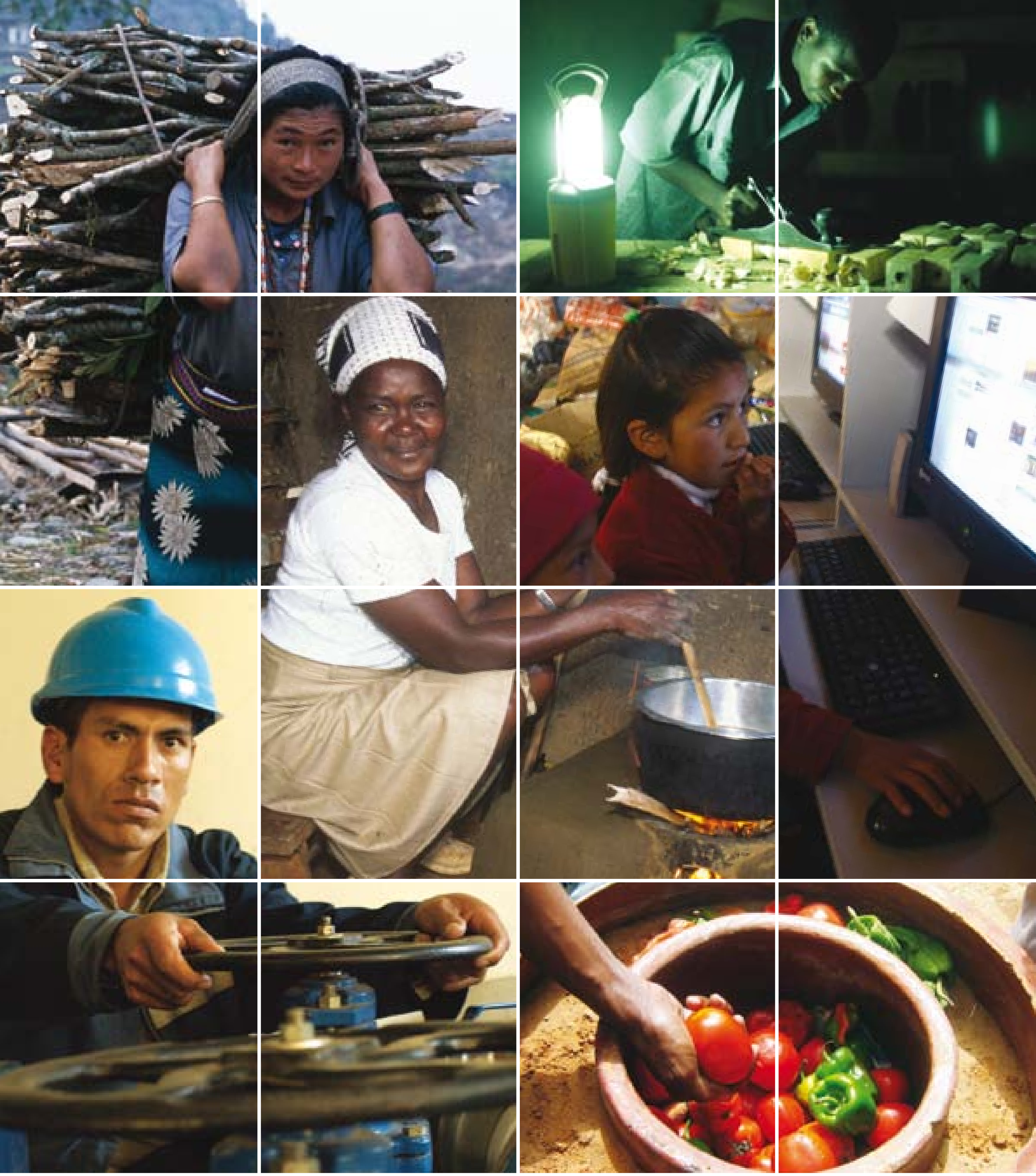

Poor people's energy outlook 2010

PRACTICAL ACTION
Technology challenging poverty

About Practical Action

Practical Action is a development charity with a difference. We use technology to challenge poverty by building the capabilities of poor people, improving their access to technical options and knowledge, 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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The practitioners' views expressed in Chapter 2 of this publication are those of the authors and do not necessarily represent those of Practical Action.

Poor people's energy outlook 2010

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Contents

List of figures

List of tables

Foreword

Access to modern energy services is a fundamental prerequisite for poverty reduction and sustainable human development. Energy services impact upon all aspects of people's lives and livelihoods – people without access are constrained to a life of poverty. The importance of energy access demands greater attention from the development community.

The accounts of women like Rosa in Kenya make the challenges of a life spent in energy poverty abundantly clear:

> *"For me getting energy for cooking and lighting is a daily worry. It's so hard to find firewood that I cook for my family only once a day, in the evening. The fire provides the light for cooking and eating a meal with my children. After eating is bedtime."*

Apart from the physical impact imposed in terms of fuel collection, the wasted time and the inefficient burning of woodfuel in three-stone fires, there is a huge burden on health. A staggering 1.4 million people – mostly women and children – die each year as a result of inhaling smoke from traditional cooking stoves. That's 50% more than worldwide deaths from malaria.

In September 2010 the United Nations Secretary General, Ban Ki Moon launched the target of universal energy access by 2030. He described the importance of energy access in poverty reduction and the role of energy services in meeting the Millennium Development Goals (MDGs):

> *"Universal energy access is a key priority on the global development agenda. It is a foundation for all the MDGs. … Without energy services, the poor are cut off from basic amenities. They are forced to live and work in unhealthy, polluted conditions. Furthermore, energy poverty directly affects the viability of forests, soils and rangelands. In short, it is an obstacle to the MDGs."*

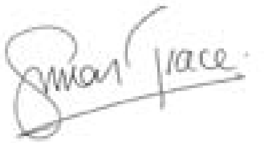
But today's approach to providing energy access to those who lack it is, from a poor person's perspective, fractured and incoherent. National energy planning still assumes that the formal energy sector will be the principle means to ending energy poverty. But reality shows something different. The energy provided by rural electrification programmes is rarely sufficient or affordable for cooking, the most energy-consuming household activity. This leaves millions of families who have been lucky enough to benefit from such a programme preparing their evening meal under the glow of an electric light – in a smoke-filled kitchen over an unimproved wood or dung-burning stove. Meanwhile national planning for improved access to mechanical power, which is so necessary for small enterprises and the development of local economies, remains almost entirely forgotten.

The Poor People's Energy Outlook seeks to highlight today's energy access apartheid, as a first step to ending it. The report presents the perspective of those living in energy poverty through direct testimonies, and proposes a new series of energy service standards in response. Practitioners present their perspectives on the big challenges. Finally, a new framework for action is proposed that recognises the full range of actors needed to eliminate energy poverty, and focuses energy policy on creating an energy access 'ecosystem' in which these various actors can effectively work and flourish. This report asserts that such a change is possible. The UN Secretary General's call for universal energy access by 2030 can still become a reality.

Access to modern energy can truly transform the lives of people living in poverty. Stories like Mamdhur's from Nepal must inspire us to act:

> *"Now we have electric lighting, we are very much relieved. We have more time to spend with our children and families, and no longer breathe in the smoke from the kerosene lamp that used to hurt our lungs. It was my dream to have lighting facilities in my village. The dark has turned to light."*

I hope you, like me, will find the Poor People's Energy Outlook a compelling call to action: energy access for all.



Simon Trace
CEO
Practical Action

Executive summary

One and a half billion of the world's people have no access to electricity at all. Three billion people rely on traditional biomass and coal for cooking.

These global numbers have a shock value in highlighting the sheer size of the energy access problem facing humanity. But from the perspective of people living in energy poverty, they are merely abstractions that disguise countless stories of human suffering. And for people working to address the massive gap in energy access, these numbers are all too familiar.

We know that energy poverty is critically undermining the achievement of the Millennium Development Goals (MDGs). As long as hundreds of millions of people remain deprived of the basic energy services needed to stay fed and healthy, earn a living, and allow the time needed for learning and fulfilment, the MDGs will remain out of reach.

However, while aggregated national and supranational estimations are increasingly produced in an attempt to drive policy urgency, there remains a massive lack of reliable information on energy issues which might be useful at community, project or enterprise levels. Further, the people who have the least access to energy are reflected least in the limited data that are collected. Their voices and experiences are lost – and thus the expression of their needs, desires and preferred solutions.

In the Poor People's Energy Outlook (PPEO), we set out to reconnect policy with people by bringing together a more textured picture of energy access. The PPEO draws on testimonies from people living in energy poverty, field case studies, interviews and focus groups, as well as available data at district, provincial and national levels. Our analysis of these provides insight into the ways people currently use energy, the constraints on expansion of access to energy, and the indicators that can be used to measure progress.

The challenge

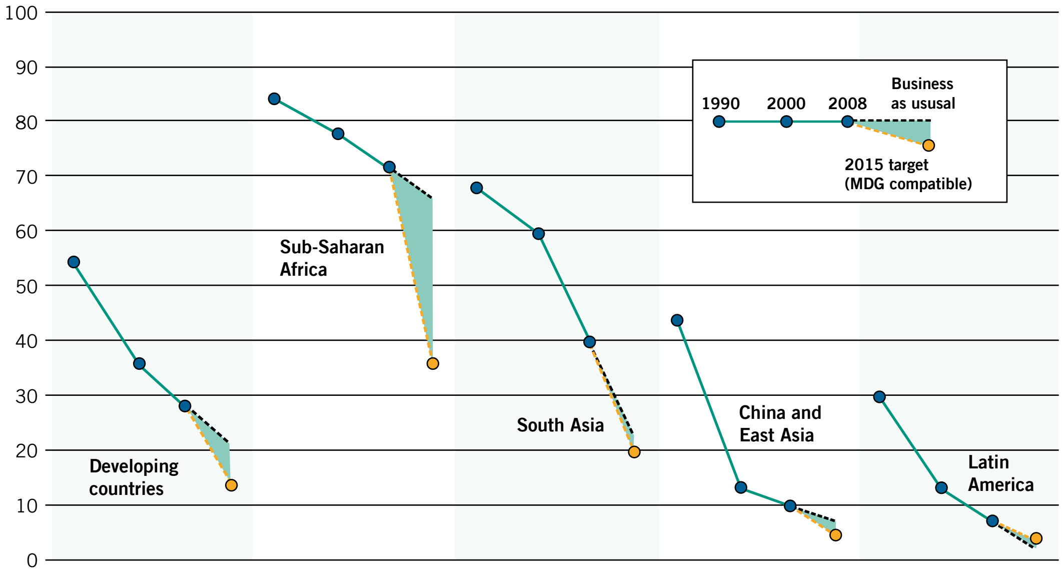
The two graphs below contrast the current business as usual trajectory for energy access with what is required if the MDGs are to be achieved; the first looks at electricity, the second at fuels for cooking.

While gains have been made in access to electricity over the past two decades, huge gaps remain. This is especially clear in Sub-Saharan Africa, where over 70% of the population does not have access to electricity. To reach its MDG targets, the region needs to cut that figure in half. Without a dramatic intervention to improve the situation, around 67% of the population will still lack access to electricity in 2015 and as a result progress on the MDGs will remain constrained.

Access to modern fuels for cooking presents an even greater and more widespread challenge. While there has been modest improvement in overall numbers, many billions of people will miss the MDG targets simply because they do not have adequate fuels to cook with. Proof again that countries cannot address individual development goals without finding an integrated energy solution.

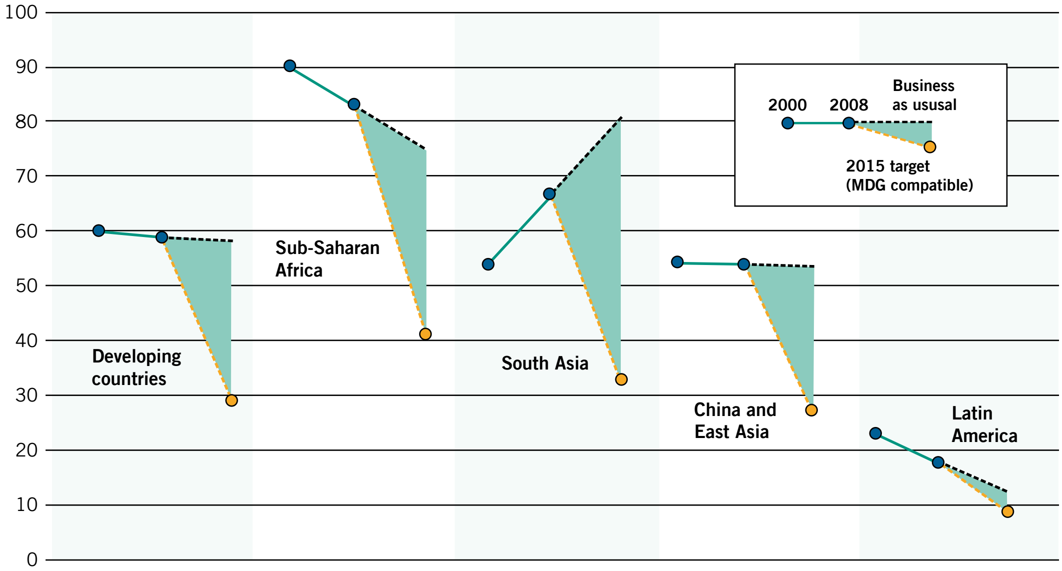
To people living in energy poverty, these statistics are life and death issues. Indoor smoke from traditional cookstoves causes 1.4 million deaths per year.

Percentage of people without access to electricity; progress towards the MDG-compatible target



Source: IEA, 2002; IEA, 2008; Legros et al., 2009

Percentage of people without access to modern fuels for cooking; progress towards the MDG-compatible target



Source: IEA, 2002; Legros et al., 2009

And it is often women who are hit hardest by energy poverty. It is they who are condemned to spend much of their day on menial tasks that energy could make simple and gathering wood so the family can eat and stay warm. Without access to energy, daughters are doomed to follow in their mothers' footsteps.

The scale of the challenge is daunting. However, the PPEO concurs with a recent report of the UN Secretary General's Advisory Group on Energy and Climate Change (AGECC, 2010), stating that universal energy access is a goal which can be met by 2030 – provided there is the political will and the commitment to do it.

The solution: Total Energy Access

The PPEO details the actual needs of those affected by energy poverty and suggests attainable targets based on those needs. These targets are summarised in Total Energy Access, a new set of minimum standards and indicators.

Chapter 1 identifies the six key energy services that all people need, want and have a right to: lighting, cooking and water heating, space heating, cooling, access to information and communication technologies, and energy for earning a living. In this way, the PPEO seeks to move beyond the typical focus on energy sources and electricity – which so often dominate energy data collection and reporting – to reveal more clearly the real range of needs for energy at the household, enterprise and community levels.

Total Energy Access is energy access defined at point of use and in all its dimensions. We propose a series of minimum standards, detailed below, with the hope that they will stimulate further debate and a move towards consensus on a standard for total access to energy.

Total Energy Access

Energy service	Minimum standard
1 **Lighting**	300 lumens at household level
2 **Cooking and water heating**	1 kg woodfuel or 0.3 kg charcoal or 0.04 kg LPG or 0.2 litres of kerosene or ethanol per person per day, taking less than 30 minutes per household per day to obtain Minimum efficiency of improved wood and charcoal stoves to be 40% greater than a three-stone fire in terms of fuel use Annual mean concentrations of particulate matter ($PM_{2.5}$) < 10 μg/m³ in households, with interim goals of 15 μg/m³, 25 μg/m³ and 35 μg/m³
3 **Space heating**	Minimum daytime indoor air temperature of 12°C
4 **Cooling**	Food processors, retailers and householders have facilities to extend life of perishable products by a minimum of 50% over that allowed by ambient storage All health facilities have refrigeration adequate for the blood, vaccine and medicinal needs of local populations Maximum indoor air temperature of 30°C
5 **Information and communications**	People can communicate electronic information beyond the locality in which they live People can access electronic media relevant to their lives and livelihoods
6 **Earning a living**	Access to energy is sufficient for the start up of any enterprise The proportion of operating costs for energy consumption in energy-efficient enterprises is financially sustainable.

Drawing on a series of attempts in recent years to measure energy poverty (Bazilian et al., 2010) we have also developed the Energy Access Index to indicate progress on the supply side towards the energy service standards outlined above. The index measures the three main supply dimensions of energy access – household fuels, electricity and mechanical power – by assigning a numerical value to the qualitative dimensions of people's experience of accessing energy supplies, with 1 being the lowest and 5 the highest level of access.

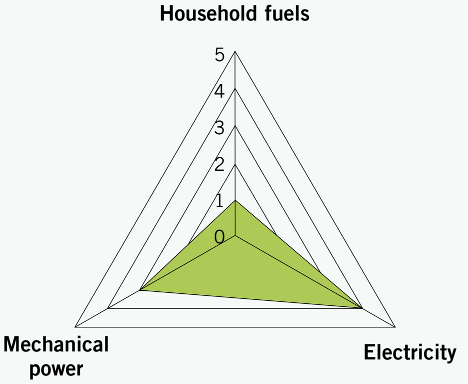
Energy Access Index

Energy supply	Level	Quality of supply
Household fuels	1	Collecting wood or dung and using a three-stone fire
	2	Collecting wood and using an improved stove
	3	Buying wood and using an improved stove
	4	Buying charcoal and using an improved stove
	5	Using a modern, clean-burning fuel and stove combination
Electricity	1	No access to electricity at all
	2	Access to third party battery charging only
	3	Own low-voltage DC access for home applications
	4	240 V AC connection but poor quality and intermittent supply
	5	Reliable 240 V AC connection available for all uses
Mechanical power	1	No access to mechanical power. Hand power only with basic tools
	2	Mechanical advantage devices available to magnify human/animal effort
	3	Powered (renewable or fossil) mechanical devices available for some tasks
	4	Powered (renewable or fossil) mechanical devices available for most tasks
	5	Mainly purchasing mechanically processed services.

The index can be used to measure the energy access of an individual household, or if included in a village or national census, could characterise simply and clearly, but in unprecedented detail, energy supply quality at community and country levels.

Energy Access Index

Household level: Parvati and family in Nepal



Household fuels – 1

Parvati has to walk 3 hours to collect fuel and burns it in a smoky and inefficient stove.

Electricity – 4

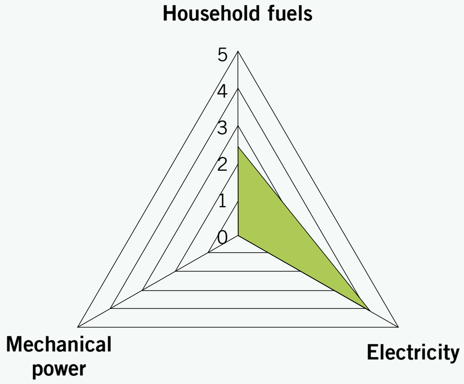
The family have just received grid power, but only for a few hours per day. They only have lightbulbs, no other appliances.

Mechanical power – 3

They have access to a community mill for grinding, but use hand tools for rice dehusking, etc.

Source: Practical Action Consulting

Country level: Sri Lanka



From existing national statistics a composite EAI can be produced as follows:

Household fuels – 2.4

A 2006/07 Household Income and Expenditure Survey provides data for this measure.

Electricity – 4.2

Although 79% of people have grid connections, no estimate of intermittency is available.

Mechanical power – 0

No data available.

Source: Household Income and Expenditure Survey 2006/07, Department of Census and Statistics, Sri Lanka.

The framework for success

In addition to measuring and publicising energy poverty, the PPEO investigates the barriers to increasing energy access and explores the ideas that could overcome these barriers. In Chapter 2, leading energy access practitioners review and propose approaches to issues concerning bioenergy and health, energy financing, gender, off-grid opportunities and delivery models for sustainable energy access.

Clearly, achieving universal access to energy by 2030 will demand increased collaboration between key actors in order to unblock barriers. These include government and international agencies and those in the formal energy sector, as well as enterprises, universities, non-governmental organisations, community groups, financiers and more. This 'ecosystem' of energy access service providers must expand in order to meet the objective of Total Energy Access.

A political and financial commitment is crucial to kick-starting this process. Chapter 3 outlines a number of key policy priorities, advising countries to set national targets and formulate policies based on our proposed minimum service standards and the energy access index. Streamlined frameworks would help enable a range of actors to participate in delivery, and can be supported by multilateral and non-profit organisations.

Breathing easier in Nicaragua with solar power

Antonio Martinez, a farmer living in a remote part of Nicaragua, has recently installed a solar panel for his family. "We moved to this farm 25 years ago and have been without electricity for 24 years. We used to use paraffin lamps for lighting. They gave off a lot of fumes and the black smoke would irritate our eyes and skin and harm our lungs. As soon as we installed the panel we noticed big differences in our health. It's safer to use lights indoors and the air is so much cleaner. We're even able to use a television and a phone, listen to the radio and have a light in every room."

Photo: Matt Barker

An additional US$36 billion per year (representing only 3% of global energy investment for 30% of the world's population) is needed to achieve universal access to electricity by 2030 (IEA, 2009). A variety of financial sources, including government, multilateral and bilateral aid agencies, civil society, the private sector and local finance initiatives, must be harnessed to raise this sum and develop mechanisms for its effective application. These mechanisms might include targeted government subsidies, concessional loans, grants and cross-subsidisation of end-user tariffs, in addition to commercial practices and finance linked to climate change mitigation and adaptation.

Capacity, knowledge and capabilities must be reinforced throughout the energy service delivery 'ecosystem'. This means accelerating development of local institutions for the delivery, operation and maintenance of energy services. Technology transfer that draws from and builds on existing global expertise and knowledge is needed to strengthen national public, private and civil society capacity to plan and implement sustainable energy solutions.

While the last two decades have seen some progress in increasing energy provision, overall it is a story of widespread and sustained underachievement from the top down. It is time to end this energy apartheid. Poor people cannot thrive while chained to a subsistence way of living. Fair energy access for all is the only way to break the chain of energy poverty.

Introduction

In April 2010 the United Nations Secretary General's report (AGECC, 2010) called for universal access to energy and the eradication of energy poverty by 2030. The lack of access to modern energy services systematically undermines development efforts and consigns the world's poorest to an ongoing cycle of poverty. In the Poor People's Energy Outlook (PPEO), we seek to better represent the dimensions of need, analyse the barriers to change, and propose a way forward with metrics to measure real progress.

By giving a voice to people living in energy poverty, the PPEO provides a unique perspective on both energy use and deprivation, and portrays a more textured picture of the realities of energy access at the human scale. The PPEO seeks to go deeper than current analysis, much of which focuses only on energy at the macro scale. In so doing we hope to highlight the importance of access to affordable, safe and environmentally sustainable energy services in achieving poverty reduction goals.

We hope this understanding will stimulate and encourage the wider community in private enterprise, civil society, and academic and public sectors to engage with the challenge of energy access. A broad alliance of interested parties can raise the voices of those in energy poverty and trigger the changes needed in policy, funding patterns and practices.

Our concerns are shared by the POWERFUL Group, a coalition of private and non-governmental organisations (NGOs) formed in 2010 to identify and pursue joint activities to improve access to energy in developing countries. The group seeks to scale up funding for renewable energy-based options, to support innovative solutions and to raise awareness about energy access. A wider international coalition could assist in the gathering of data and experience for future editions of the PPEO and, using the report's information, act and advocate for universal access.

A global campaign for energy access – already being promoted by members of the UN Secretary General's Advisory Group on Energy and Climate Change (AGECC) – is required to bring about the necessary policy prioritisation. But first the critical importance of access to basic energy services for poverty eradication must be recognised by governments, donors and international organisations. The PPEO demonstrates the basis for this and proposes a framework for progress.

The PPEO is organised into three chapters:

Chapter 1 – People's experience of energy

Six distinct energy services are analysed with reference to people's experience of how access – or lack of it – affects lives and livelihoods. Impact is recorded qualitatively through field case studies and human testimonies, and quantified through disaggregated statistics. We present indicators and targets for each energy service and the energy supplies that can provide them.

Chapter 2 – Practitioner perspectives

Critical issues in energy access are outlined by leading practitioners through a range of thought pieces addressing challenges and controversies in the sector, and presenting a synthesis of current analysis and argument.

Chapter 3 – Framework for action

This chapter provides an overview of the energy poverty outlook with the long-term goal of universal access to energy services from sustainable sources. It provides a framework for action and calls on the international community to rise to this challenge.

Chapter 1:
People's experience of energy

Energy poverty denies millions of people the basic standard of living that should be a right. Without access to energy to cook, heat the home, earn a living and fully benefit from health, education and cultural opportunities, whole communities are forced to live on the margins of society. This chapter examines the impact of energy deprivation on all of these key services and on the people they are meant to serve. It also highlights the transformational effects made possible when energy becomes available.

Many energy services overlap in terms of source and usage, but for the purposes of this analysis we will focus on the following six service categories at a human scale:

- Lighting
- Cooking and water heating
- Space heating
- Cooling
- Information and communications
- Earning a living

Other energy service categorisations exist, and we welcome feedback from readers to inform future editions. Mobility has been omitted on the basis that it is primarily defined by physical links (roads, railways, bridges, etc.) rather than energy access – although such connectivity can help bring fuels and create market access. Water supply (for drinking and irrigation) is another important service often linked with energy, but is omitted as it is more strongly dependent on water resource availability and pipe infrastructure (often gravity flow) than energy. A range of agricultural processing services such as milling and rice de-husking are captured under 'Earning a living' since, where energy is actually used rather than hand-tools, it is usually offered as a service at a cost to users.

This chapter is based on energy services data published in diverse national and regional reports and studies, which have been collected by Practical Action Consulting specialists in Africa, Asia and Latin America. It also draws on the testimonies of people living in energy poverty or who have recently benefitted from access, via interviews and focus group discussions. Although there is a marked lack of comprehensive and disaggregated international energy access data, the numbers that are available have been collated and analysed to produce consolidated figures. Project or initiative level data have also been incorporated, especially where national or international numbers are weak.

It is clear that improvements in energy services have a crucial role to play in achieving the Millennium Development Goals (MDGs). Measuring these improvements requires indicators for each energy service. This chapter reviews progress to date in defining these indicators and proposes a set of minimum energy service standards, as well as an index for access to energy supplies.

Universal access to energy services will require additional energy resources and may have environmental impacts. These implications, and the likely impacts on development and the achievement of the MDGs, are also discussed.

The Poor People's Energy Outlook is part of an ongoing research project. Practical Action and partner organisations hope that the content in this chapter will stimulate further debate and activity focused on improving the quality of available data, as well as the definitions and indicators proposed. We welcome your feedback.

Lighting

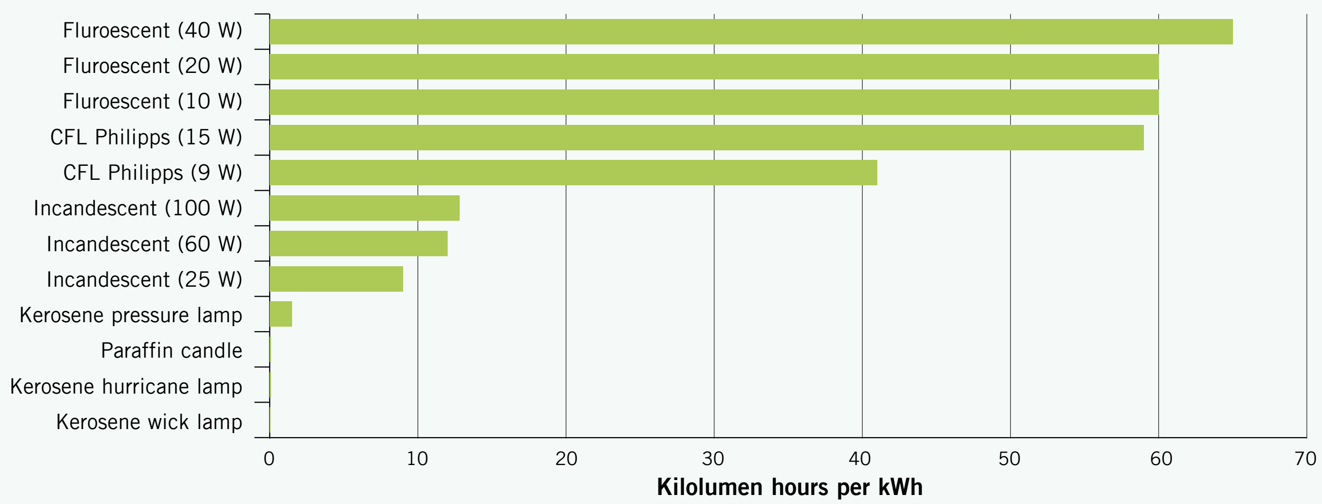
Lighting is a fundamental human need. People who can't simply flick a switch to light their homes lose many productive hours as soon as the sun sets. Nearly 1.5 billion people, around 22% of the global population, do not have access to electricity (Legros et al., 2009). For lighting, those without electricity must resort to lamps that are polluting, dangerous and provide low-quality light – and yet are more expensive than modern electric lighting. The very poor use flaming brands, candles and kerosene wick lamps, in contrast with the high-efficiency light bulbs accessible to those with electricity.

Lighting without electricity: the issues

Quality of light

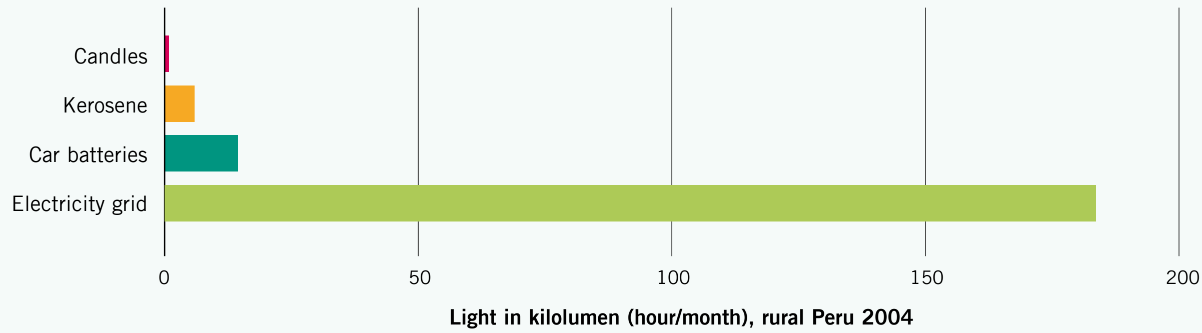
People without access to electricity use fuels for lighting that provide fewer units of luminescence, or brightness (measured in lumens)[1] for each watt of power consumed than electricity. A kerosene wick lamp or a candle provides just 11 lm, compared with 1,300 lm from a 100 W incandescent light bulb (Figure 1.1). As a result, those without access to electricity must endure light levels that are insufficient for safe work, study, or recreation.

Figure 1.1: Efficiency of lighting fuels



[1] A lumen (lm) is a measure of light energy radiated by a light source.

Figure 1.2: Lighting consumption in rural Peru



A national rural lighting survey of 6,000 people in rural Peru found that candles and kerosene lamps provided barely enough light to walk around the house. Higher-income households without grid electricity used car batteries to power electric lights (Barnes, 2010a).[2] Figure 1.2 shows the amount of light used each month by households in rural Peru.

Electric lamps are much more efficient than kerosene in converting energy into light. A 100 W incandescent lightbulb provides 12.8 kilolumens of light per kilowatt-hour compared with 0.1 kLm/KWh for a kerosene lamp. Fluorescent lights are four times more efficient again than incandescent bulbs.

A simple, small wick bottle lamp burns 10 mL of fuel hourly and gives out light equivalent to that from a small electric flashlight (torch) bulb – too dim for reading. Those who cannot access kerosene may even use burning brands (Figure 1.3).

The German development agency (GTZ) recommends[3] **300 lm** as a minimum 'entry level' of illumination required per household (Bazilian et al., 2010). This is needed for a minimum of 4 hours, preferably 6 hours. This can be achieved neither by candles nor kerosene wick lamps, suggesting they are not adequate sources of household lighting.

