sum of ecosystem members, such as NGOs, firms, and government agencies, appears a weaker predictor than this, perhaps since results are more closely linked with the degree of complementarity, co-ordination, and skills – rather than pure numbers – which can indicate fragmentation.

When the policy, capacity, and financing indicators are integrated into the overall energy access ecosystem health indicator however, then the correlation appears stronger than for any indicator alone. This may emphasize the mutual dependency of these three factors in the overall outcome.

The differential between countries in energy and development outcomes appears even more marked than that between the ecosystem health indices. It is possible that this is due to the cumulative effect of this ecosystem health offset over a period of years, as energy access outcomes (including earning a living) and ecosystem health mutually reinforce over time.

Feedback and discussion on this approach to assessing ecosystem health is welcomed. Collaboration and support is welcome with a view to strengthening the methodology and dataset further, to enable stronger assessment, ranking, and comparison of national and sub-national energy access ecosystems.

With a basic correlation evident, the question becomes whether the ecosystem health indicator can assist in guiding policy and action and identifying intervention points to accelerate universal energy access.



Accelerating energy access

To guarantee universal energy access by 2030, and to maximize the potential it has for helping poor people earn a decent living and escape poverty, the energy access ecosystem must be enhanced. In this section the three key aspects of policy, financing, and capacity are examined in more detail.

Policy

The framing of the energy access ecosystem health indicators suggests the types of policies and regulations that will affect levels of access to energy services. The multiple sources of energy and the variety of value chains involved in delivering energy services mean that the policies affecting access are not confined to the energy sector, which has conventionally been the remit of energy policy. In the case of biomass energy, for example, regulations for forestry and agriculture, land tenure, natural resource management, rural development, and health, are all relevant (PISCES, 2009).

For public policy to play a role in accelerating universal access to energy services, direction must come from an overall strategy or national goal for energy. Where there has been significant and rapid progress in increasing levels of access (e.g. China, Brazil, Vietnam), action has been initiated by a high-level political commitment. If energy access is not a clear policy objective for national governments, and for the donor governments that support them, there may be little progress towards the goal of universal access.

This is however only the first step. The policy objective of increasing access to modern energy services needs to be articulated in terms of specific national targets. International or global targets for access, such as those adopted by the Africa-EU Energy Partnership or advocated by the UN Secretary General, can provide a focus for debate in the international community and a stimulus to national policymaking, but they cannot replace national targets for energy access. About half of all developing countries currently have electricity access targets of some kind, though many are less ambitious than the universal access target. Only a few countries have targets for access to modern fuels and improved cookstoves, with even less for mechanical power.

Table 4.3 Number of developing countries with energy access targets

	Developing countries	LDCs	Sub-Saharan Africa
Electricity	68	25	35
Modern fuels	17	8	13
Improved cookstoves	11	4	7
Mechanical power	5	0	5
Total no. countries	140	50	45

Source: UNDP/WHO, 2009

A wider recognition of the role of energy services would support a refinement of national targets in line with Total Energy Access minimum standards. The *PPEO* proposes these as an improved basis for setting and tracking real progress in energy access.

Targets for increasing levels of access to modern energy services then need to be reflected through the range of regulations, institutions, and budgets that affect action. Most obviously, access to energy needs to be integrated in national poverty reduction strategies, and poverty reduction objectives need to be reflected in energy policy documents. Government institutions, including ministries need to be aligned in their objectives to the energy access goal and targets. The role of Rural Energy Agencies has been important in accelerating progress in some cases, although such institutions are no silver bullet if operating with low budgets, capacity, or mandate uncertainty with respect to related ministries. The role of standards institutions is important in safe and reliable energy sector development, as highlighted in the energy ecosystem health indicators. Local government institutions are also critical in translating national plans into local realities.

Co-ordination across government institutions and levels such as this can only be achieved by the high level and sustained political commitment that is essential to create universal energy access. The World Bank found that, ‘a long-term commitment (at least 15 to 20 years) to electrification is a crucial step that frames the institutional, technical, economic, and financial design and implementation of specific programs’ (World Bank, 2010). If the policy commitment is inconsistent or varies, the environment for investors and implementers is uncertain, and capacity to sustain the design and implementation of energy services cannot be built up.

