CHAPTER 15

ENERGY FOR COOKING IN DEVELOPING COUNTRIES

HIGHLIGHTS

- In developing countries, especially in rural areas, 2.5 billion people rely on biomass, such as fuelwood, charcoal, agricultural waste and animal dung, to meet their energy needs for cooking. In many countries, these resources account for over 90% of household energy consumption.
- In the absence of new policies, the number of people relying on biomass will increase to over 2.6 billion by 2015 and to 2.7 billion by 2030 because of population growth. That is, one-third of the world's population will still be relying on these fuels. There is evidence that, in areas where local prices have adjusted to recent high international energy prices, the shift to cleaner, more efficient use of energy for cooking has actually slowed and even reversed.
- Use of biomass is not in itself a cause for concern. However, when resources are harvested unsustainably and energy conversion technologies are inefficient, there are serious adverse consequences for health, the environment and economic development. About 1.3 million people – mostly women and children – die prematurely every year because of exposure to indoor air pollution from biomass. Valuable time and effort is devoted to fuel collection instead of education or income generation. Environmental damage can also result, such as land degradation and regional air pollution.
- Two complementary approaches can improve this situation: promoting more efficient and sustainable use of traditional biomass; and encouraging people to switch to modern cooking fuels and technologies. The appropriate mix depends on local circumstances such as per-capita incomes and the availability of a sustainable biomass supply.
- Halving the number of households using traditional biomass for cooking by 2015 – a recommendation of the United Nations Millennium Project – would involve 1.3 billion people switching to other fuels. Alternative fuels and technologies are already available at reasonable cost. Providing LPG stoves and cylinders, for example, would cost at most $1.5 billion per year to 2015. Switching to oil-based fuels would not have a significant impact on world oil demand. Even when fuel costs and emissions are considered, the household energy choices of developing countries need not be limited by economic, climate-change or energy-security concerns.

- Vigorous and concerted government action is needed to achieve this target, together with increased funding from both public and private sources. Policies to promote cleaner, more efficient fuels and technologies for cooking need to address barriers to access, affordability and supply, and to form a central component of broader development strategies.

Household Energy Use in Developing Countries

According to the best available figures, household energy use in developing countries totalled 1 090 Mtoe in 2004, almost 10% of world primary energy demand.[1] Household use of biomass in developing countries alone accounts for almost 7% of world primary energy demand. In OECD countries, biomass demand comes mostly from the power generation and industry sectors, while in developing countries these sectors represent only 12%.

There are enormous variations in the level of consumption and the types of fuels used. While a precise breakdown is difficult, the main use of energy in households in developing countries is for cooking, followed by heating and lighting. Because of geography and climate, household space and water heating needs are small in many countries. This chapter concentrates on fuels for cooking. Households generally use a combination of energy sources for cooking that can be categorised as traditional (such as dung, agricultural residues and fuelwood), intermediate (such as charcoal and kerosene) or modern (such as LPG, biogas, ethanol gel, plant oils, dimethyl ether (DME) and electricity).[2] Electricity is mainly used for lighting and small appliances, rather than cooking, and represents a small share of total household consumption in energy terms.[3]

Supplies of biomass are abundant in many developing countries, although local scarcity exists. Indeed, they are the only affordable energy source for some households. The commercial production and distribution of fuelwood and

1. Collecting and processing biomass energy statistics is a complex process because of the diversity of consumption patterns, differences in units of measurement, the lack of regular surveys and the variation in heat content of the different types of biomass. The IEA and the Food and Agriculture Organization of the United Nations (FAO) are the main international organisations monitoring biomass energy data in developing countries. Some countries collect specific information on fuel use at the household level, while various regional organisations and independent researchers carry out *ad hoc* surveys.

2. The terms traditional, intermediate and modern relate to how well-established a fuel is and do not imply a ranking.

3. While electricity is not the focus of this chapter, it provides important benefits to households. The number of people without access to electricity is estimated to be 1.6 billion (Annex B).

charcoal generates significant employment and income in rural areas of developing countries, though a switch to alternative fuels would also create employment and business opportunities.

In OECD countries and in most transition economies, the technologies used to convert biomass to energy tend to be efficient and the resources are generally harvested in a sustainable way. But in developing countries, the technologies and practices are much less efficient. Many people use three-stone fires, cook without ventilation or harvest at an unsustainable rate. Reliance on biomass resources, important though they are to many communities, cannot be regarded as sustainable when it impairs health and has negative economic and environmental impacts.