Figure 1.3: Burning brand used for lighting in household in Gatlang, Nepal

Pollution from lamps

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

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2 http://www.energyfordevelopment.com/2010/03/measuring-household-lighting.html
3 GTZ recommendation of 300 lm is the equivalent of a 25 W incandescent lamp – a combination of task lighting, orientation and lighting for reading and study.

The dangers of lamps

Unguarded candles and wick lamps are intrinsically unsafe and lead to injury and deaths, particularly among women and children. In northern India, of the approximately 11,000 patients admitted for burn care during an 8-year period, 2% were injured from using flame lamps. In Sri Lanka, 91 of the 221 patients (41%) who were admitted to Batticaloa General Hospital with burns between July 1999 and June 2001 cited lighting as the cause. During 1998 and 1999, 151 of 487 patients (31%) aged 12 years and older who were admitted to the National Hospital in Colombo had non-intentional burns from kerosene lamps (Peck et al., 2008).

The cost of lighting

A study on sources of lighting has shown the large variation in cost for different forms of lighting (not including candles). Figure 1.4 compares kerosene lamps with other established lighting approaches, ranging from traditional, grid-connected incandescent lamps to portable solar lanterns using compact-fluorescent bulbs. The costs in this particular study range from US\$0.003/1000 lm/m^2/hour for a grid-connected compact fluorescent lamp to \$110/1000 lm/m^2/hour for flashlights, which are widely used as a supplement to kerosene lighting in the developing world (Mills, 2003).

This information is reinforced by a World Bank study in Guatemala which shows that those without access to electricity pay a substantial premium for their lighting (Table 1.1).

Figure 1.4: Relative costs of various types of household lighting

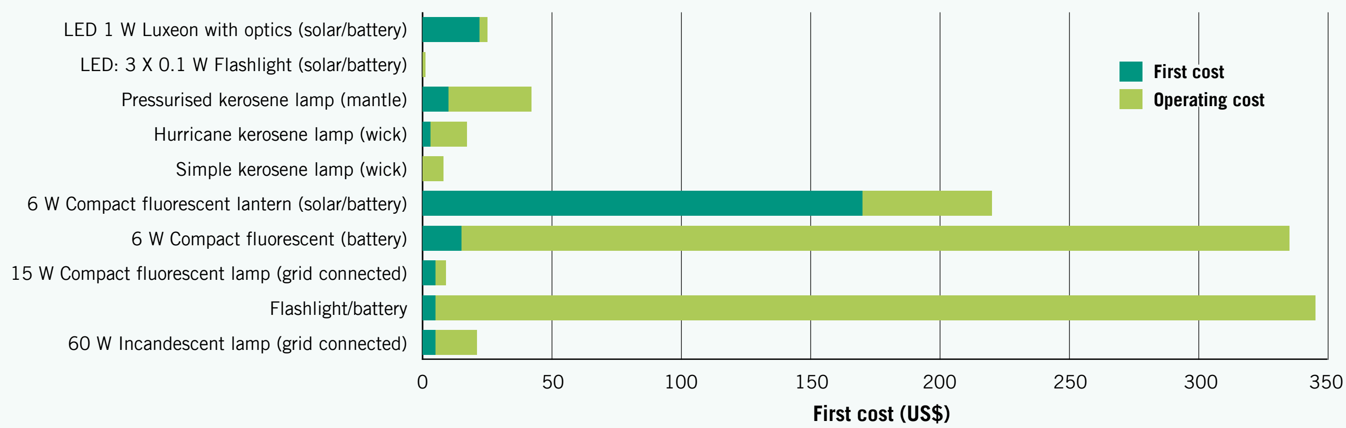


Table 1.1: Unit price for different lighting fuels (US\$/kWh)

Fuel	Household purchase price of a unit of light* (US\$/kWh)
Mains electricity	0.08
Kerosene	5.87
Candles	13.00

* The amount of energy provided by each fuel, standardised to efficient kilowatt-hours.

Source: Foster et al., 2000

Technologies for taking action on lighting

The impact of electrification

Around 22% of the global population are without access to electricity. In Sub-Saharan Africa the percentage is nearly 40% overall and over 70% in rural areas – this leaves around 561 million people without access to electricity (Legros et al., 2009). The primary – and by far the major – use of electricity in rural households is lighting, television being the next most common (IEG, 2008).

A study by GTZ on the impacts of an off-grid electrification scheme in Rwanda found that the greatest improvement observed at the household level was in lighting. Eighty per cent of electrified households had switched completely from traditional lighting sources to modern electric ones (GTZ and Senternovem, 2009). The section by Guido Glania in Chapter 2 examines the impacts of access to off-grid electrification in greater detail.

Outside of the household, lighting plays a key role in increasing income through better street illumination, enabling businesses and household enterprises to stay open for longer and allowing people to move around more safely. An example is the company Aurore, in India (Box 1.1).

Alternatives to grid electricity

Projections indicate that by 2030 Africa will still have a non-electrified population of 698 million, compared to around 809 million people in Asia without electricity (Macharia et al., 2010). Rural populations suffer more than urban populations. Table 1.2 outlines the technologies that are now available. (Note that this depends on their affordability, as increasing income is essential to providing access to safer and cleaner lighting).

Indicators for adequate lighting

The UN Millennium Development project has set out targets for providing clean and efficient energy for reading light and for illuminating schools and health facilities (Table 1.3). The target for household lighting consumption is a minimum requirement, excluding a second light bulb and lighting needs for productive use and income generation.

Box 1.1: Lighting the path from school to entrepreneurship

Aurore is a community-owned enterprise based at Auroville, near Pondicherry in Tamil Nadu, India. By 2004, it had facilitated the installation across India of nearly 2 megawatt-peak (MWp) of photovoltaic (PV) systems, including 845 PV-powered water pumps, 8,700 domestic PV systems, and over 6,000 PV-powered lanterns. By 2009 lighting systems had been set up in 17,000 homes.

One part of the company – the Aurore Products and Services, a unit of the Aurore Trust (Aurore) – supplies technology and know-how to a project to help school leavers set up businesses renting lanterns to street hawkers and market stallholders. Users pay a refundable deposit of 100 rupees (US$2.25) and a fee of 15 rupees (US$0.33) per night, which is equivalent to the cost of fuel for a kerosene lantern. All the lanterns and the PV array (from which the lanterns are charged), are owned by Aurore.[4]

[4] www.ashdenawards.org/files/reports/Aurore,%20India%202004%20Technical%20report.pdf

Table 1.2: Low-cost lighting technologies and their uses

Technology	Service	Comments
Electric lamps	Street lighting, household lighting, small business lighting	Dependent on electricity pricing policies and tariff structure. Connection fee plus a 'security deposit' to cover one or more month's bills can make upfront costs prohibitive (Foley, 2000).
Solar home systems	Household lighting	Upfront costs are high (around $150 per household), but rental schemes now operate in India. Note: The actual value for retrofitted LED lamp (a 40 W incandescent replacement) is about 60 lm/W.
Solid state lighting	Small-scale street and market lighting	Light-emitting diodes (LEDs) have (projected) efficiencies of 100–150 lm/W and the lamps last for more than 50,000 hours (such a value can be hard to prove, and electronics may fail before the lamp does).
Solar lanterns	Cooking, homework, reading, stalls	Rapidly expanding market. Can be bought relatively cheaply (for as little as $12). No fuel costs and no environmental damage from battery disposal. Batteries may be lead-acid type, which should be recycled. Portable, so can be moved from task to task.
Enclosed and pressurised kerosene lamps	Reading and general household lamps	More expensive than wick stoves, but light is good enough for reading.
Bottle lamps and other kerosene wick lamps	Low-level lighting	The Safe Bottle lamp is thick, squat, square-sided and made of unbreakable glass. It is still a polluting and low-intensity lamp, but it does reduce the risk of burns).*

* www.safebottlelamp.org

Box 1.2: When wood is the only lighting source

Rosa lives in Kakuma, a border town located in North-Western Kenya. Her husband left her to raise their three children alone. She sells foodstuffs at the market but loses one full day per week trekking to the surrounding hills to collect firewood. Rosa's low earnings mean that she cannot afford to buy firewood or kerosene: "For me getting energy for cooking and lighting is a daily worry. It's so hard to find firewood that I cook for my family only once a day in the evening. The fire provides the light for cooking and eating a meal with my children. After eating is bedtime." The lack of lighting means that the children cannot do their homework or get help from their mother after dark.

Source: Practical Action East Africa

In terms of a single minimum standard for adequate lighting at point of use, the PPEO supports the figure of 300 lm proposed by the GTZ Energizing Development project as a minimum lighting intensity for development benefits to be gained (Bazilian et al., 2010).

Achieving such a level in all houses would link to positive impacts on progress towards the MDGs, as outlined in Box 1.3.

Table 1.3: Target electricity consumption to meet Millennium Development Goals in various settings

Annual consumption	Energy for lighting (kWh per year)
Household*	75 (or equivalent)
School	2,000
Hospital	50,000
Clinic	8,000
Health post	2,000

* The recommended quantity of light does not need to be powered by electricity as it is sufficient for one reading light in one room for 4 hours per day.

Source: Sachs et al., 2004

Box 1.3: Lighting and the MDGs

MDG 1: Improved lighting **reduces poverty and hunger** by increasing the productive time that people have to work and by reducing the money spent on effective lighting.

MDG 2: Improved lighting boosts education opportunities by allowing children to study at night and by making it safe for people to attend classes. An ESMAP Philippines study found an almost two-year academic age difference (8.5 versus 6.7 years) with electric lighting versus none, and study time increased by around one hour per day in 12 countries (IEG, 2008).

MDGs 3–5: Improved lighting reduces lighting-associated dangers, which particularly affect **women and children** in the household. Safe lighting is also essential for safer births after dark and reduces damage to infants' delicate lungs from smoke particles.

MDG 6: Health care facilities need good lighting to **support those with HIV/AIDS** and other illnesses. Lighting for caregivers reduces the time spent on household tasks associated with such conditions. Clinic hours have been seen to increase with improved lighting (IEG, 2008).

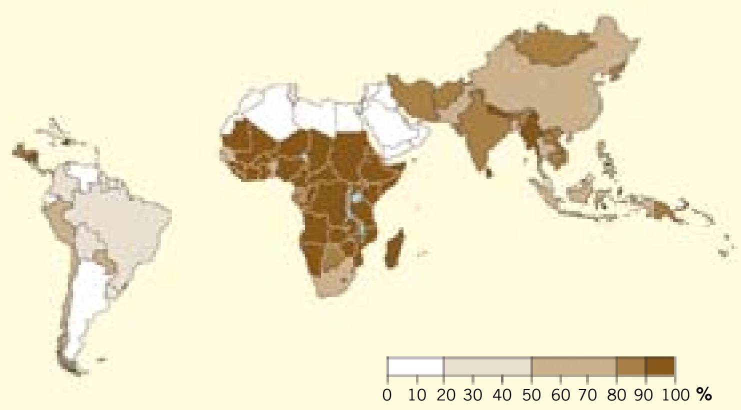
MDG 7: Lighting is an ideal end use for electricity coming from off-grid technologies such as micro-hydro and solar. **Substantial reductions in CO_2 emissions** can be made through adequate, renewably sourced lighting provision in rural areas.

Cooking and water heating

Nearly three billion people cook using biomass (such as wood and agri-residues) and coal, and nearly three quarters of these communities still cook on three-stone fires and rudimentary stoves (Figure 1.5). Around 80% of the foods we eat need to be cooked, yet even today only 2% of energy strategies in the least developed countries address cooking (Havet et al., 2009).

Only 27% of those who rely on solid fuels (biomass or coal) are estimated to use improved cookstoves. Access to these stoves is even more limited in least developed countries and Sub-Saharan Africa, where only 6% of those who use traditional biomass are taking advantage of such options (Legros et al., 2009).

Figure 1.5: Share of traditional biomass in residential consumption by country



Source: IEA databases

Impacts of energy poverty on cooking and water heating

There are several socio-economic effects of cooking in circumstances of energy poverty. Women in particular spend many hours in drudgery, gathering fuel, cooking over inefficient stoves and cleaning soot-laden pots, clothes, walls and ceilings. In Chapter 2, Sheila Oparaocha highlights that women must be involved in decision-making at all levels if the needs of women living in poverty are to be properly addressed.

The opportunities lost to women who spend so many hours labouring for energy each week have been reported in studies worldwide. These studies suggest that 2–8 hours per day per family could be spent on more fulfilling activities with improved cooking facilities. Figure 1.6 shows average daily time devoted to collecting wood in various countries.

Note, however, that measuring the time spent on drudgery is problematic. For example, family groups will often go together to collect wood – and different studies take account of this in different ways. Practical Action studies in the Maasai communities in Kajiado, near Nairobi, Kenya, show the seasonal nature of fuel use as well as mother/child locations during a typical day. Other common factors that affect the time taken to gather fuel include the availability of seasonal residues for burning and the distance to the nearest town in which fuel can be purchased. Table 1.4 provides a snapshot of three typical households from among the 30 surveyed, showing when the woman and her youngest child were present in the kitchen with the fire alight.

Box 1.4 illustrates the links between nutritious food and the need for energy to cook it, with testimony from a family living in financial poverty in Kakuma, North West Kenya.

It is not just cooking that requires a source of heat: sterilising water and heating water for washing and personal hygiene extend the amount of time for which a stove or fire must be lit – with associated impacts on fuel use and smoke in the kitchen. Space heating (see the following section) can also increase fuel use substantially.

Stoves and fires have other uses in the home in addition to cooking food and boiling water, such as for cooking animal feed and for brewing beer and spirits (both for domestic consumption and to sell). Stoves are used by many women in other home-based enterprises such as cooking and selling street foods, which often form their main source of income. Institutional stoves are used in schools, hospitals and workplaces.

Health issues

For those with the lowest incomes, who cook and heat water using biomass fuels on rudimentary stoves, smoke is one of the largest causes of ill-health and death.

Figure 1.6: Selected data on time spent in wood collection

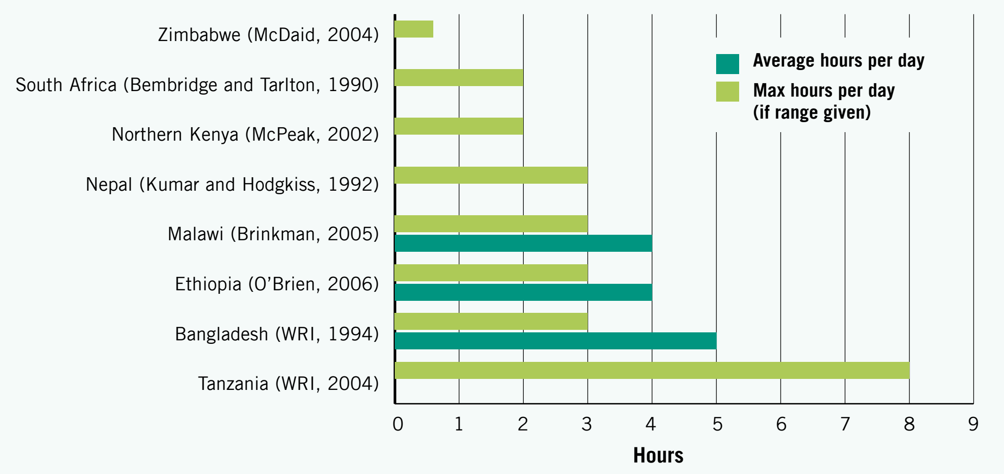
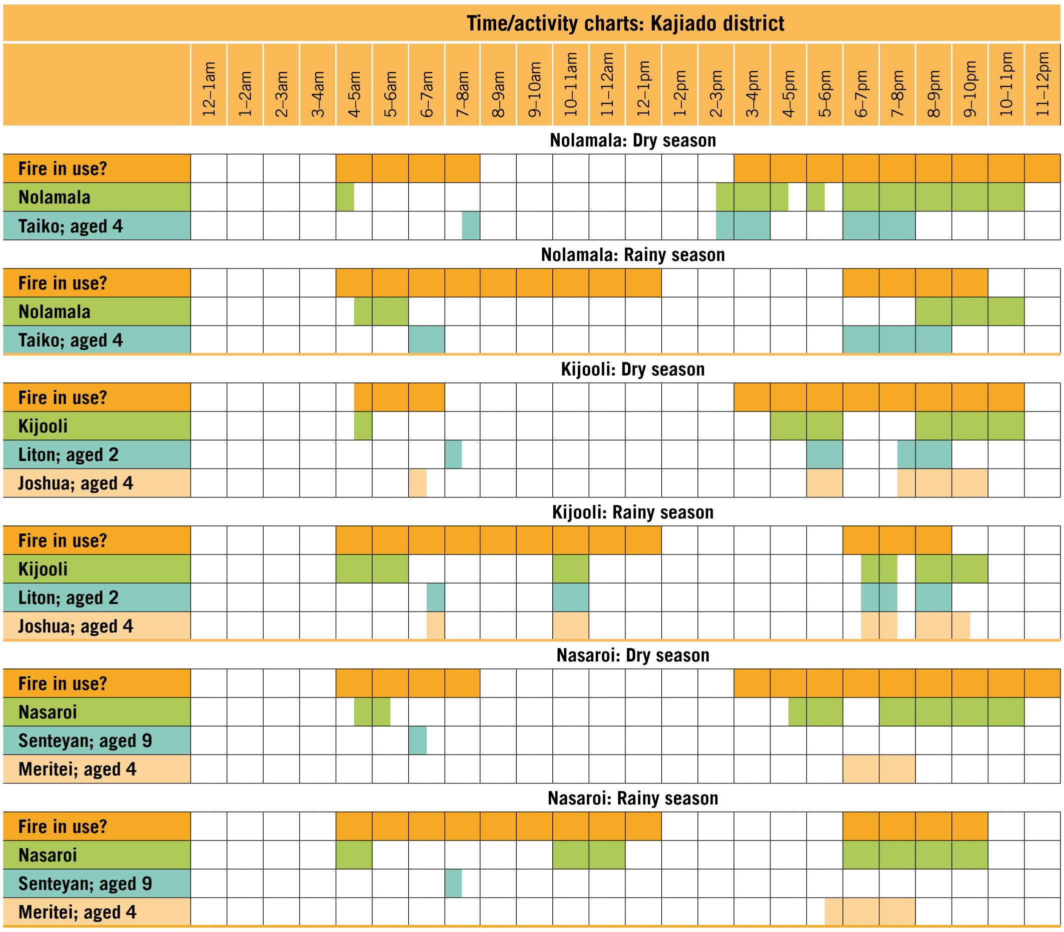
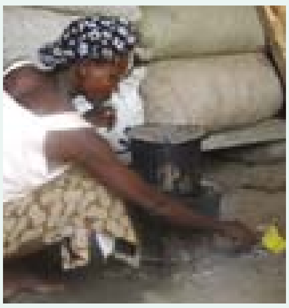


Table 1.4: Time activity data from three Kenyan households



Box 1.4: Energy to cook nutritious food

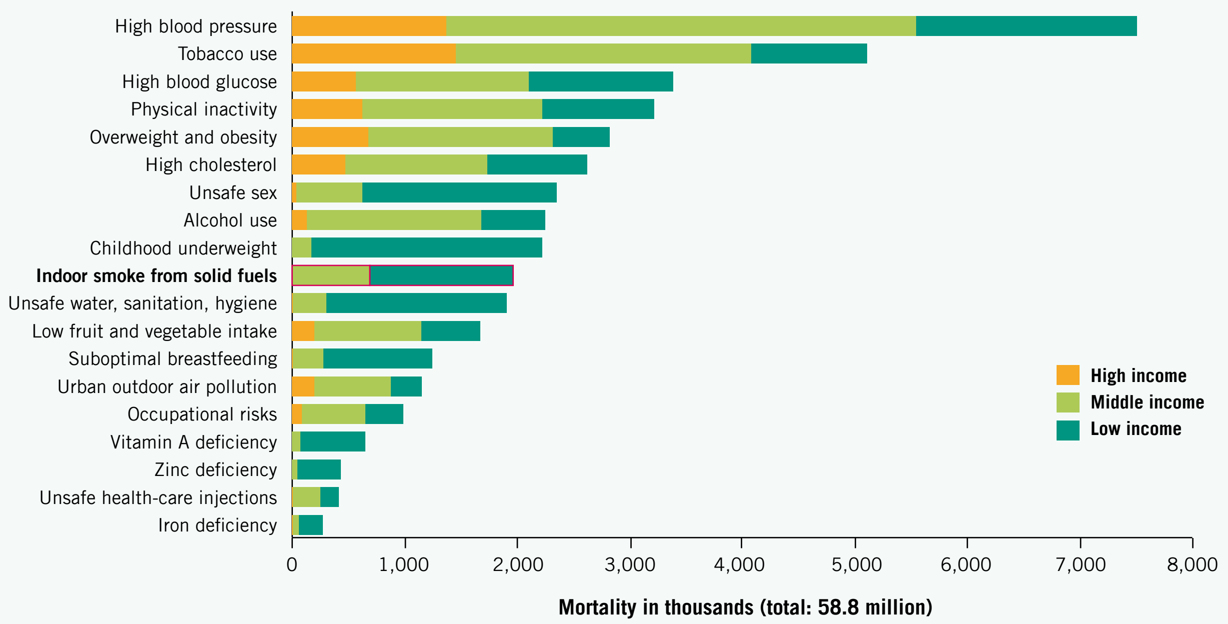
Tawisa's husband passed away a year ago, and the nearby church has since helped her to obtain relief food. Support networks such as these are an important part of people's survival mechanisms. However, despite this help, Tawisa will sometimes go hungry because there is not enough wood for cooking. On many occasions Tawisa, like her neighbours, prefers to cook porridge than the highly nutritious mixture of beans and maize, as the latter takes longer to cook and thus uses substantially more woodfuel.



Tawisa gets her firewood from the riverbed during the rainy season, collecting the many loose twigs and branches taken down by the rain. Each week she will walk three hours each way for fuel. She first builds a fence for her homestead with the branches; once they have dried out she uses them as firewood during the dry season. When this runs out, Tawisa spends about 20 Kenya shillings (US$0.25) to buy a bundle of firewood, which can last three to five meals. She uses an energy-saving GTZ stove that reduces the amount of firewood used by around 50%.

Figure 1.7 illustrates that globally, deaths from the use of solid fuels are second only to tobacco smoke as an environmental risk, and represent the tenth largest risk overall.

Figure 1.7: Deaths attributed to 19 leading risk factors, by country income level, 2004



Source: WHO, 2009

Indoor smoke from solid fuel is the cause of approximately 21% of deaths caused by lower respiratory infection worldwide, 35% of deaths from chronic obstructive pulmonary disease and about 3% of deaths from lung cancer. Of these, about 64% occur in low-income countries, especially in South-East Asia and Africa (WHO, 2009). Other health issues associated with indoor air pollution for which further evidence is emerging include increased cases of active tuberculosis, pulmonary disease, increased adverse pregnancy outcomes, low birthweight, and non-life threatening ailments such as cataract and eye discomfort and headache. In Chapter 2, Kirk Smith provides expert oversight into these major health implications.

The World Health Organization (WHO) also reports that globally there are over 300,000 deaths each year from fires alone, with even more deaths from scalds, electrical burns, and other forms of burns, for which global data are not available. Fire-related deaths alone rank among the 15 leading causes of death among children and young adults 5–29 years old.

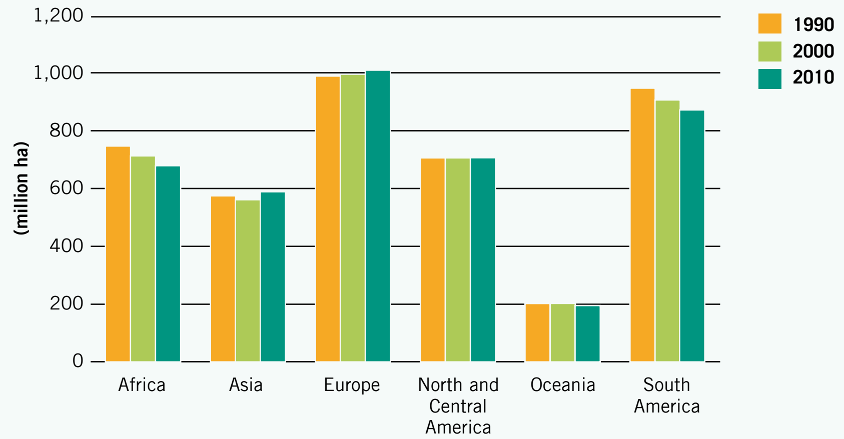
Environmental issues

Cooking and deforestation

Forests are declining worldwide and although the rate of deforestation appears to have slowed, globally around 13 million hectares of forests were converted to other uses or lost through natural causes each year between 2000 and 2010, as compared to around 16 million hectares per year during the 1990s (Figure 1.8).

Up to the end of the last century, the majority of stove improvement programmes focused on a reduction in the amount of fuel used for cooking, and therefore in the fuel gathered by people for whom biomass was the only option (Barnes et al., 1994). Thus, fuel-efficient biomass stoves can help shift the balance from over-harvesting to increased tree growth. This fuel-saving criterion is still

Figure 1.8: Global trends in forest cover, 1990–2010



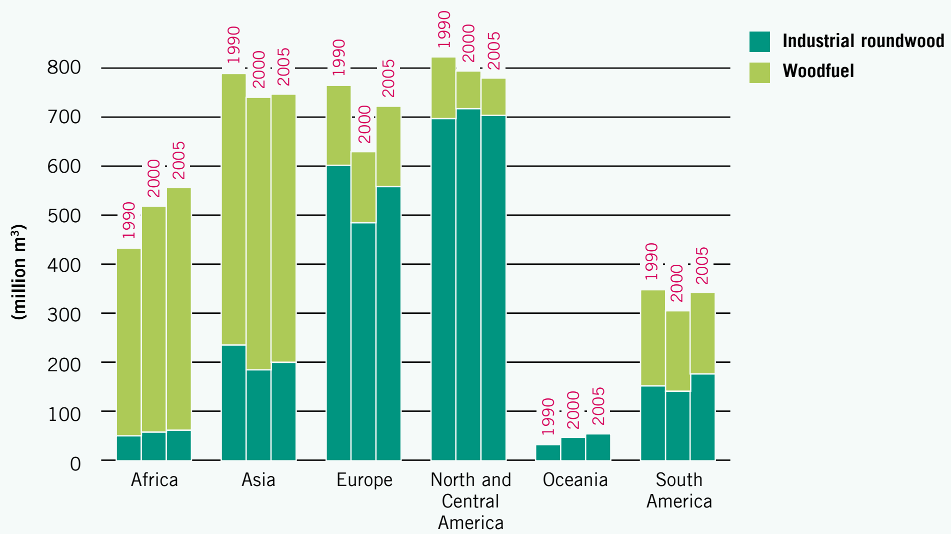
Source: FAO, 2010

vital, particularly where much of the fuel is harvested non-sustainably. Locations where deforestation is a major issue include:

- around towns and cities, where increasing areas of deforestation result from felling trees for charcoal
- where displaced communities are residing, due to the increased number of people dependent on the same land, often leading to conflicts with local populations
- in areas affected by climate change where rains have failed, reducing the areas of forested land.

The Food and Agriculture Organization has calculated that at a global level, woodfuel collection accounts for nearly half of all removed wood (FAO, 2010; see Figure 1.9). This is a complex issue because charcoal, which is in high demand in

Figure 1.9: Global trends in wood removal for industry and woodfuel, 1990–2005 (million m^3)



Source: FAO, 2010

urban areas, comes predominantly from felled trees, while the wood collected by rural women for their own use is mainly dead wood taken from the trees – as they wish to conserve the tree for the future. Much of this renewably gathered dead wood may not be included in the 'removed wood' data.

Climate change

Emissions from burning solid fuels in open areas and traditional stoves have significant global warming effects, due to incomplete combustion, and where biomass is sourced from non-renewable supplies. Globally, three billion people use biomass or coal-burning cookstoves, which are responsible for more health problems than any other category of energy use globally and are the most greenhouse-intensive fuel systems in the world, per unit energy delivered (Garrett et al, 2009).

Consequently, interventions that improve combustion efficiency and hence reduce emissions and exposure to pollutants can benefit health and mitigate climate change. This opens up possibilities for using carbon finance to help reduce the costs of accessing clean and efficient household energy services (Legros et al., 2009)

An important factor that is coming to light is the role of 'black carbon' – commonly referred to as soot – an important product of the combustion process. Black carbon reduction policies can also result in substantial health benefits, especially to citizens of developing countries. In indoor environments black carbon arises largely from cooking with biofuels such as wood, dung and crop residues. Outdoors, it is due to fossil fuel combustion and open biomass burning (associated with deforestation and crop residue burning). Black carbon aerosols absorb and scatter solar radiation and so contribute to climate change. However, once emissions of black carbon are halted, its warming effects cease within a few days. Evidence presented to the US House of Representatives (Bond, 2010a) has shown that black carbon stays in the atmosphere for only about a week and is rapidly removed by rainfall. Its short lifetime means it contributes to climate change in a different way to carbon dioxide. Cutting black carbon would provide a once-only correction to global warming, since it does not accumulate or persist, but the reduction would be substantial. The combustion of biomass and other solid fuels in the household is a complex science, and although the effects are not yet certain, it is believed to create around 23% of all global emissions of black carbon (Bond, 2010b).

Approaches to reducing fuel consumption and smoke

Stove improvement programmes

In the past, not all stoves distributed under stove improvement programmes reduced fuel use, not enough were designed in collaboration with the users, and not all reduced the amount of smoke emitted (Smith, 2002). The current approach is to increase the efficiency with which wood is burnt, which reduces damaging pollutants while increasing the efficiency of heat transfer from the stove to the pot. A good, low-cost ceramic stove can save roughly half of the wood needed. Fossil fuel stoves and alcohol stoves can eliminate the need for wood altogether, but have other cost and availability issues. Also, their high efficiency means there is little energy lost in the form of heat, creating a potential need for space heating appliances.

Box 1.5 describes the impact of the introduction of smoke hoods, improved stoves and insulation on the time required to gather fuel in the high hills of Nepal.

Box 1.5: Cooking and firewood collection

Maya Tamang describes her life in a rural village in Nepal: "We are totally dependent on firewood for cooking energy as we don't have other alternatives. Managing firewood is a very tedious job for us. We have to walk about 7 hours to collect a Bhari (about 30 kg) of firewood. The track to the forest is very difficult and unsafe. Before the interventions (smoke hoods and stove improvement), we had to go to the forest at least 100 times per year for firewood collection only. Now we have to go only about 70 times. It has been a great relief for us. Now we have more time to give to our children and also for ourselves."

Photo: Nigel Bruce

Solutions for water heating

For those using a three-stone fire or traditional stove, water is often heated using the dying embers of the fire once the cooking is completed. The newer efficient stoves and modern liquid-fuel stoves or liquefied petroleum gas (LPG) stoves cannot be used in this way. However, studies by Practical Action in Kenya have shown that for short, rapid cooking, such as making tea, even low-income households will use modern stoves if the purchase price of an LPG stove is made affordable through revolving finance. This is because they save a lot of time: in the case of the Kenya study, around 2.6 hours per day (Bates et al., 2007).

More problematic is heating the large amount of water needed for washing. However, new, low-cost technologies are coming on to the market to address this issue. Examples include black polythene containers placed in the sunshine to warm water so that it can be used for washing. Direct solar water heaters comprising a tube fitted in a zigzag fashion onto a board fixed to the roof can produce water to 60°C, even in temperate countries (Manyaapelo, 2000).

Most of the improvements to cooking and water heating from improved access to energy come from reductions in emissions, time savings and environmental benefits. Table 1.5 describes ways to achieve some or all of these benefits.

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

Targets for cooking energy

Indicators for cooking energy need to take account of pollutant levels, efficiency of fuel consumption and availability of affordable fuel (Table 1.6). For pollution levels, the indoor air quality guidelines adopted by the WHO are deemed an appropriate target.

Where such minimum standards are achieved, the development benefits described in Box 1.6 are made possible.