Design of the specific national plans and strategies needed to achieve these targets is informed by the recognition that energy services are delivered through energy access ecosystems. The contributions of the multiple existing and potential actors in expanding energy access can be recognized and, through transparent and inclusive planning processes which also include consumer groups, workable approaches can be developed. In particular, policy frameworks providing clarity

“ Only policy can set the framework enabling access for the poorest ”

Box 4.1 Practitioner's perspective – policy action and training for a countrywide stove project

It is all about commitment; it is all about putting it on a priority list. In Rwanda, it started as obligatory; today it has become life practice. Once the use of efficient stoves got adopted as a government policy, the Ministry responsible took the initiative to conduct massive countrywide training on the construction and use of stoves to a number of different groups that included women and youth. The approach was to train trainers who went around conducting the training at the locations where stoves were to be installed. This countrywide exercise saw a huge number of stoves being installed, employing and paying a number of youth groups, especially in urban and semi-urban areas; this employment goes on to date. Now, in Rwanda, use of improved stoves in homes is regarded as a basic necessity in the same way as having a roof on a house. Other alternative sources of energy, including solar (photovoltaic and thermal), and pico- and micro-hydro, are slowly following the trend.

Albert Butare, Former Minister of State for Infrastructure of Rwanda

on the roles of on- and off-grid electrification are hugely beneficial in enabling co-ordinated and complimentary action between these two sectors. Important also is establishing the legal basis for operation of the full range of energy access ecosystem players, whether they are independent power producers (IPPs) or importers of energy appliances and equipment. The ecosystem perspective also addresses the wider policy environment in overlapping policy areas, as well as issues such as corruption and ease of doing business.

Only policy can set the framework for tariffs enabling access for the poorest via an element of cross-subsidy, or the incentive structure which sets widening access to poor people as an ecosystem goal. Policy on energy access is however ultimately effective only when it triggers and reinforces activity in the other two key elements of the energy access ecosystem: financing and capacity.

Financing

The amount of investment needed to achieve universal energy access by 2030 was estimated by both the AGECC and IEA at between US\$35 billion and \$40 billion a year. Bazilian et al. (2011) estimated the annual costs as between \$14 billion and \$136 billion, depending on which assumptions are made. Though these figures are equivalent only to a small proportion of total global energy investment, they are still large amounts and far above current investment levels.

While the international community debates where this money should come from and how it will be delivered, poor women and men in developing countries are faced with financial questions of quite a different order. Even if electricity is available, can I afford it? Can I afford the connection charge? Can I afford the monthly fee? Is it worth buying an improved cookstove when I don't pay for wood fuel?

Even when the infrastructure is in place and energy is available nearby, low-income households are faced with pressing questions of affordability. The availability of an energy supply, an electricity grid, LPG distribution network or kerosene seller, for example, does not guarantee universal access to energy services. In some countries the proportion of communities electrified is much higher than the proportion of households connected (World Bank, 2010). A study for UNIDO concluded that, 'it is not proximity to the power line but cost that constitutes the main factor excluding poor people from grid connection.' (UNIDO, 2010)

“ Even when the infrastructure is in place and energy is available nearby, low-income households are faced with pressing questions of affordability ”

“ Poverty remains the main barrier to energy access – yet lack of access to energy services is a barrier to poverty reduction

Poverty remains the main barrier to energy access for the billions who currently lack adequate access. Yet, lack of access to energy services is a barrier to poverty reduction, as the ‘earning a living’ theme of this year’s edition highlights. In a further paradox, poor families devote a significant proportion of their income to energy services (7-12 per cent according to Bacon et al., 2010, and up to 19 per cent according to Winkler et al., 2011) but still cannot afford modern energy services.