Based on work done for *WEO-2002*, a database of the number of people relying on biomass as their primary fuel for cooking for each country in the *WEO* developing regions was built up using survey and census data, World Health Organization (WHO) data and direct correspondence with national administrations. We estimate that over 2.5 billion people, or 52% of the population in developing countries, depend on biomass as their primary fuel for cooking.[4] Over half of these people live in India, China and Indonesia (Table 15.1). However, the proportion of the population relying on biomass is highest in sub-Saharan Africa. In many parts of this region, more than 90% of the rural population relies on fuelwood and charcoal. The share is smaller in China, where a large proportion of households uses coal instead.[5] Poor households in Asia and Latin America are also very dependent on fuelwood (Figure 15.1).

Heavy dependence on biomass is concentrated in, but not confined to, rural areas. Almost half a billion people in urban areas also rely on these resources. Although urbanisation is associated with lower dependence, the use of fuels such as LPG[6] in towns and cities is not always widespread. In sub-Saharan Africa, well over half of all urban households rely on fuelwood, charcoal or wood waste to meet their cooking needs. Over a third of urban households in some Asian countries also rely on these fuels.

The share of biomass in household energy demand varies widely across countries and regions, primarily reflecting their resource endowments but also their levels of economic development and urbanisation. In Thailand, where per-capita income averages $2 490, biomass accounts for 33% of household energy

4. Although households in developing countries use a combination of fuels for cooking and heating, this chapter focuses on the primary fuel used. This simplification is necessary in order to perform quantitative analysis.

5. Coal is excluded from the targets and projections in this chapter.

6. Liquefied petroleum gas (LPG) is a mixture of propane and butane pressurised in cylinders for storage and transport.

Table 15.1: **People Relying on Biomass Resources as their Primary Fuel for Cooking, 2004**

	Total population		Rural		Urban	
	%	million	%	million	%	million
Sub-Saharan Africa	76	575	93	413	58	162
North Africa	3	4	6	4	0.2	0.2
India	69	740	87	663	25	77
China	37	480	55	428	10	52
Indonesia	72	156	95	110	45	46
Rest of Asia	65	489	93	455	35	92
Brazil	13	23	53	16	5	8
Rest of Latin America	23	60	62	59	9	25
Total	**52**	**2 528**	**83**	**2 147**	**23**	**461**