Table 1.5: Approaches to reducing smoke and reducing fuel consumption

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

Box 1.6: Cooking and water heating and the MDGs

MDG 1: Where a supply chain for clean fuels is not feasible, improved cookstoves that reduce fuel use and indoor air pollution can **reduce poverty** through cost savings and reducing wood collection time, which can be put to more productive uses.

MDG 2: Where children, particularly girls, do not need to gather as much fuel, they have the opportunity to **attend school**.

MDG 4: Cleaner cooking fuels and technologies are linked to improved **life expectancy for infants**.

MDGs 3 and 5: Improved **quality of life for women**, through improved health and less drudgery.

MDG 6: Indoor smoke from cookstoves and fires is a major risk factor in chronic obstructive pulmonary disease, acute lower respiratory infections and is implicated in some cancers and cardiovascular disease. Reducing indoor air pollution will have a positive impact by **reducing causes of ill-health** (see Chapter 2, Kirk Smith).

MDG 7: From the perspective of those living in poverty, the environmental gains of reduced biomass may enable them to benefit from both a cleaner cooking environment and carbon finance for the up-front costs of buying cleaner technologies.

Table 1.6: Proposed minimum standards for cooking energy

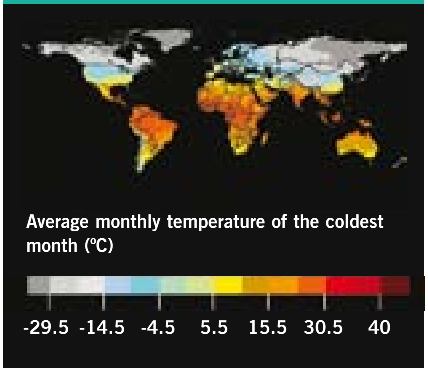
Minimum standard	Source
1 kg woodfuel or 0.3 kg charcoal or 0.04 kg LPG or 0.2 litres of kerosene or ethanol per person per day, taking less than 30 minutes per household per household per day to obtain*	PPEO
Minimum efficiency of improved wood and charcoal stoves to be 40% greater than a three-stone fire in terms of fuel use: 1 kg woodfuel or 0.3 kg charcoal or 0.04 kg LPG or 0.2 litres of kerosene or ethanol per person per day	GTZ-HERA, 2009
Annual mean concentrations of particulate matter ($PM_{2.5}$) < 10 μg/m³ in households, with interim goals of 15 μg/m³, 25 μg/m³ and 35 μg/m³	WHO, 2006

* Although dung is widely used, we have not included a minimum recommendation because of its low calorific value, high emissions, and associated skin diseases from handling. The energy output from agri-residues is too dependent on the type and calorific value of the residue to be included – *pro rata* quantities could be calculated based on their calorific values relative to woodfuel.

Space heating

Space heating is an important function of household stoves and heating appliances, particularly at higher altitudes. The map of global minimum temperatures in Figure 1.10 shows that not only do people in the temperate regions of the world need heating, but so also do those in the high altitude areas of Central Asia, Latin America, and North and Southern Africa, particularly during their cold seasons.

Figure 1.10: Global minimum temperature map



Source: FAO, 1997

Despite this, space heating is often overlooked by policy-makers and designers of stove programmes. Because a single stove often serves for both cooking and providing warmth, space heating is a selection criterion for stove buyers. However, depending on customs and traditions, people may use a separate stove to heat their homes, particularly if heating is not needed all of the time. 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).

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

Heating issues: the need for heat and the risks of heating

> *"Inadequate warmth increases the likelihood of cardiovascular and respiratory disease, directly contributing to excess winter mortality. Yet you cannot buy warmth, you can only buy the fuel, appliances, and housing necessary to create and contain it."* (Wu et al., 2004)

Mortality rates rise progressively when outdoor air temperatures fall outside the range of 20–25°C (Wu et al., 2004). Where ambient temperatures fall significantly below this, households, schools and work premises must be heated to prevent hypothermia, particularly for the elderly or infirm, who are less mobile. HelpAge International reports that older people have been severely affected in Kyrgyzstan, where the capacity to generate hydroelectric power for the national grid and electricity for heating systems during the long winter months has been limited. Small children, who have weaker immune systems, often fall under the care of older people, who remain close to the fire due to restricted mobility. Both groups are therefore at much greater risk during the cold months (HelpAge International, 2009).

Because of the colder temperatures at high altitudes, mountain people – particularly women and children – often spend long hours near stoves within confined spaces. They use substantially more energy than do people living in warmer climates or at lower altitudes and, to reduce their fuel consumption and costs, often close the doors and windows. This exacerbates the amount of smoke in the house and exposes people to greater risks associated with indoor air pollution, such as respiratory diseases.

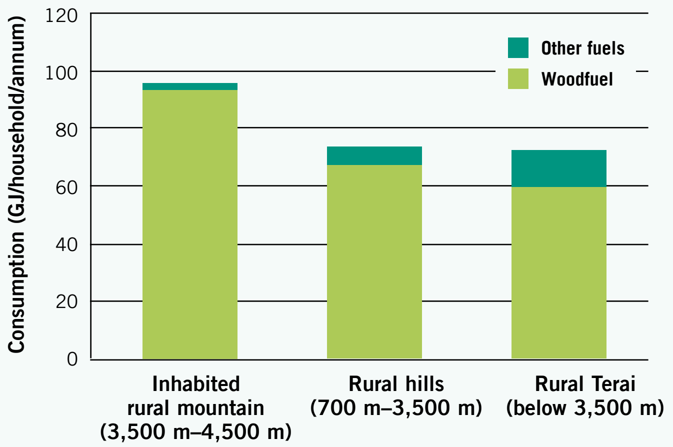
Space heating with fires or stoves also raises the risk of burns, which can often be severe. Safety is an important feature of stove design where they are to be used for heating, especially in households with children, who too often must be left unattended. Box 1.7 illustrates one organisation's approach to this problem.

Impacts on time and income

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

A similar situation is illustrated in rural Nepal (Figure 1.11), where the total energy used by rural households living at high altitudes is substantially greater than in rural communities in the *Terai* (foothills).

Figure 1.11: Total energy use patterns in Nepal as a function of altitude



Source: WECS, 1997

Box 1.7: Early years daycare health centres, Nepal

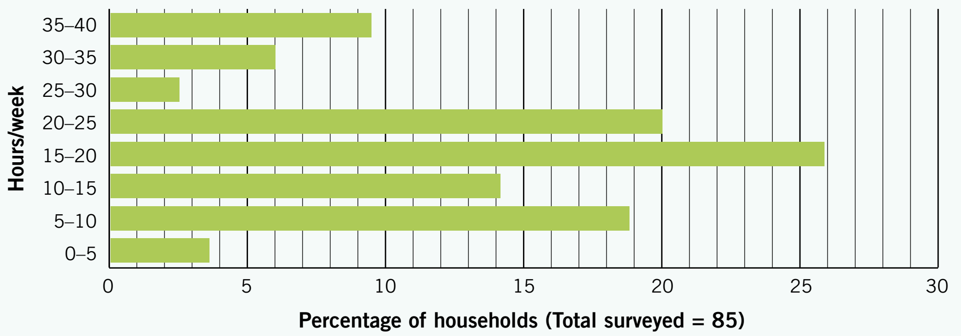
In partnership with the UK charity Child Welfare Scheme (CWS), the NGO CWSN in Nepal has built 14 daycare health centres in rural villages to help reduce infant and child mortality and to improve the quality of life for extremely poor children. As well as providing free child healthcare, the centres provide daycare for young children who are otherwise at risk from household accidents, especially those involving fire. Young children are often left with older siblings while their mothers tend their fields in the valley. The mothers' choice is difficult – either leave their children in a freezing house without a fire or leave the three-stone fire burning to keep them warm.

The centres provide very young children with a safe, warm environment so that the older children can attend school. The children receive pre-school education and a nutritious midday meal. The centre also provides an entry point for awareness-raising on topics such as HIV/AIDS, keeping healthy and hygiene. CWSN is also involved in disseminating stoves that can help reduce indoor air pollution.[5]

[5] www.cwsuk.org

A Practical Action study on smoke alleviation in Nepal showed that in the high hills, people spent many hours gathering fuel. The data in Figure 1.12 provide a 'snapshot' of the week during which monitoring took place for households that gathered fuel. Around half of the total of 85 households spent 16 hours or more gathering fuel; the mean time per week spent was 19 hours – an average of over 2.5 hours per day. Gathering time was calculated as the product of the total time spent and the number of people gathering the fuel.

Figure 1.12: Time spent gathering woodfuel in Rasuwa District, Nepal



Space heating for low-income communities in cold regions

Stove selection

Cookstoves (as opposed to three-stone fires) provide efficient means of cooking food because they focus the heat onto the pot instead of letting it dissipate. However, by their nature, they do not contribute significantly to the temperature of the room.

There are, however, various designs that use the heat from the stove for space heating as well as for cooking, while preventing smoke from getting into the room.

- Chimney stoves made of steel are used in many countries in Asia. Well-made and well-maintained stoves can provide a substantial benefit, particularly in communities where being able to see the fire is not an important social norm. Care must be taken to keep children away from such stoves because of the high temperatures reached. Badly-designed or cheaply-made stoves can distort or burn through the steel after a short time.
- Where people like to be able to see the fire, one option is to use a smoke hood over the stove, leaving the fire partly exposed.
- Separate heating stoves are used in countries where heat is not needed all the time. Typically, they are enclosed stoves with a flue pipe. Some allow a kettle to be placed on the stove top, but they are mainly used for heating. Figure 1.13 shows one from Pakistan (Saleem, 1997).

Figure 1.13: Heating stove in Northern Pakistan

Wall insulation

Space heating is all about energy balance. Once a room has reached a comfortable temperature, the energy given out by a stove has to balance the energy leaving the room through walls, floor and ceiling, as well as through doors and windows. Insulating walls and ceilings can cut the need for heat energy and substantially stabilise room temperature, particularly with stoves that allow some heat to escape. Locally available materials such as straw, dung and clay can be a low-cost solution for householders.

Buildings designed for warmth

Where new housing is being built, passive solar design can lower energy requirements and keep the house comfortable. Houses in the southern hemisphere should face towards Geographic North (±15°) for optimal solar benefit. Houses with north-facing windows have the least heat gain in summer and the least heat loss in winter, keeping the indoor air temperature comfortable. Protection from the wind is also an important consideration, as is the orientation of the main doors and the use of buffer spaces such as porches. Another option is passive thermal design, which entails using materials with a high thermal mass that are able to store heat during the day and release it slowly at night (Figure 1.14).

Figure 1.14: Principles of passive solar design

Source: Klunne, 2002

Targets for space heating

The health effects of living at various temperatures can be seen in Table 1.7. It is possible, following consideration of these effects, to propose some minimum standards for acceptable levels of space heating.

The PPEO therefore recommends a target of 12°C as a minimum daytime temperature to be achieved in all houses, by means that do not entail indoor smoke and concomitant health effects, drudgery or excessive expenditure.

Table 1.7: Health effects of various temperatures

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

Source: Keatinge, 2006

Box 1.8: Heating and the MDGs

Many of the benefits of improved space heating are shared with those of improved cooking energy. However, some links to the MDGs are specific to space heating:

MDG 3: As with cookstoves, reducing the amount of fuel needed to heat the home reduces drudgery, particularly for women. Improved space heating will **promote gender equality and empower women**.

MDGs 4 and 5: Substantially larger numbers of people die from respiratory diseases in mountainous regions than at lower altitudes. Levels of respiratory disease are closely associated with levels of indoor air pollution. Improving stoves and insulation will **reduce child mortality and improve maternal health** by reducing the levels of indoor air pollution (Shrestha and Shrestha, 2005).

MDGs 2 and 4: Creating safer space heating options can help **reduce child mortality**. Offering external daycare, for example, can remove small children from danger and at the same time allow older siblings to attend school, **supporting universal primary education**.

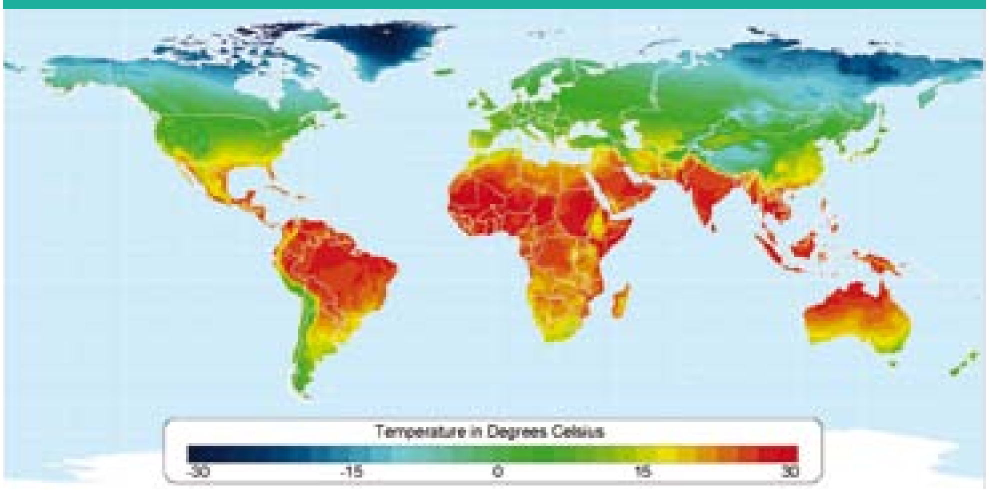
MDG 7: Promoting and supporting means of retaining heat through improved insulation, good stove selection and good house design leads to less woodfuel being collected for space heating, **contributing to environmental sustainability**.

Cooling

Cooling is a critical energy service for the preservation of food and medicines and for keeping spaces at habitable temperatures in hot countries. It can be a fundamental life-saving provision in the case of vaccine refrigerators or avoiding food wastage, a source of income by improving livelihood activities or enabling a new earning opportunity, and a source of comfort in hot climates.

The global temperature map (Figure 1.15) shows that the majority of developing countries are located in the hottest regions of the planet; nearly four billion people in developing countries live in areas with annual average ambient temperatures above 22.5°C. For more than one billion people living in South Asia and Sub-Saharan Africa, the average temperature for the hottest month of the year exceeds 30°C. With global temperatures set to rise in the future as a result of climate change, lack of cooling will increasingly challenge people without access to modern energy services.

Figure 1.15: Global annual average temperature map



Source: FAO, 1997

Issues associated with inadequate cooling facilities

Roughly 830 million people, representing 16% of people in developing regions, are undernourished (United Nations, 2010). Many factors contribute to this number; a lack of effective food preservation facilities is considered a significant one. Farm produce is harvested on a seasonal basis, fish can only be caught during good weather and animals are slaughtered infrequently. In hot climates, farm, fish and animal produce does not stay fresh for long. The rapid perishing of produce can be overcome by a number of preservation methods, including cooling, drying and curing. Cooling is often the preferred method for preserving most meat, fish, dairy, fruit and vegetables since the produce is not significantly changed by the process. 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 production. The required temperature for various cooling applications are listed in Table 1.8.

Livelihoods also depend upon cooling. Farmers and fishers must ensure their goods arrive at market in a saleable condition. The retail value of products can increase significantly if they are stored and sold out of season or at distant urban centres. Cooling is often required for processing, storage and transport of fruits, vegetables, dairy, meat and fish.

Retailers selling food and beverages without access to refrigeration are severely restricted: they can offer a smaller range of saleable products and must charge lower prices as goods quickly perish. These entrepreneurs cannot reduce purchase costs through bulk buying or hold large inventories.

Health care infrastructure in even the smallest clinics and health centres relies on refrigeration of blood, vaccines and medicines (Modi et al., 2005). Poor people in many rural areas simply do not have access to the basic health supplies required for maternal care, and for preventing and treating sickness, disease and HIV/AIDS. Vaccines and medicines must not be subjected to temperatures below 0°C or above 8°C if they are to retain their potency.

Household space cooling is a significant priority in hot and humid areas, even though many low-income households cannot afford this service (Sparknet, 2004). Many areas of the world are subject to soaring temperatures that can affect people's health, productivity and comfort.

Table 1.8: Required temperatures for various cooling applications

Application	Purpose	Required temperature (°C)
Domestic goods	Food and drink storage	2–15
Health clinics	Storage of blood, vaccines and medicine	0–8
Agriculture, dairy products and fish	Removal of 'field heat' immediately after harvesting crops, storage of fruit, flowers, vegetables, milk, meat and fish, and cooling during transport	2–15
Retail trades	Sale of fresh foods, fish, ice and cold drinks	-18–15
Buildings	Temperature regulation	15–30

Sources: Practical Action, 2006; EUFIC, 2001; WHO, 1998

Box 1.9: Solar-powered health centres in the Philippines

Solar panels are powering vaccine refrigerators in health centres in remote off-grid villages in the Philippines (Hammond, 1999). The refrigerators store medicines in specialised vaccine refrigerators. Before gaining access to local health facilities, people had to travel to the municipal capital for treatment. For remote villages this often involved a long walk, travel on an unsealed road or a boat ride – a journey that may be dangerous or impossible during the wet season, and one that is always a significant challenge for the sick.

The initiative was a joint project of the Australian and Philippine governments. The project is community based, requiring residents to manage the care and maintenance of solar batteries and set aside funds for maintenance.

Cooling energy technologies

There are three kinds of technology that provide cooling services: *mechanical compression*, *sorption refrigeration* and *passive cooling*.

Mechanical compression is the most common method for providing cooling for a range of applications. Commercially sold conventional refrigerators and freezers use this technology. Where a reliable supply of electricity exists, this is the most economic option for low temperature applications (below 10°C). Health centres in off-grid areas often use solar photovoltaic (PV) panels to power vaccine refrigerators using this technology (Box 1.9). Although solar PV has a high capital cost, the operating costs are low and it can provide a reliable supply of power with little maintenance.

Sorption refrigerators are conventionally powered by gas or kerosene. Gas refrigerators are popular with households that require deep cooling in off-grid areas.

Passive cooling methods can be used where temperatures between 10°C and 25°C are needed, such as for storing food and dairy products. Technologies include the zeer pot (see Box 1.10) and cooling chamber. Passive technologies are very economical since they require no fuel or electric input and can be built using widely available materials. However, despite their benefits there are little data available about the uptake and use of passive cooling technologies (Practical Action, 2006).

Access to refrigeration

Access to cooling services is low among the world's poorest people, and this is partly reflected in the dearth of data relating to uptake of this service in poorer countries. Data from five South American countries with high electrification rates show that refrigeration is a high priority for people of all income groups. Along with television, a refrigerator is a priority appliance for the poorest 20%. Nearly all of the wealthiest 20% own a refrigerator, and it is by far the most common appliance (Figure 1.16).

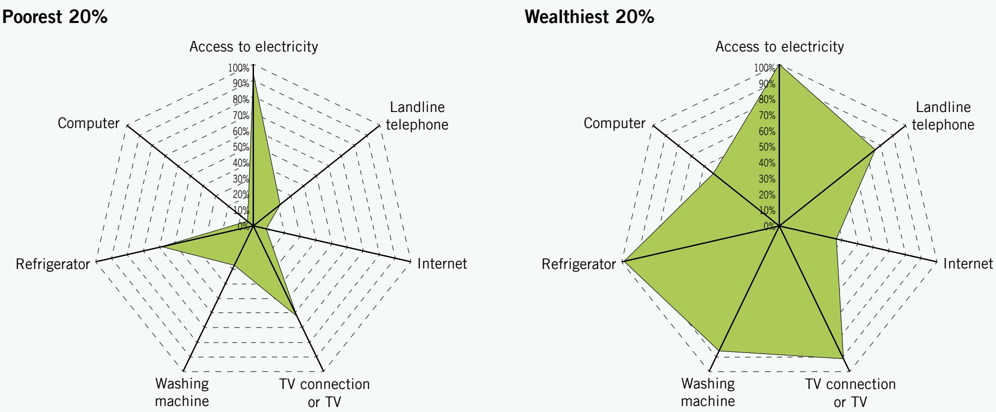
Box 1.10: Zeer pots in Sudan

In the heat of Sudan, where the average annual temperature is 30˚C, food doesn't stay fresh for long. Tomatoes spoil in just two days. After four days carrots and okra are rotten. Poor families in North Darfur and Blue Nile State without any means of preserving their crops often face hunger and even starvation. The situation is especially grave for children and elderly family members.

Produce	Shelf life without zeer pot	Shelf life with zeer pot
Tomatoes	2 days	20 days
Guavas	2 days	20 days
Okra	4 days	17 days
Carrots	4 days	20 days
Rocket	1 day	5 days

One solution is the zeer pot: a simple passive cooling 'fridge' made of local materials. It consists of one earthenware pot set inside another with a layer of wet sand in between. Zeer pots are used by poor households to improve food security. Hawa Nubia and her family in Sudan use the zeer pot to store their farm produce. "They keep our vegetables fresh for 3 to 4 weeks, depending on the type of crop. They are very good in a hot climate such as ours where fruit and vegetables get spoiled in one day," she explained (Practical Action, 2009).

Figure 1.16: Average access to appliances for the poorest 20% and wealthiest 20% of populations in five South American countries



Source: Kozulj, 2009

Even for those who have access to electricity, the cost of acquiring and operating cooling and refrigeration appliances can be prohibitive for low-income households.

Cooling targets

Cooling, as with other individual energy services, is not widely recognised as an indicator in human development targets. As such, there is a lack of focus on the provision of cooling services and a paucity of data on cooling. Access to electricity is a common proxy, but as Figure 1.16 shows, this relationship does not hold true for poor people. We propose that minimum cooling standards should include the following:

- Food processors, retailers and householders have facilities to extend life of perishable products by a minimum of 50% over that allowed by ambient storage
- All health facilities have refrigeration adequate for the blood, vaccine and medicinal needs of local populations
- Maximum indoor air temperature of 30˚C.

Box 1.11: Cooling and the MDGs

MDG 1: High levels of **poverty and hunger** are incident on poor families without any means of preserving their produce for future consumption or sale. Access to energy for cooling can enhance food security and combat hunger. Cooling services can create new income opportunities and improve existing activities for producers and retailers.

MDGs 4 and 6: To reduce **child mortality**, **improve maternal health** and **combat HIV/AIDS, malaria and other diseases**, health institutions need cooling services to provide reliable quality supplies of blood, vaccines and medications.

Information and communications

A vital need for lives and livelihoods

Information and communication are intrinsic to social and economic relationships. Information and communication technologies (ICTs) have been established as important tools for alleviating poverty because they enable the widening of these relationships beyond people's immediate surroundings. The use of ICTs and the benefits they bring cannot be realised without energy – specifically electricity.

ICTs are defined as technologies that can process and transmit information and facilitate communication via electronic means (Marker et al., 2002). This includes a wide range of technologies, from radio and television to telephones (fixed and mobile), computers and the internet.

Opinions vary on the value of ICTs in development. Because of their complexity and expense, some analysts question whether ICTs are suitable for meeting the basic and urgent needs of poor people, while proponents insist ICTs are essential tools for promoting sustainable development.

People living in poverty lack access to information that is vital to their lives and livelihoods: information about the composition and delivery of services from public institutions, about political activities and their human rights, on health issues, about the market value of their goods and produce and about education and livelihoods options.

People living in poverty may also have long-distance communication needs. Examples include families dislocated for labour migration, sick people unable to gain health advice, teachers and health workers who provide services outside of their institutions and suppliers, farmers, fisher folk and craftspeople separated from potential customers. These communication needs may be impossible to meet, or may entail a cost that limits the ability to meet them fully.

These issues are compounded by the lack of capacity or resources needed to change this situation. Information can become the knowledge and tools people need to participate in society in a progressive manner; it can also empower people to interact with public institutions, businesses or civil society.

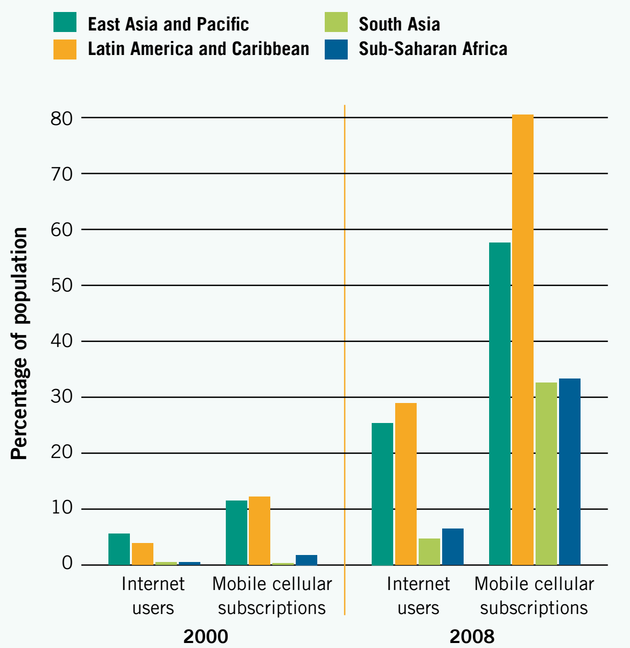
The spread of ICTs

Figure 1.17 shows that between 2000 and 2008 the amount of people using the internet and accessing mobile phones increased rapidly in all developing regions. The least poor regions – East Asia and Pacific, and Latin America and Caribbean – have the highest usage rates, but the growth rates are similar for all the developing regions. Mobile phone technology in particular has taken hold very quickly as a result of the affordability of the phones, relatively low infrastructure requirements, modest energy requirements of the phones and long-lasting batteries.

The adoption of ICTs has been broad-based, with mobile phones reaching many low-income families and those living in rural areas (IDA, 2009). There is, however, still a risk that inequitable access to ICTs may exacerbate growing inequalities in income, knowledge and power between men and women, income or ethnic groups, or urban and rural populations. For example, a woman is 23% less likely than a man to own a mobile phone if she lives in Sub-Saharan Africa and 37% less likely if she lives in South Asia (GSMA, 2010).

Experience from the telecommunications sector suggests that increased penetration of ICTs, improved service and reduced cost can be encouraged through a competitive private market (DFID, 2002). In 1997 Kenya Post and Telecommunication Corporation, the monopoly telecommunications operator in Kenya, was unbundled and the resulting private companies were licensed to operate. Safaricom was the first to do so and it now has a large market share across East and Central Africa, vying for Kenyan mobile phone customers with three other major companies. Government strategies and market incentives can prove a powerful force in increasing access to energy services and ICTs.

Figure 1.17: Spread of internet and mobile phone users in the developing world



Source: IC4D, 2009

Access to energy for ICTs

Access to energy has enabled the uptake of ICTs, even in remote rural areas of developing countries, where the electricity required to power appliances and charge batteries has been made available through extension of the grid or decentralised energy systems such as solar panels or diesel generators.

People can still benefit from ICTs without a household electricity connection; many people can watch television, use a computer, listen to the radio, or charge their mobile phone from a battery. In Kenya, only 15% of the population has electricity access at the household level, yet the penetration of mobile phones is already 50% (Legros et al., 2009). The people in the Peruvian village described in Box 1.12 have access to the internet through the local shop, which is powered by the micro-hydropower plant.

The increased use of ICTs is also contingent on a number of other factors: better infrastructure (such as signal towers for mobile phones), improved supply chains for ICTs (availability of products and services), improved and pro-poor technology and services from ICT providers (low-cost, high quality products and services such as the M-PESA banking facility on mobile phones), increased public awareness of products (through advertising and word of mouth) and greater consumer spending power (see Figure 1.18 and Box 1.13).

Box 1.12: Internet in rural Peru

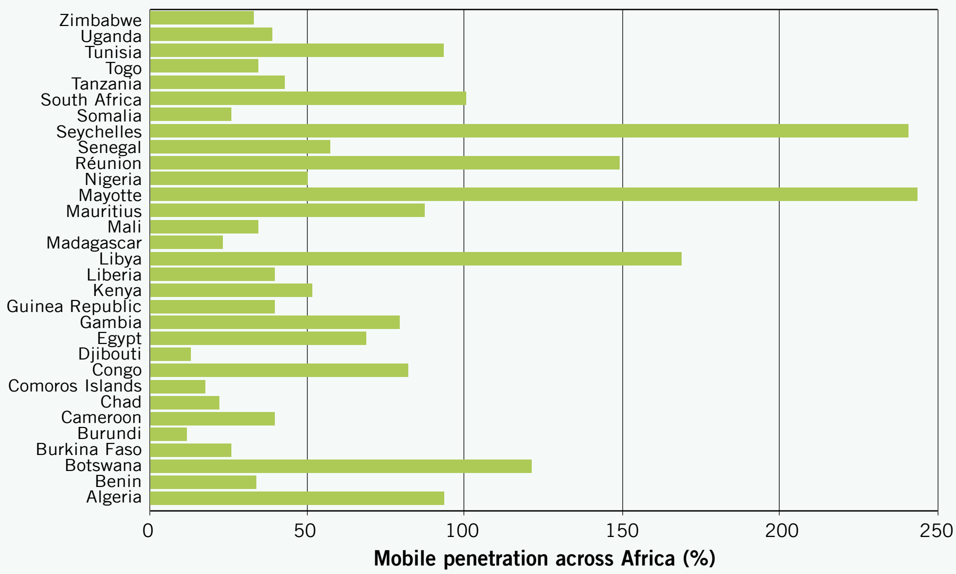
Yanacancha Baja is a village nestled in the northern highlands of Peru. A micro-hydro plant provides electricity to households and businesses in the village. Mrs de la Cruz has been able to increase her income and provide services to the community through her cyber café and shop.

"We have two computers and an internet connection in the store. The company that installed the computers gave us a crash course in using the internet and now everyone's hooked. Parents read the news or send emails to relatives living in the cities. The children use them for their school work and for playing games."

Benefits of ICTs

The ICT sector's contribution to economic growth is widely recognised. It is estimated that a 10% increase in the number of telephone subscribers in a country contributes to 0.6% GDP growth, largely through the impacts on small and medium-sized businesses (IDA, 2009). ICTs can make business practices more efficient and enable wider access to customers, suppliers, partners, sources of capital and global information.

Figure 1.18: Mobile phone penetration* across Africa (%)



* Mobile phone penetration is defined as the number of mobile phones subscriptions as a percentage of population.

Source: Safaricom, 2010

Box 1.13: Safaricom and M-PESA in East Africa

In Kenya, mobile penetration (calculated as number of mobile subscriptions as a percentage of population) has reached 50%. Safaricom, Kenya's largest communication company, has developed a business model that enables enhanced mobile phone usage for poor people. Safaricom promotes a range of innovative services and features targeting poor people, including a banking and money transfer service called M-PESA that is used by nearly 10 million Kenyans. Poor people who cannot obtain accounts with commercial banks can now gain access to banking facilities. M-PESA allows the user to deposit, withdraw and transfer money, and pay bills using their mobile phone account (Safaricom, 2010).

The main sources of energy for charging mobile phones are grid electricity or batteries charged by solar panels or diesel generators, which are prevalent in rural areas. Numerous small enterprises have arisen that offer mobile battery charging at a cost. Safaricom has 2,302 base stations across Kenya for the transmission and reception of cellular data, 135 of which are in off-grid areas and powered by hybrid energy systems comprised of wind/solar PV/diesel generators (Winafrique, 2010).

Photo: Bergey Windpower Co.

Wind turbine powering a Safaricom base station.

There are numerous examples of ICT applications that have a demonstrable impact on rural livelihoods: market information systems can increase profits for producers and lower costs for consumers, microfinance providers can reduce transaction costs and borrowers can access cheaper credit, and digitisation of land rights and land registration processing can improve transparency and the speed with which claims can be processed (infoDev, 2008).

ICTs can provide a platform from which the public and private sector can deliver health, education and other services more effectively. By helping to improve administration, they can lead to more effective and responsive organisations (ECOSOC, 2000). The ICT sector is a major generator of revenues for governments in developing countries; the government in Bangladesh collected US$300 million from ICTs in 2005 alone (IDA, 2009).