The choice of technology is one way to make energy more affordable. The adoption of low-cost technologies at the design or planning stage can reduce investment costs by 20-30 per cent without affecting the quality of energy services (World Bank, 2010). Cost reductions may also be sought through technology improvements – for example the reduced cost of solar PV. As ecosystems strengthen, additional factors can come into play lowering costs, including volume and learning effects, improved supply chains, and cost efficiencies in production, distribution, maintenance, and spares.

But it is in the area of finance that we find some of the most effective and innovative ways to reduce the costs of modern energy services for low-income households.

“ Some of the most effective and innovative ways of reducing costs are in the area of finance

The ecosystem health indicators at the national level include critical ecosystem financing aspects in terms of the volumes per capita of different types of financial resources. This includes how much government and donor support is flowing into the ecosystem and how much private investment activity there is. It is widely recognized that these volumes must increase if universal access is to be achieved. However, a critical indicator of the impact of this money on energy access outcomes is how it affects poor people’s ability to afford energy supplies and services. The ecosystem health indicator on how finance translates into end user or enterprise finance at the local level is an important dimension of this.

There are a number of ways to apply available financial resources to make modern energy services more affordable to low-income families, addressing the investment costs or the recurring costs. While support to supply has been the traditional approach and still has an important role, an increasing degree of attention should be applied to the issue of supporting the effective demand of poor people within a more vibrant energy access ecosystem. Mechanisms to do this fall into three broad categories: grants and subsidies, tariffs and pricing, and savings and credit.

Grants and subsidies

Grants and concessional loans for capital investments, and price subsidies for fuel and electricity tariffs are the conventional financial instruments used to make energy more affordable to low-income households. Grants, from governments and donors, are justified on the grounds of supporting investment that would otherwise not take place, to achieve longer-term economic and social returns. The rationale for price subsidies is social equity and welfare gains, though in practice shorter-term political considerations play a part.

Grants and concessional loans for capital investment, predominantly for infrastructure (generation and distribution capacity), are provided to energy suppliers or service providers, who face high up-front capital costs. Because of weak effective demand, commercial returns in providing energy services to poor households are often low, so many initiatives aimed at low-income consumers have received substantial start-up grants, subsidy, or non-commercial financing to initiate and maintain services. The US\$35-40 billion a year estimated investment

requirement for universal access is largely for this type of capital investment. The AGECC suggested that US\$15 billion of this would come from public finance.

While these investments remain an important ecosystem element, the low-income consumer benefits only indirectly from this form of supply-side grant or subsidy. There may be no guarantee that subsidies for investment in generation and distribution infrastructure will provide welfare benefits for low-income groups. In addition, such large capital projects often attract waste and corruption in weak policy ecosystems, and fail to address pressing needs for cleaner cooking and mechanical power, while ignoring the potential contribution of decentralized and renewable electrification.

Energy access can also be promoted through grants for investment costs incurred directly by low-income consumers. A World Bank study concluded, 'A greater emphasis on reducing the connection cost charged to the poor is a cost-effective way of increasing electricity access.' (World Bank, 2010) Though the cost of individual connections accounts for a very small proportion of total investment, the unaffordability of the connection costs to poor families can keep the level of access down. Targeted grants or subsidies on the capital costs for households in connection charges, internal wiring, and appliances etc. can boost access by putting effective purchasing power in the hands of poor consumers, who can then pull services more effectively (see also end user micro-finance in 'Savings and credit' section). This key ecosystem dimension is one for which activity and data is currently too low even for inclusion in the pilot ecosystem's health analysis in the previous section.

Price subsidies on fuels and electricity tariffs reduce the amount that consumers pay for energy from their own incomes, and are widely used. The IEA has estimated that a total of US\$577 billion was spent on such subsidies in 2008 in 37 larger developing countries (IEA, 2010). General price subsidies however, tend to favour the better off, who consume more energy. In Gabon, for instance, the richest 10 per cent of households captured 33 per cent of the subsidy, while the poorest 30 per cent received only 13 per cent (Rijal, 2007). In sub-Saharan Africa subsidies on residential tariffs were found to be highly regressive (Foster et al., 2010; World Bank, 2010). General price subsidies can also have the effect of undermining market viability, for example short-term subsidies on appliances such as improved stoves can damage developing stove markets when withdrawn.