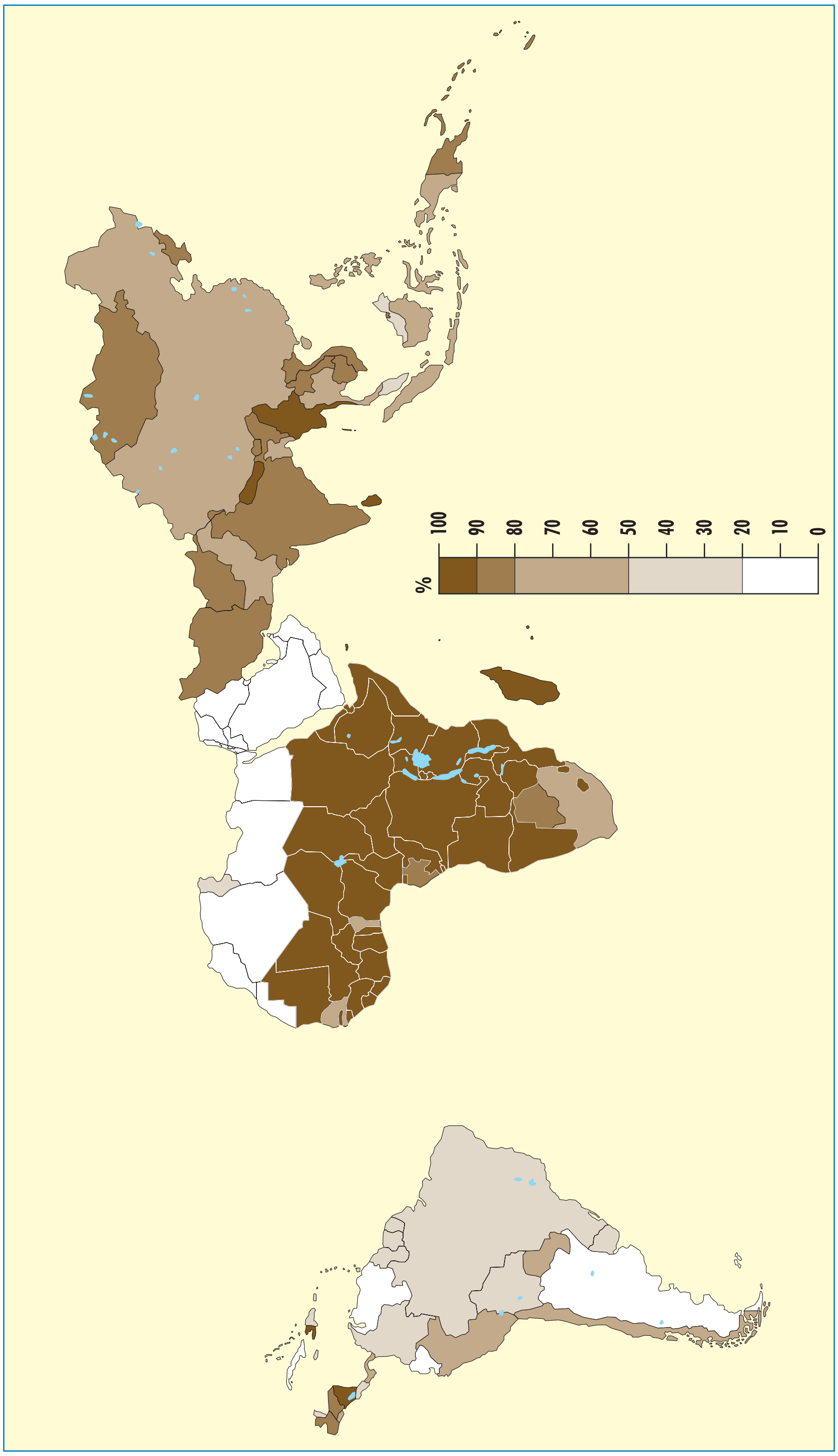
Sources: IEA analysis based on the latest available national census and survey data, including the 2001 Population and Household Census of Botswana; the 2003 Demographic and Health Survey of Nigeria; the National Bureau of Statistics of Tanzania, 2000/01; the 2001 Census of India; Energy Statistics for Indonesia, 2006; the Bangladesh Bureau of Statistics, 2005; the National Statistical Office Thailand, 2000; ORC Macro (2006); WHO (2006).

consumption, while in Tanzania, with per-capita income of only $320, the share is nearly 95%.[7] There are also important differences between rural and urban households. For example, fuelwood for cooking is three times more important in rural areas than in urban areas in both India and Botswana (Figure 15.2).

Households do not simply substitute one fuel for another as income increases, but instead add fuels in a process of "fuel stacking". Modern forms of energy are usually applied sparingly at first and for particular services (such as electricity for radio and television, or LPG for making tea and coffee) rather than completely supplanting an existing form of energy that already supplies a service adequately. The most energy-consuming activities in the household – cooking and heating – are the last to switch. Use of multiple fuels provides a sense of energy security, since complete dependence on a single fuel or technology leaves households vulnerable to price variations and unreliable service. Some reluctance to discontinue cooking with fuelwood may also be due to taste preferences and the familiarity of cooking with traditional technologies. In India and several other countries, for example, many wealthy households retain a wood stove for baking traditional breads. As incomes increase and fuel options widen, the fuel mix may change, but wood is rarely entirely excluded. Over the long term

7. Per-capita incomes are taken from World Bank (2006).

Figure 15.1: **Share of Traditional Biomass in Residential Consumption by Country**



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Source: IEA databases.