Evidence shows that ICTs have made an impact on healthcare in a variety of ways. Namely, they have:

- **improved dissemination** of public health information and facilitated public discourse and dialogue around major public health threats
- **enabled remote consultation**, diagnosis and treatment through telemedicine
- **facilitated collaboration and cooperation** among health workers, including sharing of learning and training approaches
- **supported more effective health research** and the dissemination and access to research findings
- **strengthened the ability to monitor** the incidence of public health threats and respond in a more timely and effective manner
- **improved the efficiency** of administrative systems in healthcare facilities. (McNamara, 2006).

It is widely believed that ICTs can support education goals by empowering teachers and learners, promoting change and fostering the development of

'21st century skills'. However data to support these contentions are still limited (Trucano, 2005).

Because of their isolation, rural areas arguably stand to derive even more benefit from connectivity, since ICTs can deliver health, education and other services that might be less widely available there (ITU, 2010). ICTs have also promised progress influencing public opinion on gender equality through awareness campaigns.

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Information and communication targets

A range of indicators are used to measure access to ICTs, and a number of targets have been proposed by the development community. Setting ICT targets is a somewhat contentious issue as some feel that ICTs for poor people should be seen as a means of reducing poverty and not an end in itself. This report suggests an approach to setting indicators that focuses on the service provided by ICTs rather than simply access to the technology. In order to achieve development benefits, the proposal is for minimum standards that incorporate the following elements:

- People can communicate electronic information beyond the locality in which they live
- People can access electronic media relevant to their lives and livelihoods.

Box 1.14: ICTs and the MDGs

MDG 1: Access to ICTs can **reduce poverty and hunger** through impacts on economic growth and rural livelihoods. Poor people benefit from improved information flows and the ability to communicate, which improve the effectiveness and equitability of markets.

MDGs 4, 5 and 6: ICTs can help **reduce child mortality**, **improve maternal health** and **combat HIV/AIDS**. ICTs enable more efficient delivery of healthcare services, enhance training and skills development, provide health information to the general public and increase the capacity of health institutions. ICTs are important tools for information dissemination and public health campaigns.

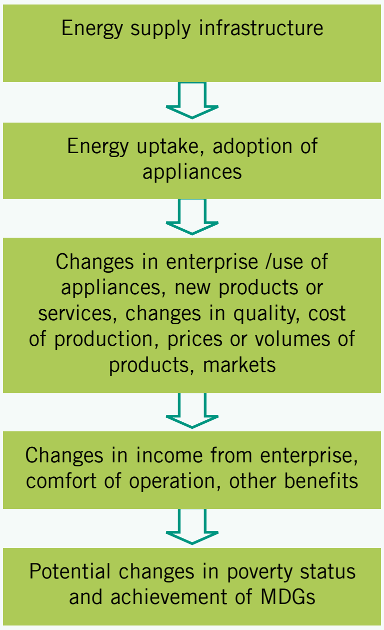
Earning a living

A form, an outcome and a cause of poverty

Lack of access to modern energy services by an individual or household is a form of poverty in its own right, since it can be seen as a "deprivation of people's capabilities and freedoms which enable them to satisfy their ends" (Sen, 1999). However, lack of access to energy services is also caused by poverty: if people had additional financial resources, they could afford the amenities that are available in wider markets and the expansion in capabilities and freedoms that they bring. Finally, the absence of energy access also reinforces constraints in income generation potential, because many product and service-based enterprises and public services either rely on energy or are substantially improved in their productivity, profitability or efficiency by the introduction of improved forms of energy access.

Given these three interlinked factors, a vicious circle can be identified: a lack of energy access leads to limited income-earning capability, which reduces purchasing power, which in turn limits the access to energy that could improve incomes. This section focuses on the connections between energy access and earning a living. The connection, however, is not straightforward as indicated in Figure 1.19. Even if energy supply infrastructure is available, there is no guaranteed or linear path to universal uptake of appliances, use of energy in the creation or improvement of enterprise characteristics, increase in incomes or job creation. As illustrated by the statistics of 3 billion people without modern fuels and 1.5 billion without electricity (Legros et al., 2009), this energy supply infrastructure is all too often absent for poor people. What the existing gross figures do not capture, however, is situations in which the available infrastructure functions poorly or is too expensive (see Table 1.11 for alternative disaggregated access indicators).

Figure 1.19: The steps from energy supply infrastructure to poverty reduction



Source: Kooijman-van Dijk (2008)

The general association between energy access and incomes, GDP and the Human Development Index (HDI) is well established (and presented graphically in Figure 3.1, Chapter 3). However, what is less clear is the direction of causality. Does increased energy access lead to growth in incomes, or does growth in incomes lead to increased energy access? Evidence is mixed and research is still inconclusive on this point (Aqeel and Sabihuddin Butt, 2001).

Energy access can therefore be seen as a necessary, but not sufficient, condition for increasing incomes. However, it is clear that in order to achieve the MDGs, both energy access and incomes have to increase. Energy access is a crucial input for income-generating activities. Generating revenues from energy access is also a key challenge in ensuring the sustainability of energy supply systems. Maximising the linkage between energy access and earning a living is thus crucial for poor people.

Box 1.15 illustrates the transformational effect that the introduction of electricity – the most flexible of energy carriers – can have on a range of income-generating opportunities. Other forms of modern energy are, of course, also connected with income-generation activities.

Earning from energy services

Energy access can enable people to earn a living in three ways:

- **Creation of new earning opportunities** – Certain activities, such as selling cold drinks and ice cream, welding and machining are only possible when modern energy services are available. People may switch to such new avenues,

Box 1.15: Rural electrification and gender in Chile


Photo: Matt Barker

In Pallaco, Chile, the government constructed a micro-hydroelectricity plant in 2001 providing energy to 15 ethnic Mapuche families comprising 44 women and 42 men. The project included enterprise support. Positive impacts of access to energy services included:

- **40% of women were found to spend less time on household chores** mainly due to household electrical appliances.
- **Two-thirds of the population took on additional income-generating activities**. For women, this included weaving clothes and dressmaking using electrical appliances; for men, carpentry and welding.
- **Households generated an additional income of 35% per household** from these activities. This increase is attributed principally to activities undertaken by women.
- **Half of the population noted having more time** to participate in social and community organisations and activities.

or use them as opportunities to diversify income sources, while maintaining other income-generating activities.

- **Improvement of existing activities** – Modern energy services can improve the efficiency or productivity – and thus profitability – of some activities. Examples include lighting that permits shops to stay open later, irrigation that improves agricultural yields or milling that adds value to grain.
- **Reduction of opportunity costs** – For many people, particularly women, energy-intensive tasks such as collecting firewood and cleaning soot-blackened pots can take hours out of each day. Modern energy access allows these tasks to be done more quickly, and thus releases time and physical energy for other activities, including income-generating ones.

Table 1.9 gives examples of the ways in which the energy services described in the previous sections are connected with earning a living. In addition to the five energy services profiled in the previous sections, four services often linked with mechanical power are included (irrigation, agro-processing, manufacturing, and lifting and crossing), which increase the efficiency and effectiveness of productive activities and the physical processes needed to meet human needs (Practical Action Consulting, 2009).

There remains a lack of systematic data to support the connections highlighted above, and only a few studies to date are dedicated to determining the links between energy and incomes at village level (e.g. Oakley et al., 2007; Kooijman-van Dijk, 2008). While energy services contribute to a range of enterprises on the demand side, the supply of the energy service itself represents an additional important link between energy and earning a living.

Table 1.9: Energy services and income opportunities

Energy service	New income opportunities	Improvement of existing activities	Opportunity cost saving
Lighting	Street lighting enables night-time stalls and entertainment	Later opening of restaurants, cafés and shops	Creating opportunity for night-time activities in increased safety
Cooking	Sale and distribution of commercial modern fuels and stoves	Cleaner and more cost-effective cooking	Time saved in wood collection and pot cleaning
Cooling	Selling ice, ice-cream, etc. New markets for refrigerated products, e.g. milk	Less waste of agricultural and fishery products, creating more income	Reduced time and energy spent keeping goods fresh or selling intensively in a short period
Heating	Process heat for new industrial processes	Improved comfort in hotels and cafés	Time saved in collecting wood for heating
ICTs	Internet cafés, mobile phone charging, radio stations	Finding best prices at various markets	Reduced travel time associated with communication
Irrigation	Growing new kinds of crops	Better yields on existing land compared with rain-fed agriculture	Less time spent manually watering crops
Agro-processing	Adding value by refining agricultural products	Increasing throughput and lowering costs	Less time spent manually grinding/pounding, etc.
Manufacturing	Welding and metalwork enabled	Improved quality and speed of carpentry	Time saved by mechanisation of repetitive designs
Lifting and crossing services (e.g. ropeways to transport over difficult geography, etc.)	Crossing services can be charged for	Reduced transport costs	Reduced time lost travelling to crossing points

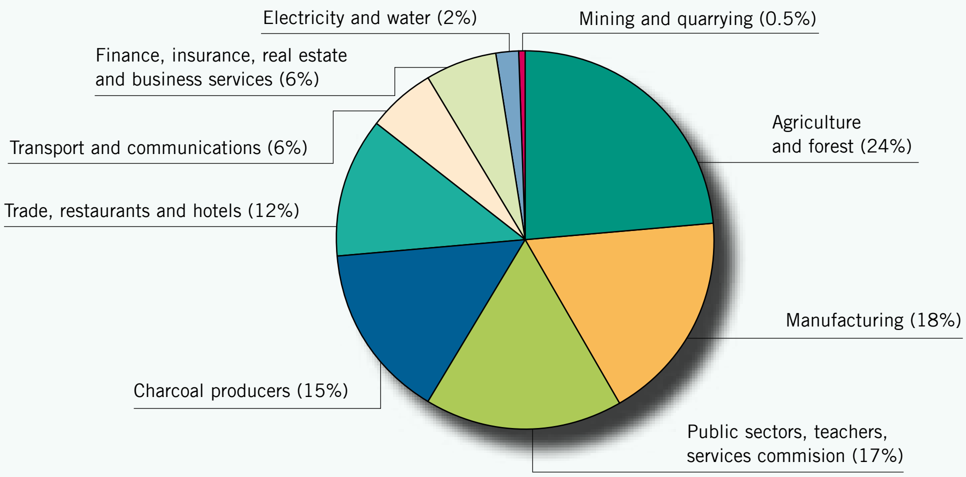
Source: PPEO, building on the work of Energia, 2006

Earning from energy provision

In rural areas of developing countries, energy provision in the form of wood and charcoal can be the second most important employment activity after agriculture, if both formal and informal sectors are counted. Figure 1.20 shows the case of Kenya. In addition to the 200,000 direct producers of charcoal and woodfuel, 500,000 people in total are involved in trade (transporters, vendors, etc.), and the total number of dependents supported by the industry is approximately an additional 2.5 million. Where such rural industries can be made sustainable through whole-chain efforts to reduce illegal deforestation, increase reforestation and increase the efficiency of conversion (kilns) and appliances (stoves), a decentralised rural industry based on indigenous renewable resources is possible.

Increasing the provision of modern energy services more widely can also boost income- generating opportunities in the production, processing, distribution and sale of modern energy fuels, as well as conversion equipment and appliances. Employment statistics for developing countries do not capture widespread informal sector activity. Energy sector employment statistics that are available are often reported with other utilities and water, as for the Kenya electricity sector. Increase in employment and increase in energy access are linked, but not linearly. Research into this connection is ongoing. For example, although electricity access

Figure 1.20: Employment types in Kenya



Source: ESD, 2005

in Europe is nearly universal, the proportion of employment in the mainstream energy industry is low and has generally been in decline for several decades as coal use has declined and more efficient infrastructure and automation have been put in place (EWEA, 2009). However, in poorer countries with low levels of energy infrastructure and appliances in place, opportunities for productive employment growth in energy sectors remain.

Globally however, renewable energy and energy efficiency is a sub-sector in which an increase in so-called 'green jobs' is predicted, although estimates vary (Greenpeace, 2010). In developing countries, carbon finance favours low-carbon technologies as a proportion of energy sector activity. The potential of new biofuel production to add to rural employment in developing countries is also an emerging policy driver. For example, in 2005 the combined sugarcane and ethanol industry in Brazil formally employed close to one million people and the country is actively exporting its model to Africa (de Moraes, n.d.).

Box 1.16: Treadle pump irrigation

Water pumping for drinking and irrigation is not always recognised as an energy technology, but it is an important energy service using mechanical power. Treadle pumps have been promoted in various forms by a variety of agencies in Africa and Asia in particular. Between 1998 and 2008, IDE helped roughly 50,000 southern African farmers to adopt the technology, and they reported the following improvements relating to earning a living:

Photo: Kickstart

- 50–80% improvement in crop productivity and output
- 100% increase in incomes earned by farmers
- 60–80% reduction in time spent by farmers irrigating plots.

Source: PAC/UNDP, 2009

Conclusions

In addition to emphasising the role of the energy sector itself in rural and national employment in Kenya, the employment sectors presented in Figure 1.20 also show the extent to which employment relies directly on energy services. None of the sectors mentioned could operate to their full productive or efficiency potential without energy access. The economic cost of electricity shortages has been estimated via several methodologies (Sanghvi, 1991), but the cost to both economic performance and development of lack of energy access has not been calculated at national or international levels. One reason for this is the complexity of the relationship between energy access and development outcomes as highlighted in Box 1.17. In order to go from energy access to earning a living, it must also be recognised that other barriers beyond energy access must also be addressed, be they capacity gaps, lack of technical knowledge and finance, or lack of access to markets.

In an effort to measure the connection between energy and incomes, aggregate measures such as the energy intensity of a unit of economic output are often used. However these measures are liable to be misleading for those interested mainly in energy access for the needs and productive uses of poor people, since the figures are skewed by large industrial users. More direct indicators of energy access as a fundamental input to income generation are required in order to establish this linkage. The PPEO recommends minimum standards taking into account the following:

- Access to energy is sufficient for the start-up of any enterprise
- The proportion of operating costs for energy consumption in energy-efficient enterprises is financially sustainable.

Box 1.17: Earning a living and the MDGs

MDG 1: To **eradicate poverty and hunger**, incomes must be lifted above the international poverty line. Access to energy and increased incomes are strongly linked.

MDG 2: To achieve **universal primary education**, children must be free to attend school rather than be involved in manual labour for income generation without the support of modern energy services.

MDG 3: To **promote gender equality and empower women**, it is necessary to create income generation potential for women. Without modern energy, time is lost in manual tasks such as wood collection, while productive activities are limited.

Summarising people's experience of energy

The preceding sections have outlined six essential energy services needed by all people and communities, drawing both on people's experiences and collated data at household, project, national and international levels.

As a result of this evidence we propose the following minimum energy service levels across this full range for what could be considered Total Energy Access (Table 1.10).

It is recognised that the exact numbers linked to these targets would be context-dependent in some cases. However, using Table 1.10 as a checklist, a

Table 1.10: Total Energy Access

Energy service	Minimum standard
1 **Lighting**	300 lumens at household level
2 **Cooking and water heating**	1 kg woodfuel or 0.3 kg charcoal or 0.04 kg LPG or 0.2 litres of kerosene or ethanol per person per day, taking less than 30 minutes per household per day to obtain
	Minimum efficiency of improved wood and charcoal stoves to be 40% greater than a three-stone fire in terms of fuel use
	Annual mean concentrations of particulate matter ($PM_{2.5}$) < 10 $\mu g/m^3$ in households, with interim goals of 15 $\mu g/m^3$, 25 $\mu g/m^3$ and 35 $\mu g/m^3$
3 **Space heating**	Minimum daytime indoor air temperature of 12ºC
4 **Cooling**	Food processors, retailers and householders have facilities to extend life of perishable products by a minimum of 50% over that allowed by ambient storage
	All health facilities have refrigeration adequate for the blood, vaccine and medicinal needs of local populations
	Maximum indoor air temperature of 30ºC
5 **Information and communications**	People can communicate electronic information beyond the locality in which they live
	People can access electronic media relevant to their lives and livelihoods
6 **Earning a living**	Access to energy is sufficient for the start up of any enterprise
	The proportion of operating costs for energy consumption in energy-efficient enterprises is financially sustainable.

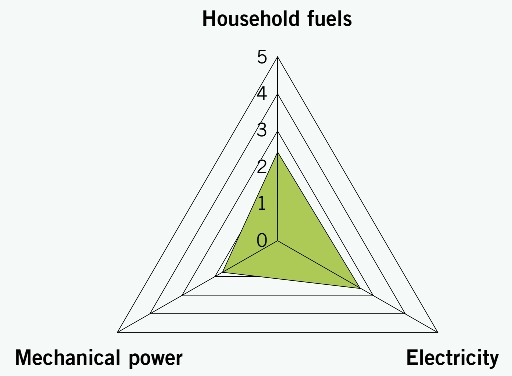
service-oriented picture of the energy access status of households and communities can quickly be built up, gaps highlighted and a score out of 12 generated. Using minimum service standards, the level of amenity which people enjoy from energy can thus be more clearly and comparably evaluated, and improvements tracked in the dimensions that matter to people. We look forward to feedback and discussion from readers on these proposed targets, and to refining and reporting on them in future editions.

Access to energy supplies

Indicators based on energy services are important in helping define the conversion of energy into development benefits at household or community level. However it is also important to measure the extent to which energy supply is available to people in order to meet these service needs. While measures of numbers of people with and without electricity and modern fuels, for example, are useful, they also give an incomplete picture of the types and quality of energy supplies in people's real experience. In response to this, the Poor People's Energy Outlook also proposes a hybrid set of indicators that assign a numerical value to the qualitative aspects of energy access in its three main supply dimensions: household fuels, electricity and mechanical power. The measures proposed could be asked of an individual household, or if included in a village or national census, could characterise in unprecedented detail the people's experience of energy supply at community or national levels. The categorisations are proposed in Table 1.11, with 1 being lowest and 5 the highest levels of access.

The results of such an analysis could be presented graphically for an individual household or for a population, as in Figure 1.21. Here the proportion of the population at each level of access leads to a composite view of the relative energy access experience in the three crucial energy supply dimensions for a household, village, country or region.

Figure 1.21: Energy Access Index



The energy access index could complement the existing aggregated indices of electricity access or biomass use with more disaggregated measures relating to the energy supply dimensions of importance to people. Graphically representing the proportion of the population at each level for each carrier provides a visual snapshot of where needs are greatest, since difficulty of access to each type of energy supply is associated with specific, known detrimental effects. So, for example, drudgery is implied by a low household fuel value because of the implications of collection of woodfuel.

The levels also expose the challenge associated with defining 'adequate' energy access in terms of supply. For example, level 3 for all three supply types

Table 1.11: Energy Access Index

Energy supply	Level	Quality of supply
Household fuels	1	Collecting wood or dung and using a three-stone fire
	2	Collecting wood and using an improved stove
	3	Buying wood and using an improved stove
	4	Buying charcoal and using an improved stove
	5	Using a modern, clean-burning fuel and stove combination
Electricity	1	No access to electricity at all
	2	Access to third party battery charging only
	3	Own low-voltage DC access for home applications
	4	240 V AC connection but poor quality and intermittent supply
	5	Reliable 240 V AC connection available for all uses
Mechanical power	1	No access to mechanical power. Hand power only with basic tools
	2	Mechanical advantage devices available to magnify human/animal effort
	3	Powered (renewable or fossil) mechanical devices available for some tasks
	4	Powered (renewable or fossil) mechanical devices available for most tasks
	5	Mainly purchasing mechanically processed services.

would represent a very substantial improvement for the poorest at levels 1 and 2, but would still fall short of the most convenient, healthy and productive forms of energy available. Nonetheless, a key advantage of such a textured approach is that progress can be clearly measured in terms of real-world, real-experience increments.

Energy sources and environmental impacts

The access index above does not include environmental aspects – such as those associated with climate change – and so does not prioritise renewable energy. However, the issue of where the energy will come from and the impacts of its use on the environment remain important. In the short term though, neither should be a governing restriction on the achievement of energy access for those living in poverty.

Regarding energy resources, the World Energy Council Survey of World Energy Resources states: "Concerns [about energy supply] are not based on the overall availability of resources, but on the concentration of strategic energy resources in a few countries" (WEC, 2004). The analysis paints a picture of large reserves of fossil energy relative to consumption as well as widespread renewable resources. Many renewable resources remain almost completely untapped in developing countries. For example, the WEC notes that only 33% of the technically and economically feasible global potential of hydropower has been exploited.

With respect to carbon emissions, analysis has shown that even in a scenario where all those in energy poverty achieved a basic level of access via LPG and fossil-based grid power, there would only be a 1.6% increase in global emissions (Sanchez, 2010). This carbon emission impact can be considered minor compared with the 60% cuts that highly emitting industrialised countries need to make in carbon and the human development gains linked to such a shift. Issues relating to climate equity and responsibility are discussed further in Chapter 3.

This is not to underplay the importance of environmentally sustainable approaches to energy access, including sustainable forest management, renewable energies, life cycle analysis and energy efficiency – particularly in the medium to long term. However, from the poor people's perspective, energy access for development takes priority.

The impacts of improving energy access

Development gains from increased access to energy would be very substantial. Meeting our recommended energy service standards – including through the provision of energy supply access indices at upper levels for all – addresses the MDGs directly. Table 1.12 summarises the connections between the six identified energy services and the MDGs.

In summary, we hope that the evidence and testimonies presented in this chapter will serve to highlight the pressing issues and raise the voices of those in energy poverty so that they are heard by policy-makers. We also advocate for improved data collection in the dimensions proposed, which must go hand in hand with the required actions. For the hundreds of millions forced to live in energy poverty, this is an urgent need.

Table 1.12: Energy services contribution to the MDGs

MDG			Energy service					
			ES1	ES2	ES3	ES4	ES5	ES6
			Lighting	Cooking and water heating	Space heating	Cooling	ICTs	Earning a living
MDG	1	End poverty and hunger	Increased productive time at night for work and sales; reduced money spent on low-quality lighting	Reduced time lost gathering wood, increasing time available for other productive activities Food can be cooked safely	Reduced time lost gathering wood, increasing time for other productive activities	Reduced food waste and increased incomes for producers	Information enables better market prices for producers ICTs support economic growth	New and improved income earning
MDG	2	Universal education	Children allowed to study at night Rural schools and colleges attract teachers	Less time spent collecting wood means more time for education	Less time spent collecting wood means more time for education	–	Access to educational software and information from global sources	Children released from earning into learning
MDG	3	Gender equality	Women's domestic burden reduced by improving lighting	Reduced burden on women to obtain cooking fuels	Reduced burden on women to obtain cooking fuels	–	Equal access to information, including information on government programmes	Broader income-generation opportunities for women, decreasing the importance of physical strength
MDG	4	Child health	Reduced deaths and injury from unsafe lighting; less lung damage from sooty flames	Reduction in smoke inhalation–related diseases among young children	Reduced child deaths due to cold–related illnesses	Vaccine refrigeration enables inoculation	Information about child healthcare more available	Higher incomes linked with improved health
MDG	5	Maternal health	Improved lighting for clinics, essential for safe night births and treatment	Increased birthweight of children without smoke. Hot water available, essential for childbirth	Improved comfort and health of mother in pregnancy and childbirth	–	Information about healthcare options more available	Higher incomes linked with improved health
MDG	6	Combat HIV/AIDS	Improved lighting, essential for clinics	Needles can be sterilised	–	Liquid anti-retrovirals can be refrigerated	Information about protection and healthcare options more available	–
MDG	7	Environmental sustainability	Lighting is an ideal end-use for renewable electricity	Improved practices reduce deforestation and emissions	Improved practices reduce deforestation and emissions	–	Monitoring and communication of environmental impacts is possible	–
MDG	8	Global partnership	–	–	–	–	Communications enable dialogue, information exchange and partnership	–

Chapter 2: Practitioner perspectives

In this chapter, thought leaders in the sector put forward their analyses of some of the main issues relating to energy access for people living in poverty. These issues are health, financing, gender, electrification and approaches to energy sector development. Each issue is approached in terms of its interplay with energy poverty, and its potentiality for increasing safe and sustainable energy access.

The kitchen hearth provides food and warmth, but because of it, 1.6 million people will die prematurely each year, and millions will suffer respiratory ailments. Of these deaths, 1.4 million are caused by cooking with wood and other forms of biomass, affecting mainly women and small children (Smith et al., 2004). This is one of the most pressing issues that must be addressed if progress towards the MDGs is to be accelerated. In his section, Professor Kirk Smith discusses issues relating to the health and quality of life of people living in poverty – the most vulnerable of whom are women and children – in the context of biomass-based cooking and heating. His analysis shows what is required to reduce the burden of energy-based ill health on the most vulnerable.

People with very little money often find that the major stumbling block to finding a way out of energy poverty is lack of access to finance. In his discussion of the financial aspects of energy and poverty, Dr Grant Ballard-Tremeer highlights the issues raised in meeting the needs of women and men on very low incomes. What is the role of the open market? If subsidy has a place at all, how should it be used? Ballard-Tremeer looks at four key aspects; optimal market mechanisms, local ownership, sustainability and funding, and the effects of the global economic crisis.

Energy for people in energy poverty, often equates to 'household energy', for which, in many developing countries, women are largely responsible. Despite this, it is usually men who decide the way in which energy is accessed, and whether scarce money is used to make that access easier or better. For this reason, Sheila Oparaocha discusses ways to ensure that women as well as men have the power to make decisions, participate in implementing those decisions, and benefit equally from improvements in energy access provision.

Electrification is seen by many as a central pillar in the creation of a more equitable society – but what sort of electrification is best in which circumstances? What are the advantages and disadvantages of decentralised electrification when compared to grid electricity? What particular impacts are associated with rural, locally managed systems? Guido Glania discusses the implications of these systems, especially for the empowerment of rural communities.

While the barriers to achieving sustainable energy access are multiple, there are also many different approaches proposed to solving them. But which approaches can apply in which situations? Who are the key actors and what are their potential roles? These questions are addressed in the section by Steven Hunt, who discusses ways to develop successful, vibrant and equitable energy access sectors in developing countries.

It is hoped that some of the many other issues in energy and development will be taken up in future editions of the PPEO. Future topics could include: a deeper analysis of the role of carbon finance in poverty alleviation, a comparison of urban and rural energy access challenges, integration of energy access into specific livelihood sectors (such as water provision and agriculture), the role of energy access in climate change adaptation, and others. We are indebted to our team of peer reviewers and authors for many of these suggestions, and welcome more from interested readers.

Being poor is not a static condition. For those living in poverty, improved energy access can provide the key to a better quality of life. The following specialist practitioner perspectives cut through some of the thornier issues to reveal paths to making energy access a reality.

Wood, the fuel that warms four times

Kirk R. Smith, University of California at Berkeley

"(Logs) warmed me twice," wrote Henry David Thoreau in 1854, "once while I was splitting them, and again when they were on the fire." Unfortunately, firewood has the potential to heat a third time, because the smoke from its burning is a major risk factor for respiratory infections and the fever that often accompanies them; and a fourth time due to the climate-active pollutants it contains. The WHO now believes that the burning of simple household biomass fuels – wood, crop residues, animal dung, shrubs and grasses – is responsible for some 1.4 million premature deaths annually, mainly among women and young children in developing countries (Smith et al., 2004).[6] This ranks household air pollution from household fuels second in importance – after unsafe water and poor sanitation – among global environmental risk factors, and tenth among risk factors of all kinds (Ezzati et al., 2002). The health burden from household air pollution is well above that from all outdoor air pollution in cities (Figure 2.1).

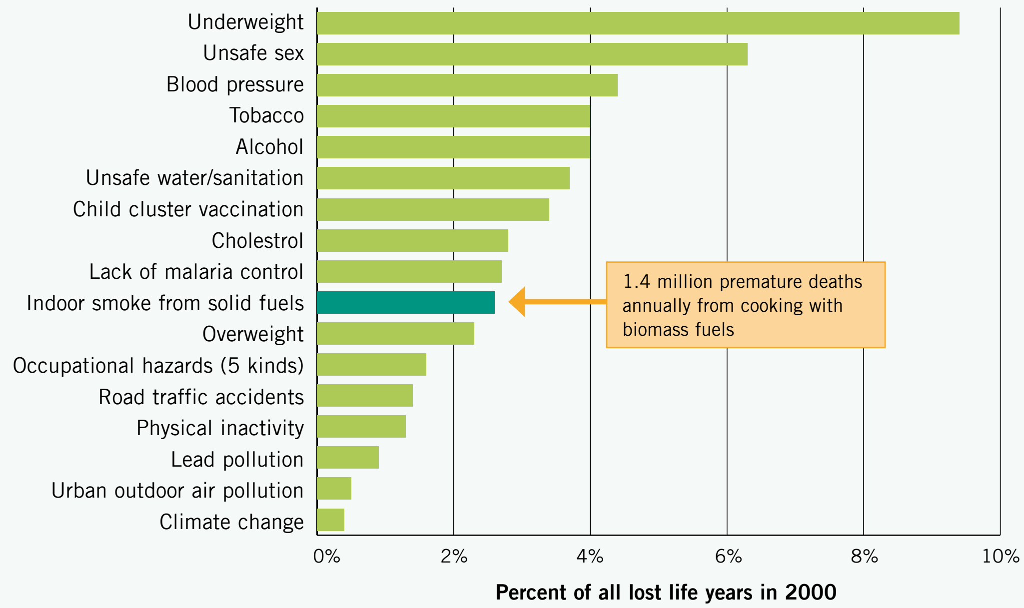
In addition, there are so many households burning such fuels in poor countries that they contribute significantly to outdoor air pollution – as much as one third of the total in many Asian countries (Figure 2.2).

Black carbon and other climate-active pollutants released by burning household biomass are responsible for a significant portion of human-induced global warming – in some global climate models, second only to ground transport over the coming decades (Unger et al., 2010). Figure 2.3 shows economic sectors ranked according to their net climate impact, i.e. the effect of longer-lived warming agents such as carbon dioxide minus that from shorter-lived cooling agents, such as sulphur oxides, which produce light-coloured particles. Some sectors actually create a net cooling effect over this period. Note that household combustion of biomass ranks second in this analysis up to 2020 (Unger et al., 2010).

Chemically, wood is almost entirely composed of carbon, hydrogen and oxygen, and – unlike coal (the other major solid fuel) – contains essentially no toxic materials (Smith, 1987). Thus, in good combustion conditions it can be burned completely to non-toxic carbon dioxide and water. Unfortunately, however, in simple household stoves, combustion is far from complete and wood

[6] The results of an updated and expanded Global Comparative Risk Assessment are expected in early 2011. See http://www.globalburden.org/index.html

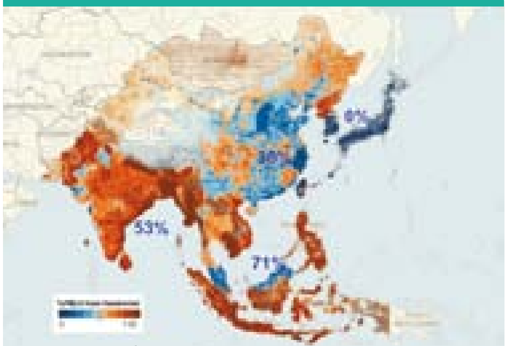
Figure 2.1: Global burden of disease from major risk factors listed in the World Health Organization Comparative Risk Assessment



Source: Smith et al., 2005, based on Ezzati et al., 2002

releases much of its carbon as respirable particles, volatile organic chemicals and carbon monoxide. Studies of typical Indian and Chinese biomass stoves, for example, show that 5–20% of the carbon is diverted to such products (Smith et al., 2000; Zhang et al., 2000). Because of the complex chemistry created by the greatly varying levels of temperature, oxygen and residence times in the flame zone of a simple wood fire, a vast range of compounds are routinely emitted. Thousands have been identified, many dozens of which are known to have toxic effects according to laboratory, animal or human studies (Naeher et al., 2007).