Targeted grants and subsidies paid out on demand-side energy access results, rather than supply-side capital expenditures, are being explored as alternative ways of rewarding suppliers and targeting subsidies on those without a minimum level of access. A degree of early-stage accompanying grant support to local energy supply and service market chains can be warranted in order to build capacity and sector co-ordination, as well as local-level job creation in supplying energy (see Chapter 2). This recognizes the different stages in the lifecycle of enterprises, sub-sectors, and ecosystems. For example a start-up firm may need a grant or angel investment, whilst a more established firm may be looking for an equity investment to scale up. Equally some sub-sectors in a country may be pre-commercial and so research grants are required to improve sector data, capacity, and knowledge, while for others a results-based incentive would be most appropriate in accelerating service coverage and affordability.

Tariff and pricing structures

In some countries, energy tariffs can be fixed by the government at levels below the cost to provide the service. Although this can be a vote winner and reduces costs

to consumers as a whole, it acts like a general subsidy in benefiting most those consuming most energy, while also undermining the viability of providers (usually state utilities).

Stepped tariffs where the lowest costs are charged to those consuming least power and fuels (often called 'lifeline' tariffs) are an effective way of structuring pricing to build in an element of cross-subsidy and enable the poorest to afford electricity supplies when connected.

With respect to decentralized energy services, an additional range of options are available including fee-for-service arrangements (or leasing) allowing access to energy services by removing the need for up-front capital costs from the end user. The ownership and responsibility for maintenance of the equipment remain with the supplier until the service agreement ends. Several providers of solar home systems and lanterns worldwide are pursuing this approach, which could be expanded.

When the payback period is long, this kind of lease system can be a lower-cost way of financing capital investment for the consumer. However, the cost of fee collection can be high for the dealers, although the increasing availability of financial services via mobile phones offers a possible means to reduce transaction costs. At the same time, working through trained local distributors with better knowledge of customers can also mitigate these costs. This approach is linked to development of local level capacity, and creates new earning opportunities in energy supply.

Savings and credit

Financial services from informal and formal institutions can play a significant role in enabling poor families to access modern energy services. Financial institutions, energy service or product suppliers, and intermediary organizations, such as NGOs, can be involved in the design and implementation of financial services appropriate to the needs of low-income consumers or MSEs in energy service value chains.

Though most initiatives directed at low-income households are concerned with the provision of credit, there are also ways to facilitate savings to pay for modern energy services. In some places cash savings can be made because a modern energy service reduces overall expenditure on energy. Credit schemes can be designed so that these savings are used to repay capital costs (e.g. ToughStuff's layaway scheme using mobile banking technology). Money box schemes (e.g. as used by Toyola) are used to facilitate household budgeting that ensures that savings are available to repay loans.

Credit schemes for energy consumers, lending to individuals (sometimes with peer groups to help guarantee repayment), are usually providing credit for the purchase of appliances or equipment (e.g. LPG bottle and/or cooker). The product is often collateral for the loan. Other schemes use a guarantee fund (e.g. Rural Energy Foundation). However, there is generally a gap in credit supply, which prevents poor households from borrowing money for the up-front costs of access to energy equipment or connections. This must be addressed by appropriate sources of finance if this vicious circle is to be broken.

Sources of finance

Broadly speaking we can distinguish three sources of finance for investment in the development of energy services: the public sector, the private sector, and carbon credits. Within each of these broad categories a number of more specific sources

of finance can be identified. For example, public finance can include Official Development Assistance (ODA) from donor country governments, and funding through subsidies or capital investment programmes by national governments. The private sector includes both foreign and local investors and financial institutions, finance for equity and loans, and even finance from savings by energy consumers.

The carbon market, which is established to varying degrees in developing countries, has two main categories: certified emission reduction credits (through CDM) and voluntary market credits.

Box 4.2 Practitioner's perspective – pathways to low-carbon growth and economic development

Low-carbon opportunities enable developing countries to jump directly to cleaner technologies through simultaneously accelerating development and reducing poverty. Technologies include using solar, wind, geothermal, methane, hydro, and other locally available resources, as well as improving the efficiency of existing technologies. The Community Development Carbon Fund (CDCF) promotes tangible poverty reduction and sustainable development outcomes through purchasing emission reductions (ERs) from small-scale projects that provide direct or indirect community benefits. With this focus, the CDCF has currently committed 55 per cent of its capital to buy ERs from projects located in the Least Developed Countries, as designated by the United Nations, and countries that qualify for lending from the World Bank Group's International Development Association (IDA). In addition, the CDCF is helping to expand the reach of the carbon market by developing small-scale CDM methodologies.

Govind Nepal, Nepal National Planning Commission

All of these types and sources of finance are necessary, however no one type of finance can meet the full range of needs for investment in the energy ecosystem of a particular country. Often a variety of financing types and sources must come together in order to overcome a capital barrier or deliver a new type of service. A diversity of financial institutions and financing mechanisms is necessary to match the diversity of energy services, supplies, enterprises, and consumers that can be found in all countries.

What ultimately drives this diversity is effective demand. So while a range of sources of working and other capital for energy enterprises is important, and increasingly recognized – the range of grants, loans, and results-based subsidies available to poor consumers is also an essential element of the energy access ecosystem. This puts purchasing power in the hands of poor people to draw the energy supplies and services they choose.

“ Grants, loans, and subsidies targeting poor consumers are an essential element of the energy access ecosystem ”

Capacity

In order to deliver universal energy access more and more capable organizations within national and international energy access ecosystems will be required. Capacity will be required within the government institutions and agencies supporting achievement of policy goals and targets, within companies and utilities within the main market chain delivering energy products and services, within other companies and NGOs providing supporting services to that chain, within universities providing training and research, and within financial institutions providing loans and investments.

National and local innovation and knowledge systems are key, but knowledge and expertise from across the world can also be drawn from to inform the transfer and adoption of technologies, models, and approaches at point of need. Involvement of universities, research, and education institutions in the north and south in long-term partnerships can be an important step in this process.

Universities and training institutions have a wider role however in retaining and building sector capacity via courses and research. From the pilot survey on ecosystems health, in Peru there are 30-40 courses run each year relating to energy access, from practical courses in improved wood stoves and solar energy, to courses in law, taxation, and management for energy projects. In Nepal meanwhile, just one course is run, in renewable energy. However, as noted in Box 4.3 Nepal does have strong approaches to capacity development at local levels via District and Village Development Committees.

Box 4.3 Levels of capacity development in Nepal

Nepal's Micro-Hydro (MHS) programme places a strong emphasis on community mobilization. It works to ensure that MHSs are installed by community members in close cooperation with District Development Committees (DDCs) and Village Development Committees (VDCs). Local NGOs are developed and nurtured to act as support organizations (SOs), which carry out the process of community mobilization.

Within the MHS programme, the process of community mobilization is guided by six basic principles (known as the 'Mul Mantras'), which include: organization development, skills enhancement, capital formation, technology promotion, environmental management, and empowerment of vulnerable groups and communities. The SOs support the villagers to establish community organizations and ensure that at least one male and one female from each household are members of a community organization of the target VDC or settlement.

Source: UNDP/AEPC, 2011.

In addition to capacity within institutions and the supply sector, awareness and empowerment on the part of consumers is also an important aspect of capacity. This is related both to informing people about health issues associated with indoor air pollution, or the earning activities possible with energy access for example, as well as product marketing on the part of solution providers.

Both industry and consumer associations can contribute to and represent ecosystem capacity through the interconnections and collective action that they can enable. Such institutions can often play important roles, alongside state institutions, in building up sector data which is vital for all players in the sector, but which cannot usually be financed by a single player. This includes information on energy resources and access patterns within the country. Such institutions can also provide representation in policy discussions and also feedback to sector players on what the latest policy situation is, informing awareness in the sector. Sector support programmes such as the Lighting Africa programme can also perform some of these enabling and co-ordination functions.