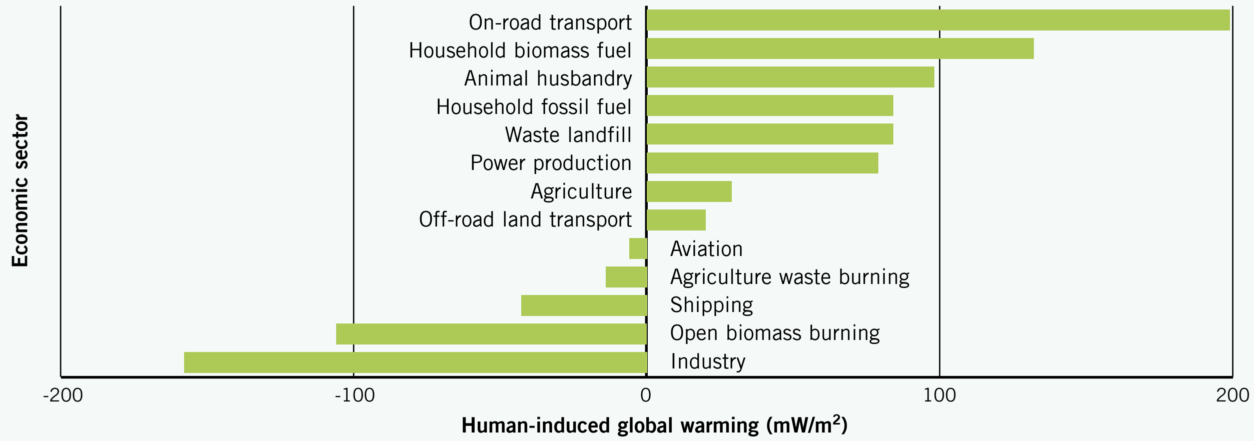
Figure 2.2: Percentage of particle outdoor air pollution from household combustion in Asia



Source: Smith, 2010

Besides containing noxious materials, woodsmoke is created in a process that is perniciously optimal for creating maximum human exposure. This 'perfect storm' combines an essential task (cooking), which is done two or three times every day in half of the world's households, with the release of a toxic mixture directly into the household – just at the times when people are present. This creates indoor pollution levels that are typically more than 20 times greater than WHO air quality guidelines (WHO, 2006). When one also considers that in nearly all cultures women are responsible for most of the cooking and the care of small children, it follows that these two vulnerable population groups are the most heavily affected. Given that the urban and rural poor are most dependent on solid fuels and simple stoves, it also exposes the populations with the lowest socio-economic (and political) status most heavily.

Figure 2.3: Estimated human-induced global warming in 2020 from emissions of climate-active pollutants by economic sector, measured as milliwatts per square metre of the earth's surface



Source: Adapted from Unger et al., PNAS 2010; 107:3382-3387, ©2010 by National Academy of Sciences

The need for epidemiological evidence

In an industrialised country, evidence of toxicology and exposure levels such as that noted above would be more than enough to warrant major and urgent protective action, even without detailed direct evidence of human health effects. Hundreds if not thousands of epidemiological studies in Asia, Europe, Latin America and North America detail the health impacts of the same pollutants in urban outdoor settings. These studies are remarkably consistent around the world (Cohen et al., 2004; ISOC, 2004; PAHO, 2005).

In the face of the high exposures to these pollutants in developing-country households, air pollution specialists may wonder why more research should be needed before action is taken. After all, we know that particle levels 10 or 100 times lower than those found in village households cause significant effects in healthy populations (WHO, 2006). Rather than waste time pinning down the effects precisely, it could be argued, interventions should be deployed now.

Paradoxically, however, in developing countries where the health and environmental conditions are worst, the need for strong evidence is greatest because of the extreme scarcity of resources for addressing health problems. In 2007, for example, India spent just $11 per capita on public health (WHO, 2010). Those who decide on the allocation of these resources must therefore be extremely pragmatic and highly critical of the evidence to ensure that available funds are spent well. To argue within the health community that funds should be reallocated to improved fuel or stoves and consequently, away from antibiotics, vaccines and clean water or sanitation, requires much more than just evidence from laboratory studies and extrapolation of human health studies in developed countries. It requires the highest-quality biomedical research carried out directly with the populations of concern: developing-country households that depend on biomass for fuel.

Current epidemiological evidence

Table 2.1 shows the major diseases associated with biomass smoke and a summary of the evidence for the association.

Table 2.1: Health effects of the use of solid household biomass fuels

Diseases	Type of evidence	Overall strength of evidence
Adults		
Chronic obstructive pulmonary disease	30 studies, mainly in women	Very strong
Lung cancer	10 studies with mixed results, mainly in women	Intermediate
Blindness (cataracts)	Nine consistent studies, all in women in South Asia	Strong
Cardiovascular disease	Strong but indirect evidence from other pollution sources	By analogy, but persuasive
Children		
Acute lower respiratory infection	30 studies; one randomised trial	Very strong
Low birthweight	Five consistent studies	Strong

Chronic obstructive pulmonary disease (COPD)

Several dozen studies have been published that show an association between COPD and household air pollution among women. COPD is a highly disabling disease with no known cure and inadequate palliative treatments available for low-income populations. It is also one of the most important causes of premature death in the world, killing perhaps 2.7 million people annually. Although much of the overall burden is due to smoking, it is now thought also to be an outcome of long-term exposure to biomass smoke in developing-country households, particularly for women cooks.

Acute lower respiratory infections (ALRI)

The largest single impact of biomass smoke exposure is thought to be ALRI in young children, who receive most of their exposure while being cared for by their mothers as they cook. As pneumonia, ALRI is the chief cause of death among the world's children, killing nearly 2 million per year. Because it affects the youngest members of the population, globally it causes more lost life-years than any other disease.

Most fatal ALRI infections are thought to be caused by organisms that are present all the time in the environments where poor children live, rather than as a result of epidemics. The main proximate causes, therefore, are those that affect the ability of children's immune systems to withstand infection and to limit the severity of infections when they occur. Malnutrition is thought to be the main problem, but air pollutants can also affect the respiratory immune system.

More than two dozen studies have been published in the international biomedical literature linking household biomass smoke exposure with child pneumonia (Dherani et al., 2008). Nearly all studies have been 'observational' in that they carefully observe existing populations with no attempt to conduct experiments under controlled conditions.

Although easier and less expensive, observational studies are not fully able to distinguish associations from causal relationships. For the most hard-nosed funders, randomised control trials – the gold standard of epidemiology – are required to make the strongest case, as is expected for vaccine and nutrition supplement trials. The first randomised air pollution trial was carried out in Guatemala and found that the introduction of a well-operating chimney woodstove reduced average air pollution exposure by about 50% and resulted in about 20% less physician-diagnosed pneumonia. For children whose exposure was reduced by 90%, the reduction in pneumonia was about 50% (Smith et al., 2006).

Cataracts

Tobacco smoke is a risk factor for both cataracts and macular degeneration, both of which are debilitating and progressive conditions that can lead to blindness. Cataracts in particular are a problem in developing regions. South Asia, for example, experiences one-third of all cataracts worldwide, but known risk factors (age, sunlight and smoking) do not fully account for their prevalence. Several studies in South Asia have found a strong relationship with biomass smoke exposure, and cataracts have been triggered in rabbits by woodsmoke in laboratory studies (e.g. Pokhrel et al., 2005).

Low birthweight

A small but consistent set of studies have shown an effect on birthweight in babies born to women exposed to biomass smoke during pregnancy (Pope et al., 2010). Low birthweight is a particularly prevalent and important problem in developing countries because it not only increases the chance of infant and child disease and mortality, but also seems to have a lifetime negative impact on cognitive development and health. Although several chemicals in woodsmoke are candidates for such an effect, carbon monoxide is likely to be a chief culprit because it interferes with the oxygen supply to the foetus.

Cancer

Although a number of chemicals in woodsmoke are known to cause cancer in humans, there is no definitive epidemiologic evidence yet of the risk of woodsmoke itself. It has recently been classified as a probable human carcinogen by the International Agency for Research on Cancer (IARC, 2010).

Cardiovascular disease

No studies of cardiovascular disease seem yet to have been undertaken in developing-country biomass-using households. However, heart disease is well established as an outcome at both higher dose levels in cigarette smokers and lower levels in outdoor air pollution. Thus, it can be expected that household biomass users also are affected (Smith and Peel, 2010).

What can be done?

Although the ultimate cause of ill health from woodsmoke is poverty, which prevents people from obtaining clean fuels and purchasing safe stoves, it does not necessarily follow that the best solution is poverty alleviation. The art and science of public health is finding ways of making people healthy before they are wealthy, through such 'magic bullets' as vaccines, targeted technologies such as clean water and sanitation, or women's education. Simple improvements in income, while eventually improving health, are usually extremely slow by comparison and much more expensive (and therefore inefficient) in achieving health goals. In addition, of course, economic goals will be more easily achieved with healthy and educated populations.

Four technological fixes are feasible:

1. Improved ventilation of households and direct venting of stoves (chimneys and hoods)
2. Improved stoves that produce lower levels of pollution through better combustion of biomass

3. Acceleration of the natural transition to clean fossil fuels, particularly liquefied petroleum gas (LPG)
4. Development of alternative gaseous and liquid fuels from biomass or coal that can be burned cleanly.

Significant efforts have been made in all four areas over the last three decades, but only the first and third technologies above have received significant sustained support from implementing agencies, and with only mixed success.

Many improved stove programmes have focused on chimneys as a means of reducing exposure, but these have proved difficult to implement and, even when operating well, chimneys usually do not reduce pollution exposure to healthy levels. At best, the smoke is moved only a metre or two away and still is around the household environment. In addition, of course, chimneys do nothing to reduce outdoor air pollution or climate impacts.

Subsidising LPG and kerosene for the poor has been a policy in many developing countries, although this has been largely for political and equity reasons, as well as a desire to reduce the impacts of fuel harvesting on natural ecosystems. Such direct subsidies, however, have generally been quite inefficient in achieving their stated goals, often operating in such a way that they do not adequately reach the poor, and at huge expense in some countries. India and Indonesia, for example, have spent more annually on such subsidies than they spend on all primary education (Smith et al., 2005). For these reasons the programmes have become quite unpopular among development agencies and international financial institutions.

Currently, the second approach – advanced combustion stoves that burn biomass fuels almost entirely – shows the most immediate promise. A range of new technologies has become available that do this, nearly all relying on small electric blowers to achieve reliable, high combustion efficiency. With expanding access to household electricity in many countries and the availability of inexpensive devices to generate sufficient electricity from the heat of the stove in others, no real barrier is posed by the need for this small amount of power. Some of these stoves have emissions per meal approaching those of LPG stoves in controlled settings, but more development and research are needed to develop models that meet consumer needs and maintain performance over time in real households.

Conclusion

Analysis shows that the number of biomass-dependent households is expected to remain approximately constant over the next few decades, although their proportion of the world's population will slowly fall as overall population grows, and simple economic growth moves more people up the energy ladder. Thus the scale of exposure will remain large unless improvements are made in combustion. The growing understanding of the importance of household fuels in outdoor air pollution and climate change may attract additional resources for interventions beyond those focused on energy efficiency and indoor air pollution (Wilkinson et al., 2009). Returning to the title of this section, although chopping and burning wood will always heat us, burning it completely without smoke can prevent the significant health, outdoor air pollution, and climate impacts that accompany this ancient technology.

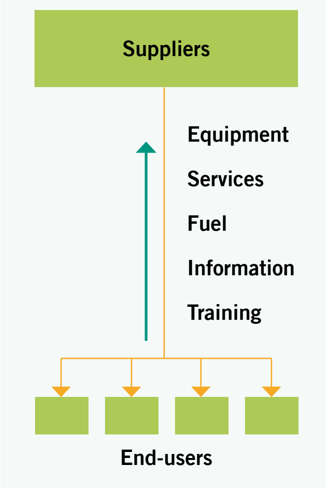
Financing for sustainable energy services

Grant Ballard-Tremeer, Eco Ltd

Energy services, along with energy for productive microenterprises, are essential for socio-economic development, for they promote social benefits and support income-generating ventures. A lack of both human and physical capital is the key characteristic of poverty, and, while affordable financing is not sufficient to address these capital needs, it is in most cases necessary. Poverty, and specifically energy poverty, is not only about lack of money; nonetheless access to financing can play a critical role in helping poor people to widen their economic opportunities, increase their energy options, and diminish their vulnerability to external shocks.

In some shape or form, finance addresses the relationship between suppliers and end-users in a market – whether commercial or not – by making money available for suppliers to provide equipment, services, fuel, information or training to end-users, and in some cases, for end-users to purchase what the supplier provides (Figure 2.4).

Figure 2.4: Addressing the relationship between suppliers and end-users



Finance is needed throughout the energy market to improve access to basic energy services. Governments need finance to provide, amongst other things, energy infrastructure, energy for public services, and to address the energy needs of those living in extreme poverty. Organisations need finance to pay for energy equipment, services and fuel. To move beyond subsistence, where stoves are self-made and fuel is collected, households need finance to pay for improved stoves, other equipment and fuel.

However, it is particularly difficult for people living in poverty to access the finance they need. Many lack collateral and credibility, easy access to financial services, and the skills to convey entrepreneurship, fill in applications and make a business case. The marginalised poor are not integrated into the formal networks of society, which reduces funders' confidence in their ability to track their investments. Financial models to address the needs of poor people must focus on their common assets, such as resourcefulness and adaptability, strong informal social bonds with neighbours, family and community, entrepreneurial and opportunistic spirit, labour, and their willingness to invest the few resources they have for a better quality of life.

Some key issues

The need for financing spans a wide range of stakeholders, from households to governments, and from individual stoves to huge power stations. Within this spectrum a number of key finance-related questions are particularly relevant to meeting the energy needs of people living in poverty.

Mechanisms, subsidies and markets

Two issues remain hotly debated when considering financing to alleviate household energy poverty: to what extent should market mechanisms be used to meet the needs of those living in poverty; and whether and how subsidies should be used (see, for example, HEDON, 2008). Some consensus has been built – although a few people disagree – around a preference for market-based approaches in all but the most extreme situations.[7]

Many projects and programmes that once promoted a do-it-yourself approach to improved energy technologies (in particular the self-built or artisanal stove) now aim for a market-based, commercial approach, believing this to be "the most promising for sustainable promotion of efficient cookstoves" (GTZ-HERA, 2009).

Figure 2.5: Adopting a market-based approach, Burkina Faso

Photo: GTZ

This approach is based in many cases on the recognition that mass production and marketing of improved technologies are needed for improved emission and other performance requirements and the discovery that the 'build your own improved stove' approach failed largely because the technology was too demanding to be successfully constructed by amateurs.

In order to be effective, funding should aim to support the creation of markets. The goal is not simply to supply stoves and lamps or install generation capacity, but to provide the conditions for the creation of a sustained and profitable industry which will result in increased use of improved devices and generation capacity and will drive down costs. Good examples can be seen in GTZ's work in Burkina Faso,[8] Stovetec's work in Northern KwaZulu-Natal, South Africa,[9] and First Energy's work in India in promoting the Oorja stove.[10]

The role of financing is dual: to stimulate energy markets so that they grow and to ensure that these markets are equitable for all participants, including the poor. For this reason, financing bodies need to take a systemic approach to market development. This involves understanding the socio-political, economic and environmental factors that support or hinder market growth as well as the support services needed to maintain a healthy market. Financing should aim to remove barriers, particularly those that affect marginalised people and to address gaps in support services, especially in poor or remote areas.

Systemic approaches

Systemic market approaches tend to be undertaken by bilateral (government-to-government) and multilateral (e.g. World Bank) funders or the public sector. Grants or investment may be allocated towards, for example, the creation of research institutions and laboratories, microfinance institutions for the poorest and for reducing risks to the banking sector. Bilateral and multilateral funders can address unfavourable policies or policy gaps. They can also fund consumer

7 See, for example, the article by Palit and Singh (2010) in *Boiling Point* 59 on Energy in Conflict and Emergency Relief, where market-based approaches to stoves and fuel supply are understandably not prioritised.
8 http://www.gtz.de/en/praxis/23198.htm
9 http://www.hedon.info/TheStovetecStoveADistributionAndMarketingStrategy
10 http://www.bioenergylists.org/node/2439

education, market intelligence and product quality assurance. These actions are all forms of subsidies, but are frequently characterised as indirect subsidies that address the market environment.

Microfinance

Microfinance offers banking services to low-income users by providing financial services such as credit, savings, insurance and fund transfer services. It enables opportunities for entrepreneurship, an end to potential exploitation by moneylenders and a system where finances can be produced, managed and maintained. Microcredit (providing small loans) is the most common form of microfinance. Microfinance aims to reduce barriers to finance, such as the administrative costs and the risk, by lending to cooperatives (e.g. groups of 10–15 women who support each other, may set up a business together, and who provide assistance to each other in paying back the loan). Examples of microfinance institutions working in the energy sector include Arc Finance in Ghana, MicroEnergy International in Tanzania, and Grameen Shakti in Bangladesh. Grameen Shakti was established in 1996 as a not-for-profit company to promote affordable, clean, modern and sustainable renewable energy technologies to the people of Bangladesh.

Other industries, such as mobile phone and lighting companies, are helping microfinance institutions to manage the risks of non-payment, for example by encouraging consumers to pay by locking lighting systems until fees are paid (as the Solar Energy Foundation does in Ethiopia) or by pioneering pay-as-you-go schemes using mobile banking. Lighting Africa is exploring complementary innovative microfinance options, such as through its collaboration with Unilever Tea Kenya Ltd. This initiative supports the company's Savings and Credit Cooperatives (SACCOs) to sell good quality lighting products to their workers (who live without electricity) with loan repayments deducted from salaries.

Subsidies

The debate on the role of direct (or 'hard') subsidies has received fresh interest in the light of the recent – although limited – availability of carbon finance. This money is frequently seen as a mechanism to subsidise, partially or completely, the price of the stove and/or fuel (HEDON, 2008). As Doug Barnes has recently reminded us (2010b), there are many old and recent publications on the role (and dangers) of subsidies in enabling energy access.

Direct subsidies are intended to finance, in part, the purchase of newly introduced market products or services, until their price is reduced through economies of scale and research and development. If subsidies are not responsive to the market and are removed before financial viability is acquired, the market can collapse. Subsidies can also exclude poor households, or increase their risks if they partly fund products that are too expensive to purchase or maintain without the subsidy. For this reason subsidies need to be accompanied by investment in cost reduction through the development of services and by alleviating market barriers. Many countries, including India, Indonesia, Ghana and Nigeria subsidise, or have subsidised, fossil fuels like LPG and kerosene in an attempt to help poor families with energy costs. In general these fuel subsidies prove to be very costly and have unintended consequences (e.g. the shift towards vehicles running on LPG). Subsidies that address the price of technologies for using energy (such as stoves) work better than fuel subsidies because they target poor people better: the 'up-front' cost of a technology may be the major barrier. Reducing the fuel cost through subsidy may persuade someone to purchase a technology that becomes unaffordable to run if the subsidy is removed.

In general, short-term end-user subsidies can ultimately undermine sustainable market development, because they do not remove barriers and can create market distortions and unrealistic expectations. In an attempt to target the very poor or vulnerable, donors frequently give away new, innovative equipment free or at a nominal cost. This can result in the stigmatisation of the technology as 'the poor person's technology'. End-users should ultimately face commercial terms for financing and technical services if a sustainable energy market is to be created. However, concessional financing has often proved valuable in helping to bring down the high costs and risks of starting up new, commercially-oriented programmes, to build necessary new capacity, and to minimise risks with new approaches (Taylor et al., 2008).

Local ownership and entrepreneurial skills

In poor or remote rural communities, external technical support services are unlikely to be available, and local ownership of the energy technology is important. Poor people are frequently marginalised or disenfranchised; local ownership can help to restore confidence and maximise buy-in.

At community level, buy-in is often the key to the long-term sustainability of energy services. However, community-level energy supplies have higher up-front costs than household technologies and communities are less likely to invest resources in unfamiliar technologies such as micro-hydro.

Most international funds prefer to support large projects rather than a greater number of smaller ones, as less funding goes towards administration and coordination, and more can be focused on overall project development. Large projects can also address large-scale infrastructure issues and theoretically benefit from economies of scale. Furthermore, tracking of performance, progress and outcomes is more manageable in one large project than in many small ones.

However many argue that small, household-scale projects have the greatest impact on livelihoods and that small projects tend to be more inclusive of project beneficiaries and more collaborative by nature. Where large projects may potentially provide for many, more often than not they still marginalise the poor, who are unable to pay tariffs or connection fees. This has been observed by the author in South Africa and India, and it is reported in Sri Lanka where, although 83% of households are electrified, more than 24% of those on the grid are unable to afford to use a basic minimum (Tennakoon, 2009).

Figure 2.6: Children taking their lanterns home from the solar charging station in India

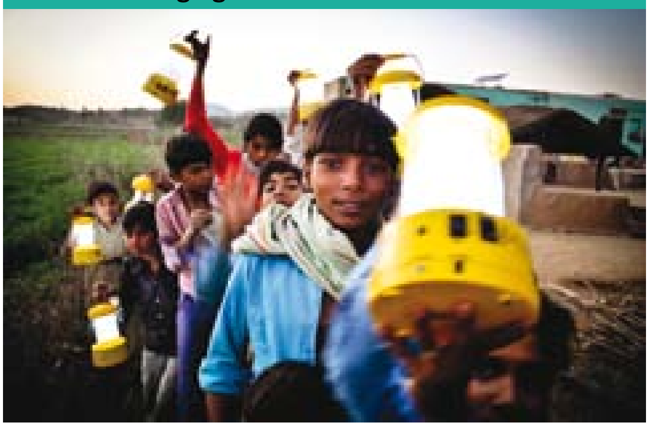


Photo: Jarnail Singh, TERI

Small projects are thus more likely to respond to the needs of poor people, meet them in their own location, and help them out of energy poverty. They are therefore to be encouraged, but they will only be successful with investment in buy-in, awareness raising, capacity building and ownership.

They also require a sustainable financing model that will meet the high up-front costs while raising awareness and skills within the community. This model also needs to allow the use of human resources ('sweat equity') to compensate for a lack of financial capital.

One example of a promising model is the 'fee-for-service' approach, used successfully in the IFC Lighting Africa programme and in India by TERI in their Lighting a Billion Lives programme (Avato and Madeira, 2010). In these solar lighting programmes, a local energy company is established that allows customers to purchase lanterns or other devices without the need to pay for charging equipment (such as a solar panel or other off-grid charging technology). The device can then be recharged for a fee at a central charging station (Figure 2.6).

The converse argument to the 'small is beautiful' approach is that by exploiting economies of scale, a continuous revenue stream and after-sales services and support can be provided. It is one of the realities of the world that there may be tradeoffs, where everything has an appropriate scale. In some cases the device itself is not purchased but leased. High initial investment is needed for the creation of the charging station, which carries a risk that insufficient customers use the charging station and that devices are charged elsewhere.

Individual entrepreneurs tend to set up small businesses that require small capital investments and produce products and services more likely to be targeted at the household level – for example, potters and vendors of PV and solar lanterns. However for some poor people, even these very small amounts of capital investment are prohibitive.

Supporting local enterprise

Community-level energy projects can attract private investors backed up by a donor or debt-financing body to reduce risk. Government legislation may also provide financial incentives for community-level renewable ventures in the form of grants.

However, the public sector in developing countries is generally not yet sufficiently embedded at the grassroots level to provide appropriate support to these initiatives, nor does it have the resources for local capacity building. The responsibility therefore, tends to fall to NGOs or social enterprises that advocate market mechanisms, to invest in capacity building. Traditionally, however, NGOs are not sufficiently experienced in business management and marketing skills.

A delivery and financial model that involves an initial investment in business-oriented capacity building and uses marketing training to raise awareness of the products and develop a client base is therefore necessary. A coordinated effort to set up several businesses or cooperatives can also attract carbon funding. One recent approach to enterprise development is the concept of micro-franchising (Box 2.1). Here a brand is created and community entrepreneurs are identified, trained in how to run the franchise business and given ownership of a 'business-in-a-box'.

In order for large funds to finance small projects, investment is needed to create a solid intervention structure down to the grassroots level that enables reporting and communication to filter reliably from the bottom up and vice versa, as has been done in the micro-franchising and microfinance models. Alternatively, investment can be made in market structures that by nature filter to the grassroots. Effort can be allocated to make these more reliable carriers of information, funds and goods, and more inclusive structures, expanding to remote or poor areas.

Box 2.1: SunnyMoney in Kenya and Malawi

Photo: Anna Wells, SolarAid

SunnyMoney is an example of enterprise development led by SolarAid (a social enterprise operating in Kenya and Malawi) that sells branded solar products including solar battery packs and micro-solar units for lighting and mobile phone charging. To be considered for operating a franchise, entrepreneurs must run an election campaign to be selected by the community as a SunnyMoney vendor. They are then interviewed, trained in marketing, sales, business planning, product repairs, etc., and are provided with initial sales stocks. Their election campaign should already have raised awareness of the product and created an initial client base. Profit can be invested in hiring more staff and growing the franchise.

Carbon financing

The Clean Development Mechanism (CDM), operational since 2006, was designed to promote sustainable development and reduce greenhouse gas emissions from developing countries using funds from developed countries. Unfortunately, the poorest countries have hardly benefitted from the CDM, and large-scale renewable energy and energy efficiency projects dominate its portfolio (Box 2.2).

As most developing countries have very limited industrial sectors, the CDM has a relatively small effect on poverty reduction.

Box 2.2: The CDM and poverty alleviation

The CDM concept allowed developing countries to propose projects that would support their development and allow the market to determine those that would deliver proven emission reductions. Even though the CDM intervention has great potential to contribute to sustainable development, emission reduction credits have rarely been used for household energy due to the relatively high transaction cost per unit of emission reduction. A relatively small number of voluntary market projects in the household energy sector have been successfully developed. Most notable of these is GERES Cambodia, which recently announced the sale of their millionth stove, made possible with voluntary carbon finance.[11] Verification of emissions reduction with large, single source volumes is relatively low-cost.

The effect of the economic and financial crisis for 2008–10

The problem with a global recession is, of course, that it affects everyone: donors, governments, businesses and the poor.[12] The poor, however, are disproportionately affected because their lack of capital (financial, human, natural, social and physical) offers them fewer livelihoods options. Because a higher proportion of their income is used for survival, they have less flexibility and more vulnerability to shocks.

In times of economic volatility, the choice of project is as important as its financing model. Projects need to promote independence through decentralisation to protect the community from external shocks. They must provide safety nets, all-round capacity building that is useful beyond the project, and should promote products that generate income (e.g. treadle pumps), use waste (e.g. bioethanol

11 http://www.geres-cambodia.org/geres_latest_news.php
12 A global recession, as defined by the IMF, is a period when global growth is 3% or less for half a year, as occurred in 2008–9.

from molasses) and have low running costs. Even in an unstable economic environment, although it may be counter-intuitive for donors to make long-term commitments, the outcomes may be more positive if they do, as the benefits are likely to accrue over a longer period.

Lessons and conclusions

Finance is needed throughout the market to address poor access to basic energy services. In order to be effective, funding should aim to support the creation of markets. Governments and donors have a critical role to play in removing the policy, regulatory and technical barriers that prevent small-scale finance from benefiting poor people. Financing mechanisms such as microfinance, micro-franchising, fee-for-service and carbon finance can bring benefits to the poor as long as subsidies are well-targeted to support market creation; local ownership and capacity building are encouraged; and small-scale, household projects, which have the greatest impacts on livelihoods, are targeted.

Access to modern energy services will grow at a higher rate in countries where governments and international organisations show strong leadership in setting proactive policies and regulations, and where they simultaneously facilitate innovative models for small-scale energy finance.

Gender, energy and poverty

Sheila Oparaocha, ENERGIA International Network on Gender and Sustainable Energy[13]

Approximately 2.6 billion people in the world will still lack access to basic energy services by 2015 unless action is taken (IEA, 2006). Despite this, there have been few attempts to analyse the energy–poverty nexus in depth. This can partly be explained by the fact that the biomass in rural areas is collected at zero monetary cost, mainly by women and children, and so falls outside national energy accounts. As a result the issue renders itself invisible.

> *"No data – no visibility; no visibility – no interest."* (Huyer and Westholm, 2001)

Energy plays a major role in meeting women's practical and reproductive needs (such as cooking, food processing and hauling water), and it is necessary to meet their productive and strategic needs (lighting to enable evening study, street lighting for safety in attending community meetings and power for women's enterprise development). It is remarkable that the use of gender analysis in energy planning is virtually unknown, although it has been successfully used for many years in the health, water and agricultural sectors. Energy planners have usually equated women's interest in energy with cooking, to the exclusion of other needs, particularly those related to productive activities and emancipatory goals. In addition, since the main focus of energy planning has been on large scale fossil fuels to the exclusion of biomass fuels, even women's practical needs have hardly

[13] ENERGIA is an international network working on gender and sustainable energy (www.energia.org). Started in 1996 as an initiative of committed individuals working on gender and energy research, the ENERGIA network today connects more than 4,000 members across the world and has an active presence in 22 countries in Africa and Asia. The ENERGIA network is hosted by the ETC foundation in the Netherlands.

been addressed. Most current energy policy focuses on electricity, and although it has many benefits, it does not help address the major energy problem that most women in rural areas face in terms of their daily cooking requirements.

In the 21st century, the vicious cycle of energy poverty needs to be broken. A first step towards this has been the widespread acknowledgement among the development community that a lack of access to clean and affordable energy can and should be considered a core dimension of poverty. The next step must be the sincere recognition in development planning and policies that energy access is an issue that can occupy a quarter of a rural woman's time, affect her health and is key to developing her gender-strategic interests.

Energy as an equity issue

Energy has an equity dimension: poor households use less energy than wealthier ones in absolute terms. The use of biomass has a number of repercussions for poor people:

- Fuel quality is low, and it emits smoke and particulates that are recognised as having negative effects on health – particularly on women.
- Several hours a day may be spent collecting fuel, usually by women and children, which means that this time cannot be used for other livelihood activities.
- Less water is boiled for drinking and other hygiene purposes, increasing the likelihood of water-borne diseases. Illness increases the vulnerability of poor people, preventing adults from working effectively and negatively affecting children's learning.
- Conflicting demands on poor women's time results in longer working hours than men in their families, greater fatigue and nutritional deprivation, and the withdrawal of children – especially daughters – from school to help with chores.

Figure 2.7: Energy access is a key developmental issue

Photo: ENERGIA

Energy poverty has distinct gender characteristics and clearly has a disproportionate effect on women and girls. This raises a number of important questions for energy planners when considering pro-poor–pro-women interventions regarding who makes the decisions about energy within the household, and who benefits.

Gender mainstreaming in the context of energy

At the United Nations Fourth World Conference on Women in Beijing in 1995, Objective G of the Platform for Action called for mainstreaming a gender perspective "in all policies and programmes so that before decisions are taken, an analysis is made of the effects on women and men, respectively" including an analysis of the differing effects on women and men before decisions are taken (ECOSOC, 1995). In 2001, the ninth session of the UN Commission on Sustainable Development (CSD-9) affirmed that gender mainstreaming constituted a critical strategy in the implementation of the Beijing platform for action (ECOSOC, 1995) which specifically committed governments to "support equal access for women to sustainable and affordable energy technologies through needs assessments, energy planning and policy formulation at the local and national level" (ECOSOC, 2001).

These commitments imply gender mainstreaming in energy interventions to ensure that women, as well as men, participate and benefit equally. Since women may be more disadvantaged than men in similar circumstances, this may require special provisions in the design of an energy intervention, in order to enable women to participate. Thus, rather than asking which particular technology is best for a productive application, the pertinent question is how to enlarge the range of choices available to women and enable them to choose the option that best meets their needs and fits their circumstances (Clancy and Dutta, 2005). Such a shift in decision-making requires women's social, economic and political empowerment. To this end, a number of key issues need to be addressed:

Informal nature of enterprises. Women-headed enterprises are frequently located in the home, and tend to be overlooked by agencies because they can be indistinguishable from other household activities. As a result, the majority of women entrepreneurs operate in a policy vacuum – in relation to energy as well as other areas – and have no automatic recourse to supportive legal and policy structures.

Heavy reliance on process heat. The majority of enterprises operated by women use process heat, generated from wood, which is usually purchased. Given the focus on electricity supply within energy planning, it should not be forgotten that for many of these applications, electricity is not the most cost-effective option.

High use of women's metabolic energy. The tasks in women's enterprises typically involve large quantities of metabolic energy. Tasks such as spice and grain pounding are extremely arduous and time-consuming. Much could be done to reduce the demands on women's metabolic energy by mechanising these tasks.

Energy's contribution to sustainability of rural enterprises. The role of energy in the sustainability of women's enterprises is not well understood. In food processing enterprises it has been estimated that energy costs are 20–25% of the total inputs (Clancy and Dutta, 2005). Small enterprises can be severely affected by rising energy costs, fuel shortages and deforestation.

Role of complementary inputs. Women are typically excluded from or marginalised in decision-making and they suffer barriers related to illiteracy and the lack of information and training. The informal nature of these industries makes it difficult for women to access credit, equipment and other support services. Women may be forced to close their enterprises for non-business reasons, linked to factors associated with working from home.

Gender, energy and the MDGs

Although energy is not mentioned as a separate MDG, modern energy services are an essential element of the enabling conditions that can allow a country to meet the MDGs (Modi et al., 2005). In recent years, empirical evidence documented by United Nations Development Program (UNDP) and ENERGIA, amongst others, has shown the connections between expanding energy access, easing the burdens of women living in poverty, improving overall health and education, and meeting environmental goals (Cecelski and CRGGE, 2005).

MDG 1: Extreme poverty and hunger

Women's time availability is a key constraint to agricultural production, income-earning and family nutritional status. Good energy access allows savings of 1–4 hours daily in cooking, fuel collection and food processing. Savings in household expenditures on energy can reach 20–50% with more efficient and lower-cost cookstoves and lighting fuels.

MDG 2: Universal primary education

Access to modern energy could free up time for girls to go to school or to spend time on homework. There is some evidence of an increase in girls' schooling when the time they spend on domestic chores, especially fetching water, is reduced (Khanam, 2008).

MDG 3: Gender equality and women's empowerment

Most studies show that women choose to devote any time saved through reduced drudgery to increasing their productive work and household chores, and sometimes to increased leisure activities. In households with electricity, women's access to information, and in some cases empowerment, has been increased through access to the media. Street lighting and lighting in community centres can open the way for adult education and community involvement by increasing street safety. The few studies on women energy professionals show that they face the same obstacles as those experienced by women in other scientific and technological professions. The PPEO recommends that professional women working in energy inhabit roles at senior levels, which allow their voices to influence major energy policy decisions.

Figure 2.8: Biogas stoves reduce smoke and improves maternal and child health

Photo: HIVOS/SNV

MDGs 4 and 5: Child mortality and maternal health

Child survival rates, birthweight and maternal health are clearly improved by the use of modern cooking fuels, with good evidence of reduced acute respiratory infections (ARI) and reduced drudgery affecting neonatal survival. The role of electricity in the provision of primary health services has been documented, but generally not specifically related to health outcomes. There is evidence that women collecting fuel are at risk of sexual violence (Women's Refugee Commission, 2006).

MDG 6: HIV/AIDS, malaria and other major diseases

Improved energy access can have an impact on disease management through, for instance, facilitating the adoption of recommended health behaviours such as cooking food for people living with HIV/AIDS. Improved energy access should reduce the burden of care and drudgery for carers (who are usually women).

MDG 7: Environmental sustainability

There is good evidence that improved stoves save thousands of tonnes of woodfuel. Where large quantities of wood are used (for example, in urban or locally deforested rural areas), the use of improved cookstoves could be significant in reducing deforestation. Most forestry projects that aim to provide sustainable woodfuel for city populations entail higher commercial fuel prices to cover the cost of replanting, which has serious short-term implications for urban women's budgets.

Policy recommendations for energy interventions

A major goal of the Collaborative Research Group on Gender and Energy (CRGGE)[14] has been to provide gender-sensitive policy and operational research frameworks in order to improve energy project design and policy-making (Cecelski and CRGGE, 2005). The group made the following policy recommendations:

- **Invest in energy infrastructure technologies and end uses that directly meet poor women's energy demands and make their labour more productive**. Technologies with high potential include improved cookstoves, fuels and other household energy interventions, food processing technologies such as grinding mills, drinking water pumps and transport, and electric lighting and media.
- **Promote sustainable livelihoods through modern energy services that permit poor women to increase their productivity and income, and hence the value of their labour**. Actions include women's involvement on the energy supply side, in producing and marketing new energy resources and services, and support to women's micro-enterprises in accessing and using modern energy services and complementary business inputs.
- **Increase poor women's choices of cooking fuel**. Substituting more efficient biomass or fossil fuels for existing polluting fuels would add little to global emissions. MDG 5 (reducing child mortality) cannot be met without improvements in the household energy system.
- **Prioritise complementary inputs for gender equality**. Modern energy services are most likely to produce benefits for women if they are implemented in the context of one or more of the following: a deliberate gender strategy in project planning, implementation and institutions; a supportive policy and/or institutional environment for women's needs; a community-based organisation with women's effective participation; gender relations that value women's labour; and/or industry objectives that coincide with women's interests.
- **Integrate energy areas into energy policy that have incomplete but highly suggestive evidence of their benefits**. Actions could include increasing education for girls through electrification and labour-saving energy services, use of modern energy services to lessen the burden of care for those with HIV/AIDS and reducing the risk of sexual violence during woodfuel collection.
- **Include and document gender analysis at each step of policy, programme and project planning, implementation, monitoring and evaluation**. The use of logical frameworks with gender-specific goals and targets can improve our understanding of how modern energy services can contribute to development.
- **Build capacity of women to work in the energy sector, and of both women and men to engage with gender issues in energy systems**. There is a need for capacity building at all levels, ranging from training for poor rural women who

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14 Collaborative Research Group on Gender and Energy (CRGGE) was made up of leading researchers, institutions and networks from France, India, Kenya, the Netherlands, the Philippines, Senegal, South Africa, Sri Lanka, Uganda, the UK and the USA who had shown a long-term commitment – through the ENERGIA network – to policy research on gender and energy.

need skills to operate energy technologies and businesses, to female and male energy practitioners, researchers and policy-makers who need tools to engage effectively with gender.

Rural electrification with modern off-grid solutions

Guido Glania, Alliance for Rural Electrification[15]

Grid electricity, generated in large power plants and distributed on high voltage transmission lines, transformed and distributed to households is the prevailing mode of electricity generation and supply in developed countries. For this reason, many people see electrification as more or less synonymous with the extension of the national grid. Many also believe that developing countries should imitate the economic path of industrialised countries for overcoming poverty, and so for them grid extension is the obvious and only strategy for providing electricity.

In reality, in many developing countries the national grid is weak, power outages are an everyday occurrence, grid extension is slow, and underfinanced utilities are unable to improve the situation in the near future. Against this background, most of the 1.5 billion people living without electricity in their homes cannot expect to be connected to the national grid in the foreseeable future.

At the same time, another model of energy generation is increasingly gaining ground and becoming convincing as a flexible, low-cost and environmentally friendly solution. Off-grid technologies, ranging from small appliances to mini-grids, are demonstrating that they are reliable and cost-effective solutions for people in rural areas. Renewable energy is the backbone of modern off-grid systems.

Although until recently governments in most developing countries were sceptical about renewable energy technologies (believing they were too costly

Table 2.2: Electricity access in 2008: Regional aggregates

	Population without electricity (millions)	Electrification rate (%)	Urban electrification rate (%)	Rural electrification rate (%)
North Africa	2	98.9	99.6	98.2
Sub-Saharan Africa	587	28.5	57.5	11.9
Africa	**589**	**40.0**	**66.8**	**22.7**
China and East Asia	195	90.2	96.2	85.5
South Asia	614	60.2	88.4	48.4
Developing Asia	**809**	**77.2**	**93.5**	**67.2**
Middle East	**21**	**89.1**	**98.5**	**70.6**
Developing countries	1,453	72.0	90.0	58.4
Transition economies and OECD	3	99.8	100.0	99.5
World	**1,456**	**78.2**	**93.4**	**63.2**

Source: IEA, 2009

15 www.ruralelec.org

and not mature enough), we are currently witnessing a paradigm shift. Now, governments and agencies in developing countries are realising that renewable energy is not only a strategy in the fight against climate change but can become an important pillar of the energy mix of their countries.[16] However, this interest in renewables has not yet resulted in boosted efforts for rural electrification. A key task in overcoming energy poverty is to spread the news about the potential of renewable energy and off-grid solutions for accelerating rural communities' access to electricity.

In most developing countries, access to electricity is not ranked among the key development goals. This is partly due to the fact that enhanced access to electricity is not an MDG. It is also based on the superficial assumption that electricity is only a question of convenience. However, a closer look at the ways in which electricity can be used in rural communities makes it very evident that access to electricity can significantly improve health and sanitation, facilitate learning and provide new opportunities for income generation (IEA, 2010). Electrification has so many positive development effects that it is difficult to imagine that the MDGs related to health, education and income can be achieved without accelerated electrification.

Needs and technical solutions

Electrification by extension of the grid is based on the traditional assumption that the state provides the infrastructure and that citizens are the passive beneficiaries who do not have to do anything but find out how much the tariff will cost them. In modern off-grid electrification, end-users have a central and active role to play in financing, organisation, management and use, as well as regarding technological aspects. The process needs to start with an assessment of their specific energy needs.

The needs of a community must be assessed based on interviews and discussions with future end-users rather than on theoretical assumptions or experience gained in similar environments. Typically, the following needs and uses can be accommodated by off-grid technologies in rural areas:

- lighting (e.g. for learning at home)
- radio/TV (e.g. for schools, allowing access to electronic learning material)
- telecommunications (e.g. cell phones providing local market information for farmers, banking or medical services)
- cooling (vaccines often have to been kept cold in order to be viable); electricity can chill cabinets and portable cool-boxes so they can be made more widely available
- water pumping and purification

Box 2.3: Micro-hydropower plants in Indonesia

Around 105 million people in Indonesia lack electricity. The People Centered Economic and Business Institute, an innovative establishment in Indonesia, is behind an initiative to electrify 60 villages. In these villages, community cooperatives own and operate 100 kW micro-hydro plants. The cooperatives plan and own the plant, as well as providing maintenance and managing billing. The set-up of the plant was 50% subsidised through grants. The running expenses are paid by tariffs from villagers and revenue from selling electricity to the grid. Each village receives a gross monthly income of about $3,300 in this way. Surpluses go to the village development fund for school fees, health care, seed capital for businesses and value-added agricultural processing (Aron et al, 2009).

16 Personal dialogue with senior officials of ministries and agencies in Sub-Saharan Africa

- small business appliances (e.g. sewing, cutting machinery, woodworks and food processing).

However cooking is less amenable to off-grid systems due to its high-power, short time-span energy demand profile. In many cases, improved biomass cookstoves and solar cookers are the technologies of choice for this purpose.

The needs assessment, together with an appraisal of parameters such as natural conditions (e.g. solar irradiation, wind speeds and hydropower potential), the ability and willingness to pay, the relevant policy framework and the population density, will lead to specific technological solutions. Typical examples are:

- solar lanterns for the provision of light
- solar home systems for lighting and the operation of radios and TV sets
- wind-powered home systems for isolated small businesses
- specific, energy-efficient fridges for the cooling of vaccines
- mini-grids powered by photovoltaics (PV), such as small wind power or small hydropower, catering for the needs of both households and small businesses.

Hybrid mini-grids that are primarily powered by PV, wind or hydropower but backed up by a diesel generator are, under most circumstances, a more cost-effective alternative to systems relying totally on renewable energy, since their battery banks can be much smaller.

So that a community can choose the right technology and scale, their needs must be evaluated in conjunction with an assessment of the options for improving energy efficiency. Recent progress in lighting technologies provides a good example of the way in which energy efficiency plays a key role in accelerated electrification. The same brightness that was formerly provided by a 60 W incandescent light bulb can now be provided by an energy efficient 12 W compact fluorescent lamp (CFL). Light-emitting diodes (LEDs) have a longer lifetime than CFLs and are even more energy efficient, and so are increasingly used for lighting in rural areas. In this context, energy efficiency is not an environmental consideration but a parameter that directly affects the investment required and the life cycle costs and affordability of the off-grid solution. Measures to enhance energy efficiency can bring down the investment costs by more than 66%.

Box 2.4: Solar lanterns: An example of rapidly changing lighting technologies

d.light design is a firm that provides Light-emitting diode (LED)-solar devices in India, East Africa, and around the world. Initiated in 2006, the product line was launched in 2008 with a target of two million sales by the end of 2010. The lamp is funded by private investors, without subsidies, with a market- and for-profit based approach. The product range provides lighting for education, household activities and working at night as well as mobile charging. There are three lamps: a premium model ($25 to $45), a task lamp model ($12 to $20) and an entry-level model ($10 to $15), all of which include a solar PV and can be AC charged. Optional attributes include mobile charging and battery load indicator. Compared with the running costs of kerosene, return on investment is around 6 months or less, assuming that no mains electricity is used.

Source: Aron et al, 2009

There is a close relationship between technologies, costs, financing models and the potential for improving a community's livelihood. Two considerations are important in this context: first, the value of renewable energy systems for lighting in place of kerosene lamps and candles (note that the money saved can be invested in off-grid technology) and second, the importance of electricity to the development of the local economy and the improvement of local livelihoods.

Electricity, opportunity and enterprise

Benefits accrue when the provision of electricity is complemented by targeted efforts to develop the local economy and boost productive end-uses. Typical small businesses in rural areas include:

- charging mobile phones and car batteries (which are used as sources of electricity at home)
- selling clean water (which requires water pumping and purification)
- small-scale craft production (electric cutting, food processing, sewing, etc.).

The provision of electricity-related services in off-grid areas can itself be a successful business model. The time is ripe for a roll out of energy kiosks that offer cell phone charging, telecommunications, internet and television to villagers who otherwise do not have access to electricity.

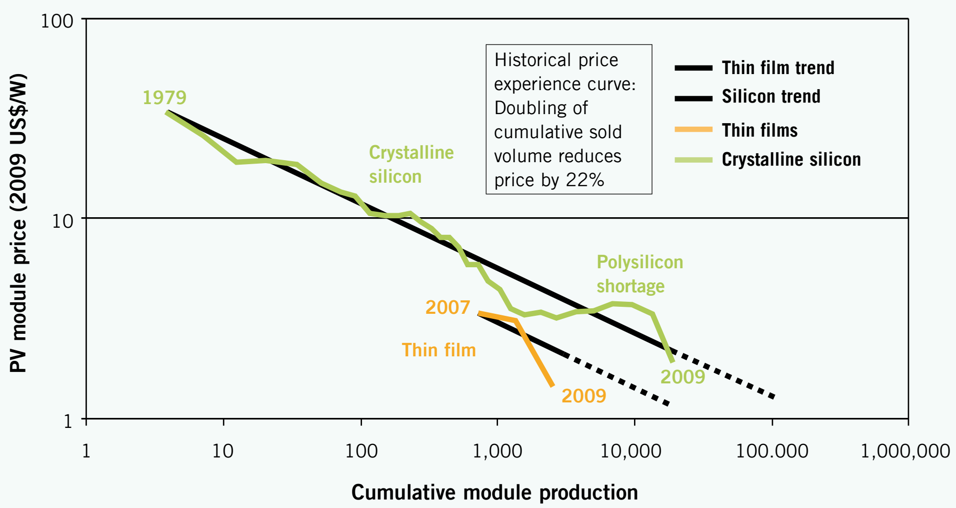
Providing off-grid systems to health stations and schools is also important, since such institutions benefit so obviously from electricity (for example for refrigerating medicines and vaccines and for lighting).

Technology focus versus market orientation

Recent technological and market developments mean that renewable technologies are now favourable, low-cost or cost-effective solutions for rural electrification. Prices for PV systems, for example, have fallen dramatically in the last few years (Figure 2.9).

Energy-efficient lighting technology, particularly CFL and LED, have also catalysed the development of powerful small lighting appliances. But it is not only the technology that has developed; so has our understanding of the financial and managerial requirements for sustainable electrification solutions to be viable.

Figure 2.9: PV module price experience curve since 1979 (2009 US$/W)



Source: EPIA, 2010

In recent decades many rural electrification programmes and projects have failed due to the neglect of these requirements. The underlying assumption of the traditional approach was that off-grid rural electrification should focus on the provision of the technology, and that its sustainable operation, management and financing would follow almost automatically. Recent years have seen a paradigm shift from this technology-focused approach to one that is market-oriented, following the realisation that a technology is only a solution when the right conditions for its sustainable use are in place.

The need for sustainable solutions for the operation and long-term financing of off-grid electrification cannot be overemphasised. For example, a savings mechanism that funds the replacement of batteries – important components in home energy systems and mini-grids – can be a critical factor for financial sustainability. Financial models that cater to initial investment costs but result in underfinancing of the operations and management phase are doomed to fail.

Success stories and lessons learned

Perhaps the most renowned success in the field of solar home systems is the Grameen Shakti programme (a sister project of the acclaimed Grameen Bank, which won its founder, Muhammad Yunus, the Noble Peace Price in 2006).

By 2007, Grameen Shakti had deployed more than 110,000 solar home systems to rural people in Bangladesh. The success of the initiative stems from its comprehensive approach to sustainability at every level. It is based on reliable, quality technology, trained technicians who care about proper installation and maintenance, microfinancing, and a focus on women (as technicians as well as consumers). Grameen Shakti forms part of a programme of the Bangladesh Government, which has established a legal and financial framework conducive to Grameen Shakti's success. This provides a good model for successful rural electrification programmes, which should feature a long-term strategy, commitment from the national government, genuine involvement of end-users, and trained private operators who can achieve a reasonable return on their investment.

Another success story is the Rural Energy Foundation. This is an organisation headquartered in the Netherlands, with nearly its entire staff located in the target countries of Sub-Saharan Africa. Here their work involves training small businesses in rural areas about PV systems. The Rural Energy Foundation helps local business people to understand the technology, advise customers and install solar home systems. Training is also provided in financing and management. The concept operates under the brand name Solar Now! (Box 2.5).

The elements of success outlined in the above examples are equally valid for successful mini-grid projects. The involvement of the end-user is essential for smooth tariff collection, and private sector involvement can help ensure sufficient technological know-how and reliable operational systems. Financial support from the state is needed to keep end-user costs at an affordable level that promotes the development of local businesses.

This approach overcomes the familiar downsides of using donor funding, which can lead to, for example, end-users receiving appliances and systems for free and then disregarding the value of the technology and the need for maintenance.

Box 2.5: Solar Now!

Solar Now! is a branding concept from the Rural Energy Foundation that allows prospective purchasers and end-users of PV systems to identify quality installers easily. The brand is publicised through local and national radio stations. From 2006 to 2009 the Rural Energy Foundation[17] facilitated the sale of more than 332 000 solar home systems, each requiring a very low financial contribution of less than €4 ($5.5) per system. The Rural Energy Foundation is active in East and West Africa and is expected to grow further. Its success signals that, with targeted support, the market is ready for take-off.

SOLAR. NOW!

17 www.ruralenergy.nl

Off-grid steps for overcoming energy poverty

The need for electricity in rural areas of the developing world is indisputable and growing; rural electrification can contribute greatly to progress towards the MDGs. A broad range of cost-effective and reliable off-grid technologies is available. We know that to be sustainable, rural electrification requires a market-oriented approach that involves end-users, private companies and government.

It is important now to empower end-users and private actors and to build capacity for governments and agencies, to enable them to set the right political and financial framework conditions. To this end, the international community must acknowledge the need for accelerated rural electrification and prioritise its attainment. Lack of access to electricity in rural areas of the developing world is not a destiny: it is a challenge that can be overcome in the foreseeable future.

Approaches to energy sector development

Steven Hunt, Senior Energy Specialist, Practical Action Consulting

There is clear international agreement on the need to improve energy access for poor people, reduce the carbon intensity of energy use, and ensure stable energy supplies for development and long-term prosperity. However, agreement often ends here – and is followed by a series of disagreements about the importance of these three issues, relative both to each other and to other pressing global challenges. Most crucially, disagreement remains over what should be done to improve access to energy, by whom and with what money.

This section offers a review of, and perspectives on, some of the approaches being taken to develop the energy sector globally. Its aim is to offer guidance and tools, particularly for developing the sustainable energy sectors envisioned for developing countries in the coming decades. Any approach should primarily serve poor people's energy needs, while also reducing climate impacts and supporting the achievement of the MDGs.

Roles and responsibilities

There are several approaches to the development of the energy sector, and a tension between them that arises from differing views on where to allocate the roles and responsibilities for the required tasks. Establishing and maintaining energy access by means of a given technology entails many such tasks. The approaches vary from vertically-integrated state-owned utilities that conduct all operations, to decentralised systems in which a range of public, private and civil society actors are responsible for different aspects of the provision of equipment and services.

Table 2.3 illustrates the multiplicity of actors, as well as their potential respective roles and responsibilities in energy service provision.

In recent years, western public policy has emphasised the role of the private sector above the responsibility of the state in ensuring energy service provision. This is linked to an ethos of economic liberalisation which has led, in turn, to the privatisation of many state energy utilities. This prescription has been passed on via international donor agencies to developing countries with mixed success (World Bank, 2009). This private sector approach to energy poverty alleviation has also been supported by the *Fortune at the Bottom of the Pyramid* philosophy (Prahalad,

Table 2.3: Roles and responsibilities of different actors for energy provision

ACTORS / ROLES	International agreements	National policy formulation	Regulation, tax and incentives	Resource assessments	Project/initiative design	Grant funding	Commercial financing	R&D/technology development	Technical assistance	Loan guarantees	Construction	Product/service distribution	Microfinance provision	Provision of feed stocks/fuel	Marketing	Operation	Services purchase/lease	Maintenance
International bodies	●					○	○			○								
National government	●	●	●	●	○	●	○	○		●								
Local government			○	○	○	○	○											
National utilities				○	○			○		○	○	●			○	●		○
Banks/financial institutions							●											
International donors				○	○	●	●		○	●								
Technical experts				●	○			○	●		○							
Large private sector					●			○	○		●	●		●	●	●		○
Small-scale entrepreneurs					●			○			●	●		●	●	●		●
Agriculture and forest sector					○									●				
Microfinance institutions					○		●						●					
Universities/R&D								●	○									
NGOs					●	○		○	○	○	○		○		●	○	○	○
Cooperatives					○						○		○		●	●	○	●
CBOs					○						○		○		●	○	○	○
Consumers/householders											○					○	●	○

● Often undertake ○ Potentially undertake

(Key: ● = teal cell, "Often undertake"; ○ = green cell, "Potentially undertake".)

2004). This approach, mainly applied to products rather than infrastructure, suggests that poverty can be addressed by profit-seeking entities with the right business models and products. In the energy sector, this has led to the emergence of a variety of privately-oriented energy access initiatives, including some by large multinationals, which claim to uphold objectives of social good via commercial means (Aron et al., 2009). The combination of the private sector profit motive to generate adequate revenues with the socio-environmental objectives of poverty alleviation and environmental protection (for example, through renewable energy) is also evident in the proliferation of so-called 'social-enterprises'.

In general, the level of activity of different types of actors in any given country is strongly linked to the politics and power dynamics of that country, as well as the capacity and financial strengths of the public, non-governmental and private sectors. It is also closely associated with the stage of development of the energy sector and technology sub-sectors within it.

Evolution of a sector

The stage of development of an energy sector must be recognised when considering approaches to the development of that sector in any country or region. This applies regardless of whether it is the on- or off-grid sector, or a technology sub-sector such as geothermal, wind or hydro.

Depending on the stage of evolution, different stimuli or approaches may be required to develop the sector. For example, while power sectors in many industrialised countries are in advanced stages of development, many renewables sub-sectors within these countries are still in earlier phases. In many developing countries, a wider range of sub-sectors may be in early phases, although not all. This does not only apply to electrification: the Anagi stove in Sri Lanka (Box 2.6) illustrates the same evolution for the cooking sub-sector (Nissanka, 2009).

Those energy sectors that have achieved high levels of development (broadly measured by wide public access and diverse, high-quality energy supply options) have generally done so with a strong component of public support and direct intervention in their early evolution. How exactly this public support should be applied remains under debate, both in the context of specific developing countries and in light of the experiences of developed country energy sectors, given that the same path towards fossil fuel dependency should not necessarily be taken.

Box 2.6: Anagi stove sector development in Sri Lanka

Table 2.4 shows phases in the development of the Anagi stove, an improved cookstove of which over 3 million units have been sold, with annual private production of 300,000 stoves per year. The evolution of this sector was not due to any one project or body but was the result of a series of linked initiatives forming rough 'phases' of evolution that involved different actors, activities, types of finance, stimuli and policy and regulatory actions. Various entry points and approaches have led to a final market-based outcome in this product sector – although it did not – and it is argued, could not – start that way.

Anagi stoves

Delivery models for energy access

Given the complexities entailed in overcoming the barriers to energy access, many 'delivery models' have been proposed that address one or more of the barriers relevant to one or more energy technology sub-sectors (Table 2.5).

Given the diversity of the levels at which these models operate in practice, it is challenging to compare and analyse the various approaches. While most approaches may be characterised as in one or more 'types' of model, a variety of actor types are usually involved in different roles, from the design phase and throughout its evolution. This makes it difficult to identify respective success (or failure) factors that may be replicated (or avoided) with respect to each dimension of a 'delivery model'. A framework for this analysis has been proposed through the Department for International Development (DFID)-funded Policy Innovation Systems for Clean Energy Security (PISCES) project and is presented in Box 2.7. This illustrates the main components of a delivery model for energy access, and

Table 2.4: 'Phases' in the evolution of the Anagi stove

Period	'Phase'	Lead organisations	Donor agencies
1972–1983	Initiation, design and testing	CISIR (Gov–R&D); IDB (Gov–R&D); Sarvodaya (CSO); ITDG (NGO); NERD (Gov–R&D)	Ministry of Industries; ODA; Ministry of Housing
1984–1990	Promotion and dissemination	CEB (Gov–utility)	Ministries of Power and Energy, Environment, Plantation, and Public Administration; DGIS; NORAD; SIDA
1987–1996	Commercialisation	CEB (Gov–utility); IDEA (NGO); ITDG (NGO); Private sector	MPE; ODA; ITDG; NORAD
1996–2002	Diversification and reaching the poor	IDEA (NGO); Private sector	ARECOP
2002–Date	At scale	Private sector	None

The 'phases' noted in this table are only visible in retrospect: the evolution of the improved cooking stove sector was the outcome of a series of different projects and initiatives. It remains tempting as a practitioner or policy-maker to try to ascribe one actor, project or donor with the 'key' role in the evolution of the improved cookstove sector in Sri Lanka. The Anagi example frustrates such simplification, as it is unlikely that the sub-sector would have reached this stage without most of the various contributions. Without government intervention in R&D, the product evolutionary process may not have happened; without NGO support, the initiative may have failed to reach poorer consumers when policy attention moved elsewhere; and while private sector delivery is at the core of the final solution, their leadership of the earlier stages would not have been commercially viable at that point.

Key to acronyms:

ARECOP (Asia Regional Cookstove Programme)
CEB (Ceylon Electricity Board)
CISIR (Ceylon Institute of Science and Industrial Research)
DGIS (Netherlands Directorate-General of Development Cooperation)
IDEA (Integrated Development Association)
IDB (Industrial Development Board)
ITDG (Intermediate Technology Development Group, now Practical Action)
MPE (Ministry of Power and Energy)
NERD (National Engineering Research and Development Centre)
NORAD (Norwegian Agency for Development Cooperation)
ODA (Overseas Development Administration of the UK, now the Department for International Development)
SIDA (Swedish International Development Cooperation Agency)

Table 2.5: Energy delivery models

Model	Main 'type'	Main proponent	Examples
Cooperative utility models	Community/cooperative	Coop (NRECA)	Bangladesh Rural Electrification
Energy service companies	Private	Private/donor (E+Co/USAID)	Nicaragua Rural Electrification
Energy consumer companies	Community/private	NGO (Practical Action)	Sri Lanka Hydro
Small enterprise management model	Community/private	NGO (Practical Action)	Peru Hydro
Rural electrification services companies	Private	Private (EDF Energy)	EDF South Africa
Decentralised virtual utilities	Private	Donor (World Bank)	Honduras Solar PV
Energy equipment retailers	Private/NGO	Donor (World Bank)	Grameen Bank Bangladesh
Electricity concessions	Private	Government/donors (World Bank)	Senegal Rural Electrification Program

Source: Sanchez, 2010

Key to acronyms:

NRECA (National Rural Electric Cooperative Association)
USAID (United States Agency for International Development)

starts by positioning the model in terms of the user, energy services, energy form and delivery system (relating to technology type), in a common basic model. It then guides the user through a range of compatible approaches that address the way in which the three necessary elements for energy access are made available: the energy resource, the conversion equipment and the appliance. The framework highlights various approaches to issues such as ownership, purchase model, maintenance responsibility and financing source, as well as their respective compatibilities and incompatibilities.

The final level of the model addresses the leadership of the initiative. Proponents of 'privately-led', 'community-led' or 'government-led' approaches are often exclusively focused on this single issue. However, experience from case studies in the bioenergy sector (e.g. Practical Action Consulting, 2009), has shown that a variety of types of actor is almost always required to initiate and pursue an energy sector development approach. Even where leadership may come nominally from one type of actor, others may be involved in different stages of implementation according to their skills and interests. Further, as discussed above, it is generally necessary for the major proponents of initiatives, and the focus of their respective activities, to change over time as the sector evolves. This is particularly true for policy stimulus packages, as requirements for research and development, subsidy, training, expanding equitable access, standards and incentives change over time.

Although the tool in its online format is able to show basic compatibilities and incompatibilities between strategies at the different levels, it is not able to define an 'ideal' approach – if such a thing exists given the diversity of contexts found. For those focused on approaches at one level, such as financing mechanisms or designing a business model, the categories will seem hopelessly broad. The issue of temporality (the required changes over time) is also not captured. However, the framework does provide a basis for comparison of an entire model, not just one aspect. A series of initiative delivery models are currently being fed in and it is hoped that an analysis of these enabled by the tool will offer further insights.

Entry points and end games

A dramatic boost is needed in the level and quality of energy access, as well as a transition towards a lower carbon energy future.

Achievement of this revolves around the right combination of policy measures needed to initiate the change and bring the required range of actors to bear on the issues. While NGOs and others may see binding commitments from governments to carbon reductions or aid allocations as a starting point, companies, by contrast, may seek incentives or long-term policy stability. At the same time, governments and international donors must prioritise the leverage of available funds, while attracting finance into energy sectors that will provide sustainable public services. Although a vibrant private sector efficiently meeting energy needs within a clear and progressive regulatory regime may be the preferred end game for some, it should be recognised that some sub-sectors and some countries are not in a phase of development to pursue this goal directly in all sectors – or perhaps at all. In these cases intermediary goals with stronger public policy direction and support may be required to build sustainable and inclusive energy sectors, and so widen access to the energy services that form a key foundation for development.