Building ecosystem capacity in strength, breadth, and depth remains a critical challenge in building healthy energy access ecosystems. The elements above are created and reinforced by policy and finance aspects related to investments in research and development, as well as experience in the successful delivery of projects. Again, a virtuous circle can be developed with sustained commitment to the building of capacity where more experience, creating more capacity, improves returns on these investments.



Building a movement for change

The overarching global push on energy access is being led by the United Nations, and sustainable energy (with a primary focus on access, but also with efficiency and renewable targets) is central to the Secretary General's second term. In order to generate momentum and commitments to energy access, 2012 has been voted the UN Year of Sustainable Energy Access for All by the General Assembly.

Rio+20 is a pivotal point in the year at which a new Secretary General's Initiative will be launched. This includes various political, business, and financial commitments to delivering sustainable energy access.

This initiative builds on the work previously carried out by AGECC, the Secretary General's Advisory Group on climate change and energy, and the ongoing work of UN-Energy chaired by UNIDO Director General Kandeh Yumkellah. More information, including a diary of action opportunities and platforms during 2012 is accessible at www.sustainableenergyforall.org

While the UN has the mandate to call for action, recognition of the ecosystem nature of energy systems is required. This recognizes in turn the interlinked contributions of multiple stakeholder groups.

What needs to happen?

Above all, what is needed is leadership. But not just from political leaders, leaders across all sectors must demonstrate a collective will to succeed if universal energy access is to be achieved by 2030. The *PPEO* calls on these key players to take the following actions:

- **Government leadership** – Set national targets for universal energy access by 2030 and formulate and implement plans to deliver these targets (targets should recognize Total Energy Access minimum standards and the Energy Supply Index of supply quality).
- **Donor/lender leadership** – Increase investment in energy access, targeting stimulation of the ecosystem delivering energy services meeting the needs of poor people at the level of the household, enterprise, and community institutions.
- **Civil society leadership** – *In developing countries* – demonstrate and report on good practice, create awareness of the benefits of energy access on health and development amongst communities, represent people living in energy poverty internationally. *In donor countries* – raise awareness amongst the public, donors, and private sector, of the importance of access to energy services in achieving development and environment goals.
- **Private sector leadership** – *In developing countries* – respond to government and donor incentive structures on expanding the quality and quantity of energy access products and services. *In donor countries* – increase investment and activities in energy access sectors in developing countries targeting base-of-the-pyramid markets.
- **International institutions** – Pursue international agreement and commitment to the goal of universal access to energy by 2030. Create high points of support for energy access that have an inspiring and galvanizing effect in forming a movement for change.

It is hoped that this report will also play a role in informing and promoting the movement for change on energy access.

In this second edition, the *PPEO* has taken as its theme the role of energy services in helping people earn a living. We hope this will create a wider and deeper understanding of why energy access is so important to ending poverty, as well as meeting basic needs.

The *PPEO 2012* continues the development of the Total Energy Access minimum standards and Energy Supply Index, as more evolved definitions of energy access. We hope these will inform the goals and targets which are set at national and international levels, bringing them closer to the needs and aspirations of those in energy poverty.

And in this final chapter, the *PPEO* has proposed the idea of energy access ecosystems as a way of understanding the massive change which will have to take place if universal energy access is to be achieved. We hope that the concept of ecosystem health will develop to inform more joined-up and transformative approaches to policy, financing, and capacity for energy access.

Creating sustainable energy access for all will be one of the great challenges of this century. To achieve it will require a step change in the efficiency and equitability of human organization. This will take bold leadership, and leverage of the skills and resources of people and organizations all over the world. But we believe it is possible, and 2012 should be the launch pad for an energy access revolution.