Box 2.7: The energy delivery model tool

THE BASIC MODEL	**User**					
	Who is the end user of the energy service?					
	Public building/ service	Household	Enterprise			
	Use/energy service					
	What is the nature of the energy service required by the user?					
	Heating/cooking	Lighting	Communications	Refrigeration	Process/ production	Mobility
	End user energy vector					
	What is the form of the energy as a direct input to the appliance providing the energy service? (For example if the system is a diesel generator, select ‘electricity’ not ‘liquid’ here)					
	Solid	Liquid	Gas	Electricity	Direct conversion	Mechanical power
	Delivery system					
	What is the mechanism through which the energy vector is delivered to the user?					
	Stand alone	Decentralised system	Centralised system	Commodity markets	Self-collection	
THE ENERGY EQUIPMENT	**Equipment purchase model**					
	How does the user pay for capital equipment other than appliances relating to the provision of the energy vector? (For example generators, refineries, or mining equipment)					
	Cash or trade	Credit	Leasing	For service	None/free	
	Equipment ownership model					
	Who is the legal owner of capital equipment other than appliances associated with provision of the energy vector?					
	Government	Energy company	Community	User	None	
	Equipment maintenance model					
	Who has primary responsibility for operation and maintenance of the delivery system other than the appliances?					
	Government	Energy company	Community	User		
	Equipment financing model					
	The way in which provision of the energy service is financed not including design and piloting					
	Capital support	Ongoing supply support	Ongoing demand support	None/private		
RESOURCE	**Resource rights model**					
	Which party has the legal right to manage and exploit the original energy resource converted to the energy vector? (This may be on a concession, ownership or natural rights basis)					
	Government/State	Private owner	Community	User	Free/none	
APPLIANCE	**Appliance model**					
	How are the appliances (for example as lightbulbs, stoves, pumps etc) which use the energy vector obtained by the user?					
	User responsibility	Assisted user purchase	Supported supply	Integrated delivery		
INITIATIVE	**Initiative management model**					
	How is the overall energy initiative (whether it is a project or company) led and managed?					
	Shareholder owned company	Individually owned company	Civil society/ NGO	Government	Donor/ international ageny	Partnership/ consortium

Source: PISCES, 2009

Chapter 3:
Framework for action

The relationship between energy consumption and human development is strong, but not straightforward. For instance, does higher energy consumption lead to higher incomes, or vice versa? To what extent does education, rather than income or the environment, determine the quantity and kind of energy consumed? How do energy sources and energy use change as income rises or social networks expand?

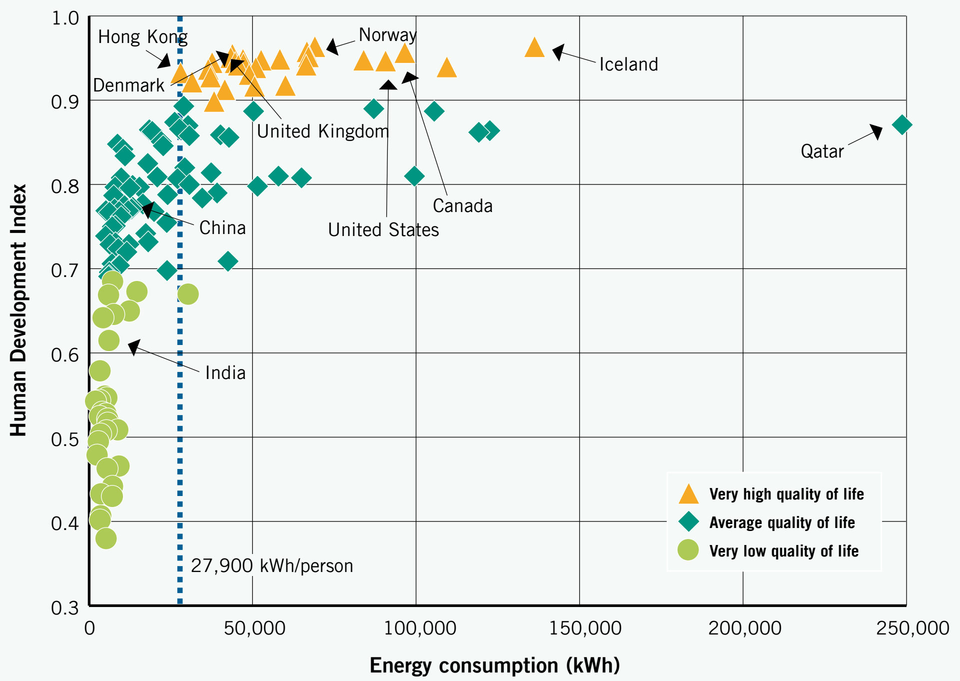
It is clear that the type and amount of energy used by households varies from country to country, and depends on income levels, natural resources, education, culture, climate and the available energy infrastructure. All households, in all regions of the world, have multiple uses of energy (six categories of use were identified in Chapter 1). The great majority rely on more than one source for the energy they use. Low-income households consume less energy than the better-off, but often the cost to them per unit of energy is higher, and they spend a higher proportion of their income on energy, as discussed in the 'Lighting' section in Chapter 1. Generally speaking, higher-income households use more energy from more sources.

At an aggregate level, there is a clear correlation between energy access, per capita Gross National Income (GNI) and human development indicators. Those countries with the lowest levels of access to electricity and highest dependence on biomass fuels also have the lowest GNI and Human Development Index (HDI). However, the relationship between energy consumption and HDI weakens once a certain level of total energy consumption is reached, between 1 and 3 toe (tonne of oil equivalent; equivalent to between 11,000 kWh and 35,000 kWh) per capita per year (Figure 3.1). Energy consumption greater than 3 toe (35,000 kWh) per year does not greatly contribute to increased HDI. In terms of electricity, per capita consumption beyond 4000 kWh per capita per year makes little difference to HDI (Goldemberg, 2001; Gaye, 2007; Sanchez, 2010).

Although the relationship between energy consumption and human development is complex and multifaceted, it is also clear that lack of access to adequate energy limits economic and human development. The 1.5 billion men, women and children without access to electricity have no light in the evening, limited access to radio and modern communications, inadequate education and health facilities, and insufficient power for their work and businesses. The 3 billion people dependent on dirty, harmful solid fuels to meet their most basic energy requirement – cooking – suffer ill-effects from indoor air pollution and often spend huge amounts of time collecting fuel (Legros et al., 2009).

Because of the strong links between energy services and human development, there is reason to regard access to basic energy services as a right (Cloke, 2010; Tully, 2006; Bradbrook and Gardam, 2006). The Universal Declaration of Human Rights and the International Convention on Economic, Social and Cultural Rights recognise the right of everyone to an adequate standard of living, which cannot be achieved without adequate access to energy services. In defining and analysing

Figure 3.1: Relationship between HDI and per capita energy use



Source: http://www.thewatt.com/node/170

energy poverty, therefore, it should be borne in mind that the basic human dignities so central to human rights lie in the ability to turn on a light and read a book, as much as in the ability to earn a living (Cloke, 2010).

Measures of energy poverty

Energy poverty can be defined as having inadequate access to energy services for basic household needs, for public services and for income generation, as described in detail in Chapter 1.

Household energy poverty can be measured in terms of physical energy requirements: the amount of energy required to meet basic needs or the amount of energy used by those living at the poverty line. Energy poverty can also be expressed in terms of household expenditure on energy, either as absolute monetary amounts or as a proportion of total expenditure (or income).

Variations on each of these energy poverty measures have been applied in a number of countries through surveys and research studies, allowing some insight into the extent of energy poverty in the countries covered. Heltberg (2003) found energy poverty to range between 4% of households in Brazil, 12% in South Africa, 58% in Ghana and 84% in Nepal. Practical Action's study in Nepal found the incidence of energy poverty in the country to be 71% in the year 2001 and 69% in 2006 (Practical Action, 2009). Similar studies in Sri Lanka and Zambia estimated energy poverty at 83% and 86%, respectively (Tennakoon, 2009; Zwizwai, 2009). In Bangladesh 60% of households were estimated to be energy poor by Barnes and colleagues (2010).

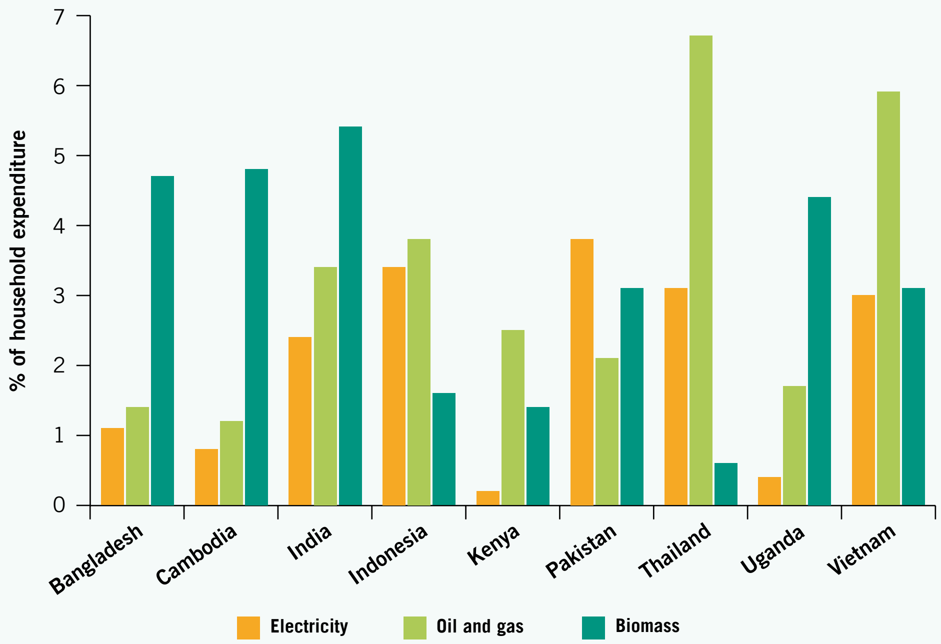
Differences in the estimated incidence of energy poverty in developing countries can be explained partly by contextual factors (such as geography, income levels, culture and the policy environment). However, the estimates from the various studies are not directly comparable because of differences in the assumptions made about the definition of basic needs, fuels used and the efficiencies of energy-using technologies.

Modi and co-authors (2005) defined minimum energy needs as the equivalent of 50 kgoe (kg of oil equivalent, or 580 kWh) per person per year (made up of 40 kgoe for cooking fuel and 10 kgoe for electricity). The IEA proposed the equivalent of 1,200 kWh per person per year as adequate for basic needs (cited in AGECC, 2010). Sanchez (2010) proposes a level of 120 kWh of electricity and the equivalent of 35 kg of LPG per capita per year, but adds a qualitative element related to cookstove efficiency.

Energy poverty measures based on income or monetary values demonstrate similar complications. Some have focused on actual expenditure on energy: for example, an analysis of the 'base of the pyramid' market found that expenditure by the lowest income group is the equivalent of $0.40 per day, or $148 per year per household. In the next income group, expenditure rises to $264 per year (Hammond et al., 2007).

Most income-based assessments of energy poverty measure household expenditure on energy as a proportion of total income or expenditure. Studies show variations between countries, between urban and rural areas, and between income groups (Figure 3.2). The poorest households, according to one cross-country study, devote an average of 9% of their total expenditure to energy (Hammond et al., 2007). Generally the share of total expenditure given to energy

Figure 3.2: Share of total household expenditure on different energy sources



Source: International Bank for Reconstruction and Development / The World Bank (2010) 'Expenditure of low-income households on energy: Evidence from Africa and Asia'. Extractive Industries for Development Series, No. 16. http://siteresources.worldbank.org/EXTOGMC/Resources/336929-1266963339030/eifd16_expenditure.pdf can be expected to decrease as incomes rise, and the share is higher in urban areas than in rural areas, but this is not universal and depends on the local context (Heltberg, 2003; Bacon et al., 2010).

Estimates of household expenditure on energy are generally built up from information about expenditure on different fuels and energy services (for example, electricity, firewood and batteries). In Burkina Faso, the poor were found to devote 5.6% of their income to firewood and 1.3% to kerosene (Heltberg, 2003). Where firewood is purchased rather than collected – for example in urban areas where there are no options for collection – poor people can spend as much as 10–15% of total household expenditure on this energy source (Bacon et al., 2010).

Expenditure on energy by poor households is not limited to fuel and electricity. The equipment that people need to carry out their domestic and productive tasks also entails a cost, and often these capital costs influence the choice of energy used. High equipment costs, such as for an LPG stove or electricity connection charges, can prevent people in low-income households from accessing modern energy services. The availability of credit for these initial costs can make a big difference to people's access to energy.

Opportunity costs

People living in poverty pay a high price in health, labour, time and cash for the energy they use. Cash expenditure on energy services competes with other uses of scarce income, including food, clothing, shelter and health services. Poor households often pay more per unit of energy than wealthy ones: for example, households that use kerosene lamps for lighting have been estimated to pay 70 times more than the equivalent costs for mains electricity, while those using batteries pay 10 to 30 times more (DFID, 2002). Because a basic level of energy consumption is essential for survival, low-income households usually spend a higher proportion of their cash income – and more time – than middle- and higher-income households to ensure their access to basic energy services (Gaye, 2007).

The time spent on the collection or production of energy services indirectly reduces the income of the poor, because it could have been devoted to socially or economically productive activities. This is a cost borne particularly by women, and by girl children for whom the opportunity cost can be their education. In Tanzania, for example, women spend an estimated 700 hours per person per year collecting firewood, while in rural India, the equivalent figure is 444 hours (Modi et al., 2005; Gaye, 2007).

Collecting firewood has a health cost for the poor. Carrying 20–40 kg of firewood over several kilometres takes a physical toll. In addition, women in many places, especially areas subject to civil conflict, are at risk of assault when out collecting firewood. However, the biggest health impact derives from indoor air pollution caused by smoke from cooking fires, resulting in 1.4 million premature deaths a year (Smith et al., 2004).

Another form of opportunity cost due to lack of access to adequate energy services comes from the costs of limited health and education services, which manifest themselves in the form of poorer health status and lack of education, and which in turn affect employment and livelihood opportunities. It also includes the costs of lost production due to lack of access to reliable energy services. In Sub-Saharan Africa for instance, 16% of the turnover of informal sector enterprises without a backup generator is estimated to be lost because of power outages (Eberhard et al., 2008).

Energy poverty indicators

It is clear from the preceding analysis that any meaningful definition or measure of energy poverty must reflect the dynamic complexity of the lives of people living in poverty, as well as the diversity of energy sources and uses that exist in different cultures and environments. At the very least, energy poverty measures need to recognise the multiple elements of people's energy portfolios. In terms of uses this means energy for lighting, cooking, heating, cooling, information and communications, and for earning a living. In terms of energy provision this means electricity, fuels and mechanical power. General indicators of these are possible, but the variation and transferability of energy forms and services suggests that detailed local knowledge and nationally specific definitions may also be needed to inform national policies, targets and programmes to address energy poverty.

It is also important for the international community to be able to assess progress towards the global elimination of energy poverty. However, without an internationally accepted standard definition of energy poverty – and a concomitant composite indicator to measure it – it is difficult to draw comparisons between countries or assess progress towards the reduction of global energy poverty.

The IEA's Energy Development Index (EDI) goes some way towards a composite indicator through its three components: per capita commercial energy consumption; the share of commercial energy in total final energy use; and the share of the population with access to electricity (IEA, 2004). However, as with the energy statistics provided in the World Bank's World Development Report, this provides a picture of the overall development of the energy sector in a country rather than one of energy poverty. Indicators that focus on national and commercial energy consumption do not reveal the energy picture experienced by people living in poverty.

Appropriate indicators would enable national governments and the international community to assess progress towards the reduction of energy poverty. A major challenge for any composite energy poverty measure will be the availability of data. As a minimum, measures of the number (or proportion) of households with access to electricity, access to modern fuels for cooking and access to mechanical power should be used. Even these measures present challenges, but we hope that the energy service standards and access index proposed in Chapter 1 of this report provide the beginning of a way forward in this regard. It is clear, however, that a new commitment to data collection on energy access would be required in order to implement these.

Investment in energy access

The United Nations Millennium Project estimated that it would cost approximately $15 to $20 per person per year to meet the basic energy needs of energy poor people. This amounts to a total investment of $37.5 to $50 billion to provide a minimum level of access for all (Modi et al., 2005). More recently, the UN Secretary General's Advisory Group on Energy and Climate Change (AGECC) estimated that between $35 and $40 billion per year would be required to the year 2030, to provide access to basic energy services for all (AGECC, 2010).

To place this in context, the IEA estimated $1.1 trillion a year as the investment required to meet global energy needs in the period to 2030. $35 billion per year, or 3% of global energy investment, would be needed from 2008 to 2030 to achieve universal access to electricity (IEA, 2009). According to AGECC, approximately 5% of global energy investments would be needed to meet the basic energy needs of almost half of the world's people (AGECC, 2010).

Overall spending on energy infrastructure (including both capital and recurrent costs), as a proportion of GDP in low- and middle-income countries declined by half between the mid-1980s and 2000. This situation is now being redressed (OECD, 2006). In the electricity sub-sector, current levels of investment are about $80 billion per year, amounting to about half of the $160 billion per year needed (Lallement, 2006).

However, investment plans continue to focus on infrastructure for economic growth with an added objective of cleaner energy. This results in a predominance of investment in large-scale energy infrastructure (i.e. large scale coal, large hydropower, the transmission grid and pipelines) which does not necessarily result in improved access to energy for the poor and rarely includes specific poverty reduction targets.

Financing for investment in the energy sector comes from three sources: funds generated internally within the sector, private financing and public funding. In developing countries, less than half of investment comes from the sector itself; two-thirds of the remainder is provided by public funding and the balance is from private sources.

There is a large funding gap in providing energy access for the poor, which has not been seriously addressed by existing financial mechanisms and institutions. Political will and government commitment are urgently needed in order to prioritise investment in energy as critical for the development of the poorest sectors. The private sector will certainly be a key player in financing energy for development.

AGECC (2010) estimated that to provide universal access to energy services, grant funding of around $10–15 billion a year and loan capital of $20–25 billion a year would be needed. The remainder could be self-financed by developing countries. Much of the grant element of this funding would need to be official development assistance (ODA). Although ODA for infrastructure, including the energy sector, declined by half over the two decades from the mid-1980s, this is now being redressed. In 2007/08 total ODA for the energy sector amounted to $5.2 billion and commitments to the energy sector amounted to 7% of all aid (OECD, 2010). How much of this was targeted at energy access is unclear, but possibly only about 9% if the World Bank's figures for the period 2003–2006 are representative (World Bank, 2007).

There is a need to redress the balance, with much more attention and investment directed towards the supply of local energy services for poverty reduction in local communities. Even allowing for investment in energy access through aid provided in other sectors, increases in ODA directed specifically towards energy access will be necessary to eradicate energy poverty.

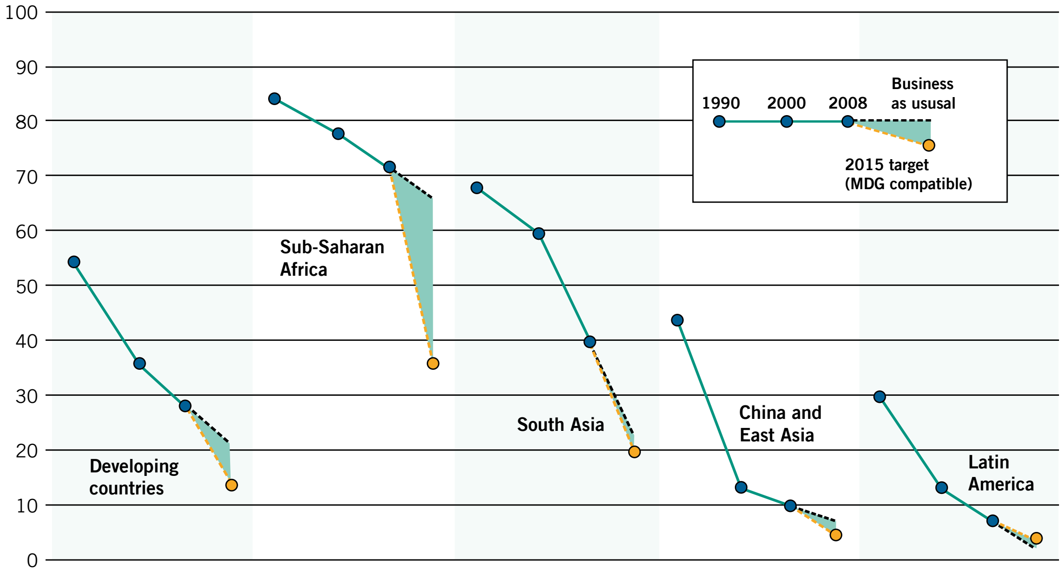
From MDGs to universal access

Access to energy services has undoubtedly improved in recent years for large numbers of people in developing countries. The number of people without electricity has fallen from around 2 billion in 1990 to 1.5 billion today, and in China 700 million gained access to electricity over the same period (IEA, 2004). Many have been able to transform their lives as a result of access to electricity or cleaner cooking fuels. But on current trends, by 2030, the number of people worldwide without access to modern energy services will be at least the same as today. The number relying on solid biomass fuels could be higher (IEA, 2002).

International and national efforts to reduce poverty in the developing world are currently focused on the eight MDGs. The inter-relationship between energy poverty and other forms of poverty or deprivation has led to widespread recognition that access to energy is a prerequisite for achievement of the MDGs (GNESD, 2007; Modi et al., 2005; AGECC, 2010). Although there are no specific energy targets associated with the MDGs, the extent to which the world, or a country, is on track to achieve the MDGs is partly determined by progress on energy access.

The absence of energy poverty from the MDGs and its low profile in development policy and plans can be explained in part by the way in which energy poverty interconnects with other forms of poverty – and because energy is needed for the activities it enables and not for itself. The multiple uses and sources of energy make addressing energy poverty a complex, cross-sectoral process, and the variety of types of energy poverty, determined by national contexts, gives rise to a variety of definitions of energy poverty, as discussed above.

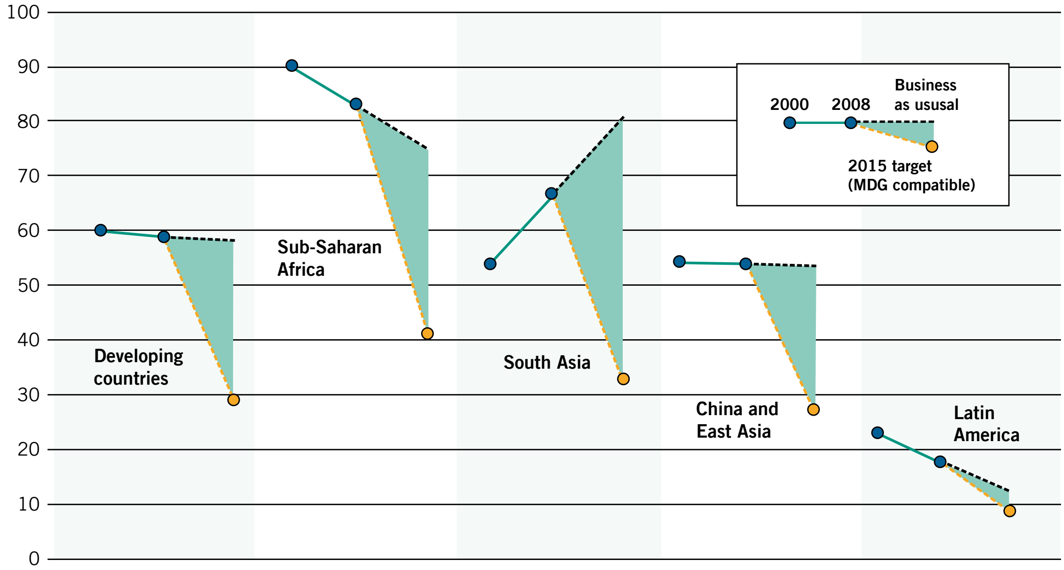
Figure 3.3a: Percentage of people without access to electricity; progress towards the MDG-compatible target



Source: IEA, 2002; IEA, 2008; Legros et al., 2009

Note: The 2015 MDG-compatible target requires a 50% reduction in the number of people without access to electricity from 2008 for a given region.

Figure 3.3b: Percentage of people without access to modern fuels for cooking; progress towards the MDG-compatible target



Source: IEA, 2002; Legros et al., 2009

Note: The 2015 MDG-compatible target requires a 50% reduction in the number of people without access to modern fuels for cooking from 2007 for a given region (Legros et al., 2009). No data are available for 1990.

MDG targets for energy access have been proposed in the past, but not adopted. These included separate targets for access to electricity and to modern cooking fuels, and some included targets for mechanical power and/or public services. Given the importance of access to energy services for achievement of the MDGs, it is appropriate to ask whether energy MDG targets would be met by 2015 if they had been agreed.

Two MDG-compatible targets can be tracked with the data that are available. These are "to reduce the proportion of people without access to electricity by half", and "to reduce the proportion of people dependent on traditional biomass fuels by half."

Progress on increasing access to electricity has been significant in many developing countries, particularly in the regions of South Asia, China and East Asia and Latin America. These regions appear close to meeting – or in the case of Latin America, exceeding – the 2015 MDG-compatible target. Sub-Saharan Africa has the lowest rates of electrification and is the region most off-track in progressing towards the 2015 MDG-compatible target.

Progress towards providing access to modern fuels for cooking has been slow; the 2015 MDG-compatible target will not be met in any developing region. Some progress has been made in Latin America and Sub-Saharan, but the proportion of people in the latter without access to modern fuels remains higher than in the rest of the world. In South Asia, the trend appears to be moving away from the MDG-compatible target.

The year 2015 is now on the horizon, and the attention of the international community is focused on actions that can be taken in the immediate term to achieve the existing MDG targets. However, the direction of the international development effort after 2015 is also beginning to be debated. Energy poverty, having been neglected in the MDG agenda, must be an element of future targets if the goal of poverty reduction is to be realised.

The target of universal access to basic energy services by 2030, recommended to the UN system by the AGECC, should be supported by national governments and international organisations. Adoption of such a target would demonstrate their commitment to the eradication of poverty, recognising the critical role of access to basic energy services.

Universal access to basic energy services – electricity, fuels for cooking and mechanical power – will have to be met from the full range of energy sources available. It will require the diffusion of more efficient, cleaner energy technologies, which are already available. The per capita energy consumption of low-income households and the average in developing countries in 2030 will still be low compared to high-income households and industrialised countries. Globally, universal access to energy would require around a 1% increase in energy consumption. Although it is unlikely that the additional energy required for universal access would be provided entirely by fossil fuels, even this would contribute less than 2% to global emissions (Gaye, 2007; Sanchez, 2010). Per capita emissions would still remain low.

A framework for action

The long-term goal must be universal access to basic energy services from sustainable energy sources. Access to adequate energy services for all is a prerequisite for achieving the MDGs, eradicating poverty and realising universal attainment of basic economic and social rights. For long-term sustainability, renewable sources of energy will ultimately be required.

To achieve this goal energy services must be provided equitably, and in ways that meet all of people's basic energy needs – for lighting, cooking, heating, cooling and ICTs – and for earning a living, as well as for social and domestic needs. These energy services must be affordable, reliable and non-damaging to human health and the environment. The PPEO's proposed Total Energy Access approach involving both minimum standards for the full range of energy services, as well as the Energy Access Index of the three major supply dimensions, could support more specific targets and progress tracking than to date – in the dimensions which matter to people.

The report of the UN Secretary General's Advisory Group on Energy and Climate Change (2010) shows that achievement of universal energy access is feasible and affordable by 2030 – provided there is the political will to do so. Despite general acceptance amongst governments, international organisations, donors, researchers and civil society that access to energy is critical for development, energy poverty is not a priority issue in policy debates. To achieve the goal, a global campaign for universal access to energy will be necessary to generate the necessary political commitment.

To achieve universal access to basic energy services, action will be required in three broad areas: policy, financing and capabilities.

Policy

National governments need to give greater priority to energy access, including:

- setting national targets for universal access to energy services by 2030. These could be based around the minimum standards for energy services proposed for Total Energy Access.
- formulating and implementing plans to deliver these targets, supported by multilateral organisations, international agencies, the private sector and civil society. Tracking of progress could involve the use of the proposed Energy Access Index.
- providing an enabling policy and institutional environment, including clear sectoral policies; this enables all stakeholders to contribute within a widening and deepening ecosystem of energy product and service providers. The extent to which more and stronger institutions of different types are active in the energy access sector would also be an important indication of policy progress towards universal access.

Financing

The large gap between the funding currently provided and what will be required to achieve universal energy access, in particular for initial capital investments, should be addressed through a variety of sources of financing, including:

- national budgets
- concessional loans from national and international financial institutions
- capital grants, with official development assistance from bilateral and multilateral organisations
- cross-subsidisation and end-user tariffs generating funds within the energy sector
- mobilisation of private investment, including local capital
- new funding mechanisms, such as those linked to finance for climate change mitigation and adaptation, or Tobin-tax arrangements.

Capabilities

Investment in the capabilities (skills and knowledge) and capacities (resources and institutions) in countries with high energy poverty levels will be essential for energy service development, policy making and monitoring of targets, financing, and the operation and maintenance of energy services. This should include:

- capacity of the full range of actors (public utilities, private enterprises and civil society) to design and deliver a variety of energy services, using a range of energy sources and technologies, including the manufacture of essential equipment and supply of fuels. The development of a flourishing energy access sector is the long term vision and the metaphor of the 'ecosystem' points towards the necessary vitality and strength of such a sector.
- the transfer and adoption of technologies at point of need, drawing from knowledge and expertise across the world, and including involvement of universities and research and education institutions in the north and south in long term partnerships.

Energy access is critical. It is also practically attainable. Join us in pursuing the goal of universal access and the eradication of energy poverty by 2030.

References

AGECC (2010) *Energy for a sustainable future: Summary report and recommendations*, The Secretary-General's Advisory Group on Energy and Climate Change, New York. Available at: www.un.org/wcm/webdav/site/climatechange/shared/Documents/AGECC%20summary%20report%5B1%5D.pdf

Aqeel, A. and Sabihuddin Butt, M. (2001) 'The relationship between energy consumption and economic growth in Pakistan', *Asia-Pacific Development Journal*, 8: 101–110.

Aron, J.E., Kayser, O., Liautaud, L. and Nowlan, A. (2009) *Access to Energy for the Base of the Pyramid*. Hysta, Paris, and Ashoka, Washington, DC. Available at: www.hystra.com/opensource/HYSTRA_Access_to%20_Energy.pdf

Avato, P. and Madeira, L. (2010) 'Innovative marketing and business models for the rapid development of off-grid lighting markets in Africa', *Boiling Point*, Issue 58, HEDON (Household Energy Network), London. Available from: http://hedon.info/View+Article&itemId=10201 [Accessed 19 October 2010.]

Bacon, R., Bhattacharya, S. and Kojima, M. (2010) 'Expenditure of low-income households on energy: Evidence from Africa and Asia'. *Extractive Industries for Development Series*, No. 16. World Bank, Washington, DC. Available at: http://siteresources.worldbank.org/EXTOGMC/Resources/336929-1266963339030/eifd16_expenditure.pdf

Barnes, D. (2010a) *Measuring household lighting: survey design issues*. Energy for Development and Poverty Reduction, [blog], 6 March. Available from: http://www.energyfordevelopment.com/2010/03/measuring-household-lighting.html [Accessed 19 October 2010].

Barnes, D. (2010b) *Rural energy subsidies: 'It's déjà vu all over again'*, Energy for Development and Poverty Reduction, [blog], 19 May. Available from: http://www.energyfordevelopment.com/2010/05/rural-energy-subsidies.html [Accessed 19 October 2010].

Barnes, D.F., Khandker, S.R., and Samad, H.A. (2010) 'Energy access, efficiency, and poverty: How many households are energy poor in Bangladesh?' *Policy Research Working Paper* 5332, World Bank, Washington, DC.

Barnes, D.F., Openshaw, K., Smith, K.R., van der Plas, R. (1994) What makes people cook with improved biomass stoves? A comparative international review of stove programs. *World Bank Technical Paper*, Energy Series, No. 242. World Bank, Washington, DC. http://ehs.sph.berkeley.edu/krsmith/publications/94_barnes_1.pdf

Bates, E. (Ed.) (2007) *Smoke, health and household energy. Volume 2: Researching pathways to scaling up sustainable and effective kitchen smoke alleviation*. Practical Action, Rugby, UK. Available at: http://practicalaction.org/energy/docs/smoke/smoke_health_household_energy_2.pdf

Bazilian, M., Nussbaumer, P., Cabraal, A., Centurelli, R., Detchon, R., Gielen, D., Rogner, H., Howells, M., McMahon, H., Modi, V., Nakicenovic, N., O'Gallachoir, B., Radka, M., Rijal, K., Takada, M., Ziegler, F. (2010) *Measuring energy access: Supporting a global target*, Earth Institute, Columbia University, New York.

Bembridge, T.J., and Tarlton, J.E. (1990) 'Woodfuel in Ciskei: A headload study', *South African Forestry Journal*, 154: 88–95. Available at: www.odi.org.uk/resources/libraries/forestry-grey-literature/headload.pdf

Bhatt, B.P. and Sachan, M.S. (2004) 'Firewood consumption along an altitudinal gradient in mountain villages of India', *Biomass & Bioenergy* 27(1): 69–75.

Bond, T. (2010a) Testimony for *Clearing the smoke: Black carbon pollution*, House Committee on Energy Independence and Global Warming, United States House of Representatives, March 16. Available at: http://legislative.nasa.gov/hearings/3-16-10%20BOND.pdf

Bond, T. (2010b) Estimate in confidence and key uncertainties in black carbon emissions and radiative impacts, SLCF Workshop, North Carolina, USA, March 3, 2010. www.cleanairinfo.com/slcf/documents/Presentations/Bond%20EPA%20SLCF%20March%203%202010.pdf

Bradbrook, A.J. and Gardam, J.G. (2006) 'Placing access to energy services within a human rights framework', *Human Rights Quarterly* 28: 389–415.

Brinkman, V. (2005) *Impact assessment at local level: Experiences from Malawi–Mulanje District*. Programme for Biomass Energy Conservation (ProBEC), GTZ, Pretoria, South Africa. Available at: www.gtz.de/de/dokumente/en-mw-impact-assessment-2005l.pdf

Cecelski, E and Collaborative Research Group on Gender and Energy (CRGGE) (2005) Website for publications from DFID-funded project 'Gender as a key variable in energy interventions: are we asking the right questions?' http://www.energia.org/knowledge-centre/energia-publications/dfid-study/

Clancy, J. and Dutta, K. (2005) *Women and productive uses of energy: Some light on a shadowy area*. Paper presented at the UNDP Meeting on Productive Uses of Renewable Energy, Bangkok, Thailand, 9–11 May 2005.

Cloke, J. (2010) Energy poverty. Unpublished discussion paper prepared for Practical Action, Rugby, UK. Available at: http://lboro.academia.edu/documents/0110/0121/Energy_Poverty_final.doc [Accessed 19 October 2010].

Cohen, A.J., Anderson, H.R., Ostro, B., Pandey, K.D., Krzyzanowski, M., Kuenzli, N., Gutschmidt, K., Pope, C.A., Romieu, I., Samet, J.M., and Smith, K.R. (2004) 'Mortality impacts of urban air pollution', in M. Ezzati, A.D. Rodgers, A.D. Lopez and C.J.L. Murray (eds.) *Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors*, World Health Organization, Geneva, pp. 1353–1433.

de Moraes, M.A.F.D. (No date) 'Reflections on Brazil's ethanol industry.' In *Biofuels in Brazil*. Available at: www.dc.mre.gov.br/imagens-e-textos/Biocombustiveis-08ing-consideracoesetanol.pdf

DFID (Department for International Development) (2002) *Energy for the poor: Underpinning the Millennium Development Goals*. Produced for DFID by Future Energy Solutions, DFID, London.

Dherani, M., Pope, D., Mascarenhas, M., Smith, K.R., Weber, M., Bruce, N. (2008) 'Indoor air pollution from unprocessed solid fuel use and pneumonia risk in children aged under 5 years: A systematic review and meta-analysis', *Bulletin of the World Health Organization*, 86: 390–398.

Eberhard, A., Foster, V., Briceño-Garmendia, C., Ouedraogo, F., Camos, D. and Shkaratan, M. (2008) *Underpowered: The state of the power sector in sub-Saharan Africa*, Africa Infrastructure Country Diagnostic Background Paper 6, World Bank, Washington, DC. Available at: www.infrastructureafrica.org/aicd/system/files/BP6_Power_sector_maintxt.pdf

ECOSOC (United Nations Economic and Social Council) (1995) *Objective G of the Platform for Action*. United Nations Fourth World Conference on Women, Beijing, China, September 1995. Available at: www.un.org/womenwatch/daw/beijing/platform/decision.htm [Accessed 19 October 2010].

ECOSOC (2001) *Mainstreaming a gender perspective into policies and programmes in the United Nations system*. United Nations Economic and Social Council Resolutions. Agenda Item: Social and human rights questions: Advancement of women (14a), Section 2001/41. Issued 26 July 2001. Available at: http://www.un.org/docs/ecosoc/documents.asp?id=167 [Accessed 19 October 2010]

ECOSOC (2000) *Report of the high-level panel of experts on information and communication technology*. General Assembly, Economic and Social Council. Substantive session of 2000. Fifty-fifth session.

ENERGIA (2006) *Economic Empowerment of Women Through Small Business Enterprises*. ENERGIA enterprises. Available at: http://www.energia.org/fileadmin/files/media/factsheets/factsheet_enterprises.pdf

EPIA (European Photovoltaic Industry Association) Solar Europe Industry Plan Draft Summary Implementation Plan 2010–2012 Brussels, 22 January 2010. http://www.eupvplatform.org/fileadmin/Documents/SC/WS100122/SEII_-_DRAFT_Summary_Implementation_Plant_2010-2012.pdf [Accessed October 2010]

ESD (Energy for Sustainable Development), Mutimba, S. and Basara M. (2005) *National Charcoal Survey: Exploring the potential for a sustainable charcoal industry in Kenya*. Energy for Sustainable Development Africa, Nairobi.

EUFIC (European Food Information Council) (2001) *Proper food storage in the refrigerator* [Online]. Available from: www.eufic.org/article/en/food-safety-quality/safe-food-handling/artid/food-storage-refrigerator/ [Accessed 20 October 2010].

EWEA (European Wind Energy Association) (2009) *Wind Energy – The Facts*, Chapter 7: Employment. Earthscan, London. pp. 488. Available at: www.wind-energy-the-facts.org/en/part-3-economics-of-wind-power/chapter-7-employment

Ezzati, M., Lopez, A.D., Rodgers, A., Vander Hoorn, S., Murray, C.J. and Comparative Risk Assessment Group (2002) 'Selected major risk factors and global and regional burden of disease'. *Lancet*, 360 (9343): 1347–1360.

FAO (Food and Agriculture Organization of the United Nations) (1997) *Global Climate Maps*. [Online] Available from: http://www.fao.org/WAICENT/FAOINFO/SUSTDEV/EIdirect/CLIMATE/EIsp0002.htm [Accessed 20 October 2010]

FAO (2010) Global Forest Resources Assessment – Key findings http://foris.fao.org/static/data/fra2010/KeyFindings-en.pdf

Foley, G. (2000) 'Tariffs for rural grid electrification', *Boiling Point* 45, HEDON Household Energy Network, London. Available from: www.hedon.info/TariffsForRuralGridElectrification [Accessed 20 October 2010]

Foster, V., Tre, J-P. and Wodon, Q. (2000) *Energy prices, energy efficiency, and fuel poverty*. World Bank, Washington DC. Available at: http://info.worldbank.org/etools/docs/voddocs/240/502/Gua_price.pdf

Garrett, S.L., Hopke, P.K. and Behn, W.H. (2009) A Research Road Map: Improved Cook Stove Development and Deployment for Climate Change Mitigation and Women's and Children's Health. Report to the US state department from the ASEAN-US Next-Generation Cook Stove Workshop, Bangkok, Thailand, November 2009. Executive summary.

Gaye, A. (2007) *Access to energy and human development*. Human Development Report Office Occasional Paper. UNDP, New York. Available at: http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/gaye_amie.pdf

GNESD (Global Network on Energy for Sustainable Development) (2007) *Reaching the Millennium Development Goals and beyond: Access to modern forms of energy as a prerequisite*. GNESD–UNEP. Available at: http://www.gnesd.org/Downloadables/MDG_energy.pdf

Goldemberg, J. (2001) *Energy and human well being*. Human Development Report background paper, UNDP, New York. http://hdr.undp.org/en/reports/global/hdr2001/papers/goldemberg-energy-1.pdf

GSMA (2010) *Women & Mobile: A Global Opportunity. A study on the mobile phone gender gap in low and middle-income countries*. GSMA, Cherie Blair Foundation for Women and Vital Wave Consulting.

GTZ-HERA (2009) 'Intervention A: Market Introduction of Efficient Woodfuel Stoves' in *Cooking Energy Compendium* [Online], Available from: http://www.hedon.info/GTZCookingEnergyCompendium?bl=y [Accessed 20 October 2010].

GTZ and SenterNovem (2009) *Energising development: Report on impacts*. GTZ, Eschborn, Germany. Available at: www2.gtz.de/dokumente/bib/gtz2009-0299en-energising-development.pdf

Hammond, A.L., Kramer, W.J., Katz, R.S., Tran, J.T., Walker, C. (2007) *The next 4 billion: Market size and business strategy at the base of the pyramid*. World Resources Institute and International Finance Corporation, Washington, DC. Available at: http://pdf.wri.org/n4b_fulltext_hi.pdf

Havet, I., Chowdhury, S., Takada, M. and Cantano, A. (2009) *Energy in National Decentralization Policies*. UNDP, New York.

HEDON Household Energy Network (2008) *CleanAirSIG Discussion: Subsidies*. HEDON Household Energy Network, London. Available from: www.hedon.info/CleanAirSIG:Subsidies [Accessed 25 July 2010].

HelpAge International (2009) *Securing our common future: Why investing in reducing aged based vulnerabilities is necessary in the global economic crisis*. Background issues paper, HelpAge International, London. Available at: www.helpage.org/download/4c48a6da22c0a

Heltberg, R. (2003) *Household energy and energy use in developing countries: A multi-country study*, Oil and Gas Policy Division, The World Bank. Available at: http://siteresources.worldbank.org/INTPSIA/Resources/490023-1120845825946/FuelUseMulticountryStudy_05.pdf

Hulscher, W. (1997) *Stoves for Space Heating and Cooking at Different Altitudes and/by Ethnic Groups*. Regional Wood Energy Development Programme in Asia (RWEDP) Report, No. 28. FAO, Bangkok. Available at: http://www.fao.org/DOCREP/006/AD589E/AD589E00.HTM [Accessed 20 October 2010]

Huyer, S. and Westholm, G. (2001) *Toolkit on Gender Indicators in Engineering, Science and Technology*. UNESCO/GAB. Available at: http://gstgateway.wigsat.org/toolkit/toolkit.html [Accessed 20 October 2010]

IC4D (Information and Communications for Development) (2009) IC4D *Online time data series* [Online]. Available from: http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2 [Accessed 25 Oct 2010].

IEA (International Energy Agency) (2002) *World Energy Outlook* 2002. IEA, Paris.

IEA (2004) *World Energy Outlook*, 2004. IEA, Paris.

IEA (2006) *World Energy Outlook* 2006. IEA, Paris.

IEA (2009) *World Energy Outlook* 2009, Fact Sheet [Online]. Available from: www.worldenergyoutlook.org/docs/weo2009/fact_sheets_WEO_2009.pdf [Accessed 20 October 2010]

IEA (2010) *World Energy Outlook* 2010. IEA, Paris (in press).

IEG (Independent Evaluation Group) (2008) *The welfare impact of rural electrification: A reassessment of the costs and benefits*. IEG Impact Evaluation, World Bank, Washington, D.C.

infoDev (2008) *Enhancing the livelihoods of the rural poor through ICT: A Knowledge Map*. Working Paper No. 9. Available at: http://www.infodev.org/en/Publication.510.html [Accessed 20 October 2010].

IARC (International Agency for Research on Cancer) (2010) IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Vol. 95 is called: Household use of solid fuels and high-temperature frying. http://monographs.iarc.fr/ENG/Monographs/vol95/mono95.pdf

IDA (International Development Association) (2009) *Information and communications technology: Connecting people and markets*. World Bank. Available at: http://siteresources.worldbank.org/IDA/Resources/IDA-ICT.pdf

ISOC (International Scientific Oversight Committee) (2004) *Health effects of outdoor air pollution in developing countries of Asia: A literature review*, Special Report 15, Health Effects Institute, Boston, MA.

ITU (International Telecom Union) (2010) *World Telecommunication/ICT Development Report 2010: Monitoring the WSIS Targets. A mid-term review*. ITU, Geneva.

Keatinge, W. (2010) Interviewed in *Why more people die in the winter* [Online]. BBC News. Available from: http://news.bbc.co.uk/1/hi/health/5372296.stm [Accessed 20 October 2010].

Khanam, R. (2008) 'Child labour and school attendance: Evidence from Bangladesh,' *International Journal of Social Economics*, 35(½): 77–98. http://www.emeraldinsight.com/journals.htm?articleid=1641951&show=html

Klunne, W. (2002) 'Energy efficient housing to benefit South African households', *Boiling Point* 48, HEDON Household Energy Network, London. Available from: www.hedon.info/BoilingPoint48 [Accessed 20 October 2010].

Kooijman-van Dijk, A.L. (2008) *The Power to Produce: The role of energy in Poverty Reduction through Small-Scale Enterprises in the Indian Himalayas*. University of Twente, Netherlands. Available at: http://doc.utwente.nl/60280/1/thesis_A_Kooijman_van_Dijk.pdf

Kozulj, R. (2009) *Contribution of energy services to the Millennium Development Goals and to poverty alleviation in Latin America and the Caribbean*. Economic Commission for Latin America and the Caribbean (ECLAC) United Nations, Santiago, Chile. Available at: http://www.eclac.org/publicaciones/xml/0/38790/lcw281i.pdf

Krugman, H. and Goldemberg, J. (1983) 'The energy cost of satisfying basic human needs'. *Technological Forecasting and Social Change* 24: 45–60.

Kumar, S.K. and Hodgkiss, D. (1992) 'Fuel collection and nutrition in Nepal', *Boiling Point* 27, HEDON Household Energy Network, London.

Lallement, D. (2006) *Energy financing issues: Prospects for developing economies*. Presentation to International Atomic Energy Agency (IAEA) Programmatic Meeting, Vienna, 31 October 2006. Available at: www-tc.iaea.org/tcweb/abouttc/strategy/Thematic/pdf/presentations/energysystemplanning/Energy_Financing_Issues-Prospects_Devp_Econ.pdf

Legros, G., Havet, I., Bruce, N., Bonjour, S. (2009). *The energy access situation in developing countries. A review focusing on the least developed countries and Sub-Saharan Africa*, UNDP and WHO, New York.

Macharia, E., Gupta, G., Tsan, M.,Avato, P., Cabraal, A., Njagi, A., Rysankova, D. (2010) Lighting Africa: Overview of off-grid solar portable lighting in Africa. Draft Report for the Second Global Business Conference and Trade Fair for Off-Grid Lighting in Africa, May 18–20. Dahlberg Development Advisors, Nairobi, Kenya. http://lightingafricaconference.org/fileadmin/user_upload/Conference_2010/16.5.2010_Lighting_Africa_2010_Conference_Report__FINAL_DRAFT_.pdf

Manyaapelo, K. (2000) 'Consumer response to mobile solar water heating in the low-income sector, South Africa', *Boiling Point* 45, HEDON Household Energy Network, London. Available at: http://practicalactionconsulting.org/boiling-point/docs/energy/boilingpoint45.pdf

Marker, P., McNamara, K. and Wallace, L. (2002) *The significance of information and communication technologies for reducing poverty*. Department for International Development (DFID), London.

McDaid, S. (2004) *Gender and Energy for Sustainable Development: A Toolkit and Resource Guide*, UNDP, New York. Available at: http://www.undp.org/energy/genenergykit/ [Accessed 20 October 2010]

McNamara, K. (2006) *Improving health, connecting people: The role of ICTs in the health sector of developing countries. A framework paper*, Working Paper No. 7, [Online]. infoDev/World Bank. Available at: www.infoDev.org/health [Accesed 20 October 2010]

McPeak, J. (2002) *Fuelwood Gathering and Use in Northern Kenya*. Paper presented at meeting of the Association for Politics and Life Sciences, August 11–14, Montreal, Quebec. Available at: http://aem.cornell.edu/special_programs/AFSNRM/Parima/Papers/M_fuelwood.pdf

Mills, E. (2003) Technical and Economic Performance Analysis of Kerosene Lamps and Alternative Approaches to Illumination in Developing Countries. Lawrence Berkeley National Laboratory, University of California. Available at: http://evanmills.lbl.gov/pubs/pdf/offgrid-lighting.pdf

Modi, V., McDade, S., Lallement, D. and Saghir, J. (2005) *Energy and the Millennium Development Goals*. Energy Sector Management Assistance Programme, UNDP, UN Millennium Project, and World Bank. New York. Available at: www.unmillenniumproject.org/documents/MP_Energy_Low_Res.pdf

Naeher, L.P., Brauer, M., Lipsett, M. Zelikoff, J.T., Simpson, C.D., Koenig, J.Q. and Smith, K.R. (2007) 'Woodsmoke health effects: A review', *Journal of Inhalation Toxicology* 19(1): 67–106.

Nissanka, R. (2009) *Scale-up and commercialisation of improved cookstoves in Sri Lanka: Lessons learnt from the Anagi experience* [Online]. PICES/Practical Action Consulting. Available at: www.pisces.or.ke/pubs/pdfs/PISCES_Anagi_Working_Paper.pdf [Accessed 20 October 2010]

Oakley, D., Harris, P. and Hazard, C. (2007) *Modern Energy: Impact on Micro-enterprise*, AEA Energy & Environment. Report produced for DFID.

O'Brien, C. (2006) 'Introducing alcohol stoves to refugee communities', *Boiling Point* 52, HEDON Household Energy Network, London. Available at: www.hedon.info/IntroducingAlcoholStovesToRefugeeCommunities [Accessed 20 October 2010]

OECD (Organisation for Economic Co-operation and Development) (2006) *Promoting pro-poor growth: Infrastructure*. OECD, Paris. Available at: www.oecd.org/dataoecd/16/46/36301078.pdf

OECD (2010) *Measuring aid for energy*. OECD–DAC, Paris. Available at: http://www.oecd.org/dac/stats/energy

Palit, D. and Singh, J. (2010) 'Lighting a billion lives: Empowering the rural poor', *Boiling Point* 59, HEDON Household Energy Network, London (in print).

PAHO (Pan American Health Organization) (2005) *An Assessment of Health Effects of Ambient Air Pollution in Latin America and the Caribbean*. PAHO, Washington, D.C.

Peck, M.D., Gerebreg E., Kruger,G. E., van der Merwe, A. E., Godakumbura,W., Ahuja, R. B. (2008). 'Burns and Fires from Flammable Non-electric Domestic Appliances: Part I. The Scope of the Problem'. *Burns Journal*, 34 (3): 303–311.

PISCES (Policy Innovation Systems for Clean Energy Security) (2009) *Energy Delivery Model Tool* [ONLINE] http://practicalaction.org/consulting/pisces/delivery_models

Pokhrel, A.K., Smith, K.R., Khalakdina, A., Deuja, A. and Bates, M.N. (2005) 'Case-control study of indoor cooking smoke exposure and cataract in Nepal and India', *International Journal of Epidemiology* 34: 702–708.

Pope, D.P., Mishra, V., Thompson, L., Siddiqui, A.R., Rehfuess, E.A., Weber, M., Bruce, N.G. (2010) 'Risk of low birth weight and stillbirth associated with indoor air pollution from solid fuel use in developing countries', *Epidemiologic Reviews*, 32 (1): 70–81.

Poppendieck, D., Apple, J., Vicente, R., Yarberry, A., Lohse, N., Tracy, J. (2010) *Exposure to particulate matter from kerosene lamps*. Report for the Second Global Business Conference and Trade Fair for Off-Grid Lighting in Africa, May 18–20, Nairobi, Kenya. Available at: http://lightingafricaconference.org/fileadmin/user_upload/Conference_2010/Day2/DAY2_PDF/Dustin_Poppendieck-Lighting_Africa_2010_-_Poppendieck.pdf

Practical Action (2006) *Refrigeration for developing countries*, Practical Action Technical Brief [Online]. Available from: http://practicalaction.org/practicalanswers/product_info.php?cPath=21&products_id=184&attrib=1 [Accessed 25 Oct 2010].

Practical Action (2009) *How a zeer pot fridge makes food last longer* [Online]. Available at: www.practicalaction.org.uk/food-production/zeerpots [Accessed 20 October 2010]

Practical Action Consulting (2009) *Small-scale bioenergy initiatives: Brief description and preliminary lessons on livelihoods impacts from case studies in Asia, Latin America and Africa*. Prepared for PISCES and FAO by Practical Action Consulting, Rugby, UK. Available at: http://www.pisces.or.ke/pubs/pdfs/FAO-PISCES%20Case%20Studies%20Final%20Report%20020409.pdf

PAC/UNDP (Practical Action Consulting / United Nations Development Program) (2009) *Expanding Energy Access in Developing Countries: The Role of Mechanical Power*. Practical Action Publishing, Rugby, UK.

Prahalad, C.K, and Hart, S.L. (2004) 'The fortune at the bottom of the pyramid', *Strategy and Business*, 26: 54–67.

Sachs, J.D., McArther, J.W., Schmidt-Traub, G., Kruk, M., Bahadur, C., Faye, M., McCord, G. (2004) 'Millennium Development Goals needs assessments for Ghana, Tanzania, and Uganda: Ending Africa's poverty trap', *Brookings Papers on Economic Activity*, 2: 117–216.

Safaricom (2010) Full Year 2009/2010 *Results Announcement*. [Online] Available from: http://www.safaricom.co.ke/index.php?id=337 [Accessed 25 Oct 2010].

Saleem, M. (1997) 'Status of improved stoves in the northern areas of Pakistan', *Boiling Point* 38, HEDON Household Energy Network, London. Available from: http://www.hedon.info/BP38_StatusOfImprovedStovesInTheNorthernAreasOfPakistan?bl=y [Accessed October 2010].

Sanchez, T. (2010) *The Hidden Energy Crisis: How Policies are Failing the World's Poor*. Practical Action Publishing, Rugby, UK.

Sanghvi, A.P. (1991) 'Power shortages in developing countries: Impacts and policy implications'. *Energy Policy* 19: 425–440.

Schare, S. and Smith, K.R. (1995) 'Particulate emission rates of simple kerosene lamps', Letters *Energy for Sustainable Development*, Volume II, No.2: 32–35.

Sen, A. (1999) *Development as Freedom*. Anchor Books, New York.

Shrestha, I.L. and Shrestha, S.L. (2005) 'Indoor air pollution from biomass fuels and respiratory health of the exposed population in Nepalese households', *International Journal of Occupational and Environmental Health*, 11: 150–160.

Smith, K.R. (1987) *Biofuels, Air Pollution, and Health: A Global Review*, Plenum, New York.

Smith, K.R. (2002) *Short primer on stove efficiencies* [Online. Available at: www.bioenergylists.org/stovesdoc/Smith/Primer/Primer.html [Accessed 20 October 2010].

Smith, K.R. (2010) Asian Emission Inventory for NASA INTEX_B 2006, In: The Kitchen Kills More than the Sword: Health and Climate Impacts of Household Fuel, presented at University of Charleston, Charleston, West Virginia, USA, May 6, 2010. http://ehs.sph.berkeley.edu/krsmith/presentations/Charleston%20May%2010.pdf

Smith, K.R. and Peel, J. (2010) 'Mind the gap', *Environmental Health Perspectives* (in press).

Smith K.R., Bruce N., Arana B., Jenny A., Khalakdina A., McCracken J., Diaz A, Schei M, Gove S. (2006) 'Conducting the first randomized control trial of acute lower respiratory infections and indoor air pollution: description of process and methods.' *Epidemiology* 17: S44.

Smith K.R., Mehta, S., Maeusezahl-Feuz, M. (2004) 'Indoor smoke from household solid fuels', in M. Ezzati, A.D. Rodgers, A.D. Lopez and C.J.L. Murray (eds) *Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors*, pp. 1435–1493, WHO, Geneva.

Smith, K.R., Rogers, J. Kirk R. Smith, Jamesine Rogers, Cowli, C., (2005) 'Household fuels and ill-health in developing countries: What improvements can be brought by LP Gas?', *World LP Gas Association and Intermediate Technology*: pp. 59 http://ehs.sph.berkeley.edu/krsmith/publications/2005%20pubs/Household%20Fuels%20Ill%20health%20(complete%20for%20web).pdf

Smith, K.R., Uma, R., Kishore, V.V.N., Zhang, J., Joshi, V. and Khalil, M.A.K. (2000) 'Greenhouse implications of household fuels: An analysis for India'. *Annual Review of Energy and Environment* 25: 741–763.

Sparknet (2004) *South Africa: Household Energy Demand and Use*. [Online]. HEDON Household energy Network. Available from: www.hedon.info/SouthAfricaCountrySynthesis [Accessed 20 October 2010]

Taylor, R.P., Govindarajalu, C., Levin, J., Meyer, A.S., Ward, W.A., (2008) *Financing Energy Efficiency*, World Bank, Washington DC.

Tennakoon, D. (2009) Energy poverty: Estimating the level of energy poverty in Sri Lanka, Report prepared for Practical Action South Asia, Sri Lanka. http://www.practicalaction.org.uk/energy/south-asia/docs/region_south_asia/energy-poverty-in-sri-lanka-2008.pdf

Teske, S. (2010) *Energy [R]evolution: A Sustainable World Energy Outlook*. Greenpeace International and European Renewable Energy Council (EREC). Available at: http://www.greenpeace.org/international/Global/international/publications/climate/2010/fullreport.pdf

Trucano, M. (2005) *Knowledge Maps: ICT in Education* [Online]. infoDev/World Bank, Washington, DC. Available from: www.infodev.org/en/Publication.8.html [Accessed 20 October 2010].

Tully, S.R. (2006) 'The contribution of human rights to universal energy access', *Northwestern Journal of International Human Rights* 4: 518–548.

United Nations (2010) *The Millennium Development Goals Report 2010* [Online]. Available from: www.un.org/millenniumgoals [Accessed 20 October 2010]

Unger, N., Bond, T.C., Wang, J.S., Koch, D.M., Menon, S., Shindell, D.T., Bauer, S. (2010) 'Attribution of climate forcing to economic sectors', *Proceedings of the National Academy of Sciences*, Vol. 107(8): 3382–3387.

WECS (Water and Energy Commission Secretariat) (1997) Data extracted from: Update and Compilation of Energy Resources and Consumption Profile of Nepal, Water and Energy Commission Secretariat, Nepal

WHO (World Health Organization) (1998) *Safe vaccine handling, cold chain and immunizations*. A manual for the Newly Independent States. WHO, Geneva. Available at: www.who.int/vaccines-documents/DocsPDF/www9825.pdf [Accessed 20 October 2010]

WHO (2006) *Air quality guidelines for particulate matter, ozone, nitrogen dioxide, and sulfur dioxide. Global update 2005. Summary of Risk Assessment*. WHO/SDE/PHE/OEH/06.02. WHO. Geneva.

WHO (2009) *Global health risks report: A response to the need for comprehensive, consistent and comparable information on health risks at global and regional level*. WHO. Available from: www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_part2.pdf

WHO (2010) *World health report 2010: Health systems financing*. WHO, Geneva.

Wilkinson, P., Smith, K.R., Davies, M., Adair, H., Armstrong, B.G., Barrett, M., Bruce, N., Haines, A., Hamilton, I., Oreszczyn, T., Ridley, I., Tonne, C. and Chalabi, Z. (2009) 'Household energy', Series on the impact on public health of strategies to reduce greenhouse gases, *Lancet* 374(9705):1917–29.

Winafrique (2010) *Winafrique project showcase* [Online]. Available from: www.winafrique.com [Accessed 20 October 2010]

Women's Refugee Commission (2006) Conference proceedings - Beyond Firewood: Fuel Alternatives and Protection Strategies for Displaced Women and Girls, Women's Refugee Commission 2006 http://womensrefugeecommission.org/docs/fuel.pdf

World Bank (2007) *Clean energy for development investment framework: The World Bank Group action plan*. Sustainable Development Network, World Bank. Available at: http://siteresources.worldbank.org/DEVCOMMINT/Documentation/21289621/DC2007-0002(E)-CleanEnergy.pdf

World Bank (2009) *Energy strategy approach paper*. Sustainable Development Network, World Bank Group. Available at: http://siteresources.worldbank.org/EXTESC/Resources/Approach-paper.pdf

World Energy Council (WEC) (2004) *World energy assessment overview*. Elsevier, Oxford, UK. Available at: http://www.worldenergy.org/documents/ser2004.pdf

WRI (World Resources Institute) (1994) *World Resources 1994–95: People and the Environment*, WRI, Washington, DC.

WRI (2004) *World Resources 2002–2004: Decisions for the Earth: Balance, voice, and power*, WRI, Washington, DC.

Wu, X., Lampietti, J., Meyer, A.S. (2004) 'Coping with the cold: space heating and the urban poor in developing countries'. *Energy Economics*, Vol. 26 (3):345–357.

Zhang, J., Smith, K.R, Ma, Y., Jiang, F., Qi, W., Liu, P., Khalil, M.A.K., Rasmussen, R.A. and Thornelow, S.A. (2000) 'Greenhouse gases and other airborne pollutants from household stoves in China: A database for emission factors', *Atmospheric Environment* 34(26): 4537–4549.

Zwizwai, B.M. (2009) *Determining the magnitude of and measures to eliminate energy poverty in Zambia*. Report prepared for Practical Action Southern Africa.

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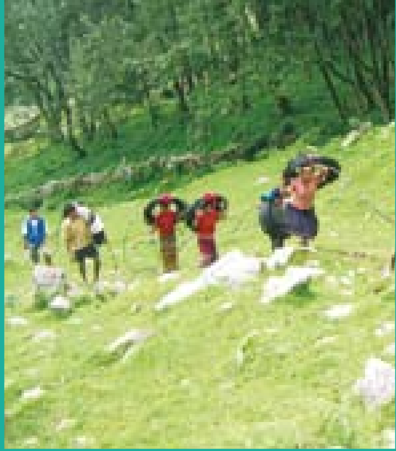
Front cover photos
Clockwise from top left: A woman carrying woodfuel in Nepal (Nigel Bruce, Practical Action); A carpenter working by the light of a solar lantern in Kenya (Zul Mukhida, Practical Action); Children studying on a computer powered by micro-hydro power in Peru (Ana Castañeda, Practical Action); A zeer pot keeping vegetables cool and fresh in Sudan (Practical Action Sudan); The community technician operating the village micro-hydro power plant in Peru (Matt Barker, Practical Action); A woman cooking on an improved wood stove (Neil Cooper, Practical Action).

Back cover photos:
Clockwise from top: Women carrying materials up a hillside to build a wind turbine in Nepal (Rakesh Shrestha, Practical Action); A man and woman irrigating their vegetable plot in Mali (Kickstart); A woman cooking on a farm-based biogas stove in Nepal (Rajesh KC, Nepal).

Editing and layout: Green Ink Ltd (www.greenink.co.uk)



Poor people's energy outlook 2010

The *Poor people's energy outlook* presents a unique perspective on energy access in developing countries. It reports in unprecedented detail the experiences of energy use and deprivation of people living in poverty.

Access to energy is a prerequisite for poverty reduction and human development – modern energy services are essential to meet basic and productive needs. And yet, the realities of the relationship people living in poverty have with energy is not well understood. This report seeks to address this issue and advocate for an increased focus on energy access as a priority for development.

The *Poor people's energy outlook* is organised into three chapters. The first describes people's experience of six vital energy services, and derives a set of minimum standards and an energy access index for mapping access experience. Leading practitioners then debate the key issues in energy access, addressing challenges and controversies in the sector. The final chapter presents an overview of the energy poverty outlook and the long-term goal of universal energy access from sustainable sources. A framework for action calls on the international community to rise to this challenge.

This publication 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.

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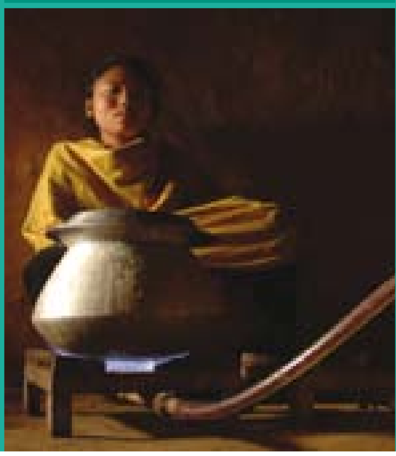

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