Annex 1. Total Energy Access questionnaire

This tool is designed to assess whether a household meets the Total Energy Access (TEA) minimum standards (defined in Table 3.1), using a simple and replicable yes/no type questionnaire:

Name			
Age		Sex	
No. of people in household			
GIS coordinates of house (or address if not possible)			
Lighting			
	QUESTION	CRITERIA	RESPONSE
L1	Do you have a fixed or portable electric light that you use regularly in your house?	No = 0	
		Yes = 1	
L2	IF YES – Do you use this light for more than 4 hours per day?	No = 0	
		Yes = 1	
Threshold – To achieve TEA1.1, L1 = 1 AND L2 = 1			Met <input type="checkbox"/> Not met <input type="checkbox"/>
Cooking and water heating			
CW1	Do you mostly use liquid or gas fuel or electricity for cooking?	No or Don't know = 0	
		Yes = 1	
CW2	IF NO OR DON'T KNOW – Do you have an 'improved' solid fuel cookstove which uses less fuel than an open fire?	No or Don't know = 0	
		Yes = 1	
CW3	Do you have a chimney or smoke hood over your cookstove or fire?	No = 0	
		Yes = 1	
CW4	Does your household spend less than 30 minutes a day collecting firewood?	No = 0	
		Yes = 1	
Threshold – To achieve: TEA2.1, CW1 = 1, OR CW2 = 1 AND CW4 = 1 TEA2.2, CW1 = 1, OR CW2 = 1 TEA2.3, CW1 = 1, OR CW2 = 1 AND CW3 = 1			Met <input type="checkbox"/> Not met <input type="checkbox"/> Met <input type="checkbox"/> Not met <input type="checkbox"/> Met <input type="checkbox"/> Not met <input type="checkbox"/>
Space heating			
S1	Is your house warm enough all year round without heating?	No = 0	
		Yes = 1	
S2	IF NO – do you have a purpose-built heating device or heating stove?	No = 0	
		Yes = 1	
Threshold – To achieve, TEA3.1, S1 = 1 OR S2 = 1			Met <input type="checkbox"/> Not met <input type="checkbox"/>
Cooling			
C1	Do you use an appliance to keep food cool in your house most of the time? (e.g. refrigerator, coolbox)	No = 0	
		Yes = 1	
C2	Is your house cool enough all year round without cooling?	Yes = 1	
		No = 0	
C3	IF NO – Do you use an air cooling device? (e.g. an electric fan or air conditioning)	Yes = 1	
		No = 0	
Threshold – To achieve: TEA4.1, C1 = 1 TEA4.2, C2 = 1 OR C3 = 1			Met <input type="checkbox"/> Not met <input type="checkbox"/> Met <input type="checkbox"/> Not met <input type="checkbox"/>
Information and communications			
IC1	Do you have a fixed or mobile phone in your house?	No = 0	
		Yes = 1	
IC2	Do you use a radio or TV in your house?	No = 0	
		Yes = 1	
IC3	Do you have internet access in your house?	No = 0	
		Yes = 1	
Threshold – To achieve: TEA5.1, IC1 = 1 OR IC3 = 1 TEA5.2, IC2 = 1 OR IC3 = 1			Met <input type="checkbox"/> Not met <input type="checkbox"/> Met <input type="checkbox"/> Not met <input type="checkbox"/>
Questionnaire completed by		Date	E-mail address

Please go to www.energypedia.info/totalenergywiki to upload completed questionnaires and data

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Since 1 January 2011, The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH has brought together under one roof the capacities and long-standing expertise of DED, GTZ and InWEnt. As a 100% federally owned, public-benefit enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development. Working efficiently, effectively and in a spirit of partnership, GIZ supports people and societies worldwide in creating sustainable living conditions and building better futures. GIZ operates in more than 130 countries worldwide.

Photo Captions and Credits

Front cover photo: Twenty year old Meenakshi Diwan tends to maintenance works in the solar village of Tinginapu, Orissa, India (Abbie Trayler-Smith/Panos Pictures).

Back cover photos: Right to left: Sylvia Chileshe cooks on an electric hob, Zambia (Katie Welford/Practical Action); a carpenter in Yanacancha, Peru, uses an electric sander in his workshop (Ana Castañeda/ Practical Action).

Page xiv: Gilberto Malca Molocho climbs an electricity pole in Yanacancha, Peru. The village has benefited from the introduction of micro-hydro electricity (Ana Castañeda/Practical Action)

Page 6: A women's cooperative member in Kisumu, Kenya, earns a living through making and selling improved cook stoves (Gemma Hume/Practical Action)

Page 10: A miller in Nepal using an upgraded watermill, which grinds grain down to flour more quickly and efficiently (Martin Wright/Ashden Awards www.ashdenawards.org)

Page 18: Ester Nkonge blow dries a customer's hair in her Kenyan salon. Adequate and affordable energy access has a strong bearing on the viability of MSEs (Karen Robinson/Practical Action)

Page 28: Manufacturing, such as textiles in Bangladesh, is a key employment industry in many developing countries. Manufacturing requires energy services to function (Anne Kathrin Mohr/GIZ)

Page 31: A boy learns traditional charcoal production using an earth mound kiln in Kisii, Kenya. Charcoal provides important earning opportunities to poor people (Geoffrey Ndegwa)

Page 40: An improved wood cooking stove has reduced smoke pollution in Santiago Morontmoy's house in the high altitude community of Quenamari, Peru (Marco Antonio Arango/Practical Action)

Page 44: Two men and a boy transport bricks by bicycle and trailer in Bangladesh (Zul Mukhida/Practical Action)

Page 46: Power lines in Kibera, Kenya, where research was carried out. Many residents make illegal connections to the grid for electricity access (Ella Jolly/Practical Action)

Page 60: A woman and solar panel at the school in Quenamari, Peru, which provides hot water shower facilities for the community (Marco Antonio Arango/Practical Action)

Page 70: National television arrived in the village of Chalan, Peru, via this satellite dish in 1995, powered by micro-hydro (Steve Fisher/Practical Action)

Page 79: A Ugandan woman lights a fire under a traditional three-stone fire (Karin Desmarowitz/GIZ)

Page 87: Villagers work together to erect a small wind turbine in the off-grid village of Lamag, Philippines (Drew Corbyn/Practical Action)



Poor people's energy outlook 2012

Access to energy is essential for people to earn a decent living and so escape the vicious cycle of poverty and subsistence. Whether people earn off the land, from a micro business, through a job in a larger enterprise or through the supply of energy itself, energy is fundamental.

The *Poor people's energy outlook 2012* examines the linkages between energy access and earning a living. In doing so it maps out the transition between improved energy supply, better enterprise returns, and achievement of development goals.

This second *PPEO* report also refines the definition of energy access, further developing the concept of Total Energy Access as a framework to measure progress in the dimensions that matter to people. The complementary Energy Supply Index indicates the levels of improvement in the quality of supply as people really experience it.

Change in energy access can start with one person, but it must eventually be at the level of the whole system. The concept of an Energy Access Ecosystem is presented, recognizing the energy sector as comprising multiple inter-related systems which collectively deliver energy from a range of resources. The policy, capacity, and finance elements of the 'healthy' Energy Access Ecosystems needed to accelerate energy access are identified as a guide to action.

PPEO 2012 will be of interest to anyone seeking to better understand energy access and its role in development at a human scale. It should be required reading for the international energy sector and programme planners at national and local levels.

'Defining and measuring energy poverty is absolutely vital to effectively address the issues; but it isn't necessarily an easy thing to do. The PPEO tackles this challenge in an informed, professional and highly useful manner.'

Samuel N. Shiroff, Bosch und Siemens Hausgeräte GmbH, Munich, Germany

'It's great to see such a clear voice coming out of Practical Action on behalf of the poor – I pray the world listens!'

Abeeku Brew-Hammond, The Energy Centre, Kwame Nkrumah University of Science and Technology, Ghana

'The PPEO 2012 is a valuable contribution to better understanding the links between access to energy services and economic development.'

Morgan Bazilian, UNIDO and UN-Energy

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