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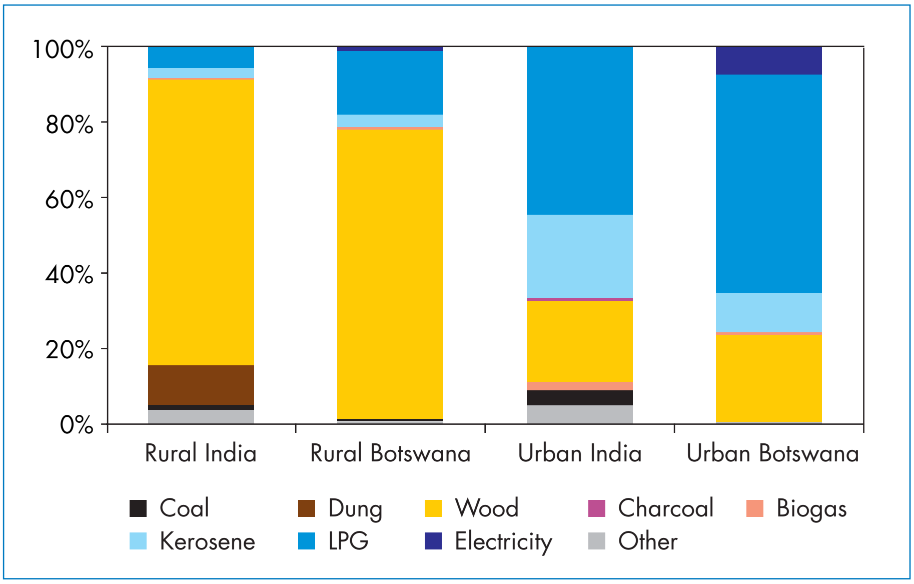
Figure 15.2: **Primary Energy Source for Cooking in Households in India and Botswana**



Note: The high electricity share in urban Botswana is due to the provision of cheap surplus electricity from South Africa by Eskom.
Sources: *Census of India*, 2001, available from www.censusindia.net and *2001 Population and Household Census of Botswana,* Census Unit, Botswana.

and on a regional scale, however, households in countries that become richer will shift away from cooking exclusively with biomass using inefficient technologies (Smith *et al.*, 2004).

Harmful Effects of Current Cooking Fuels and Technologies

Health

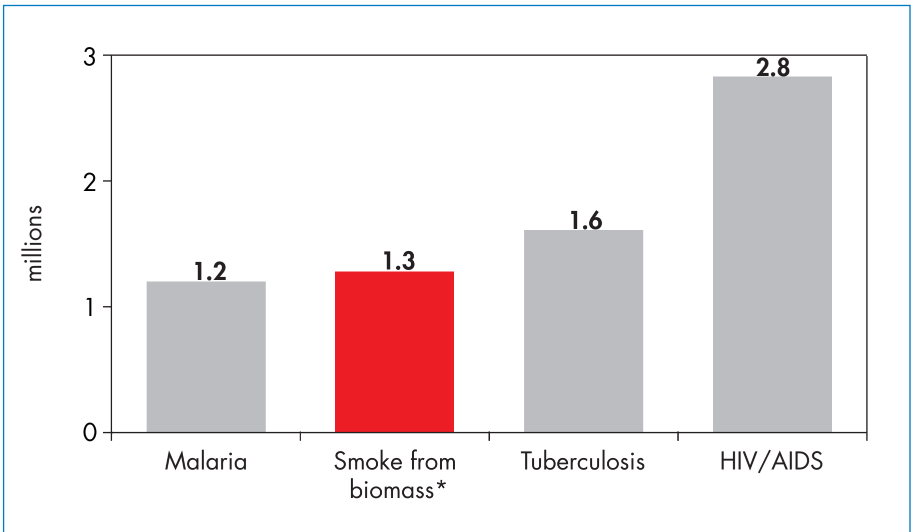
The World Health Organization (WHO) estimates that 1.5 million premature deaths per year are directly attributable to indoor air pollution from the use of solid fuels.[8] That is more than 4 000 deaths per day, more than half of them children under five years of age. More than 85% of these deaths (about

8. There are specific targets associated with each of the eight Millennium Development Goals. For each target, several indicators have been established to assess progress in achieving the goals. The WHO is responsible for Indicator 29 (Goal 7) – the proportion of the population using solid fuels. This category includes coal and biomass resources. In this chapter, the targets and projections consider biomass only.

1.3 million people) are due to biomass use, the rest due to coal. This means that indoor air pollution associated with biomass use is directly responsible for more deaths than malaria, almost as many as tuberculosis and almost half as many as HIV/AIDS (Figure 15.3). In developing countries, only malnutrition, unprotected sex, and lack of clean water and sanitation were greater health threats (WHO, 2006). Just as the extent of dependence on polluting fuels and inefficient stoves varies widely around the world, so does the death toll due to indoor smoke. The number of premature deaths is highest in southeast Asia and sub-Saharan Africa (Figure 15.4).

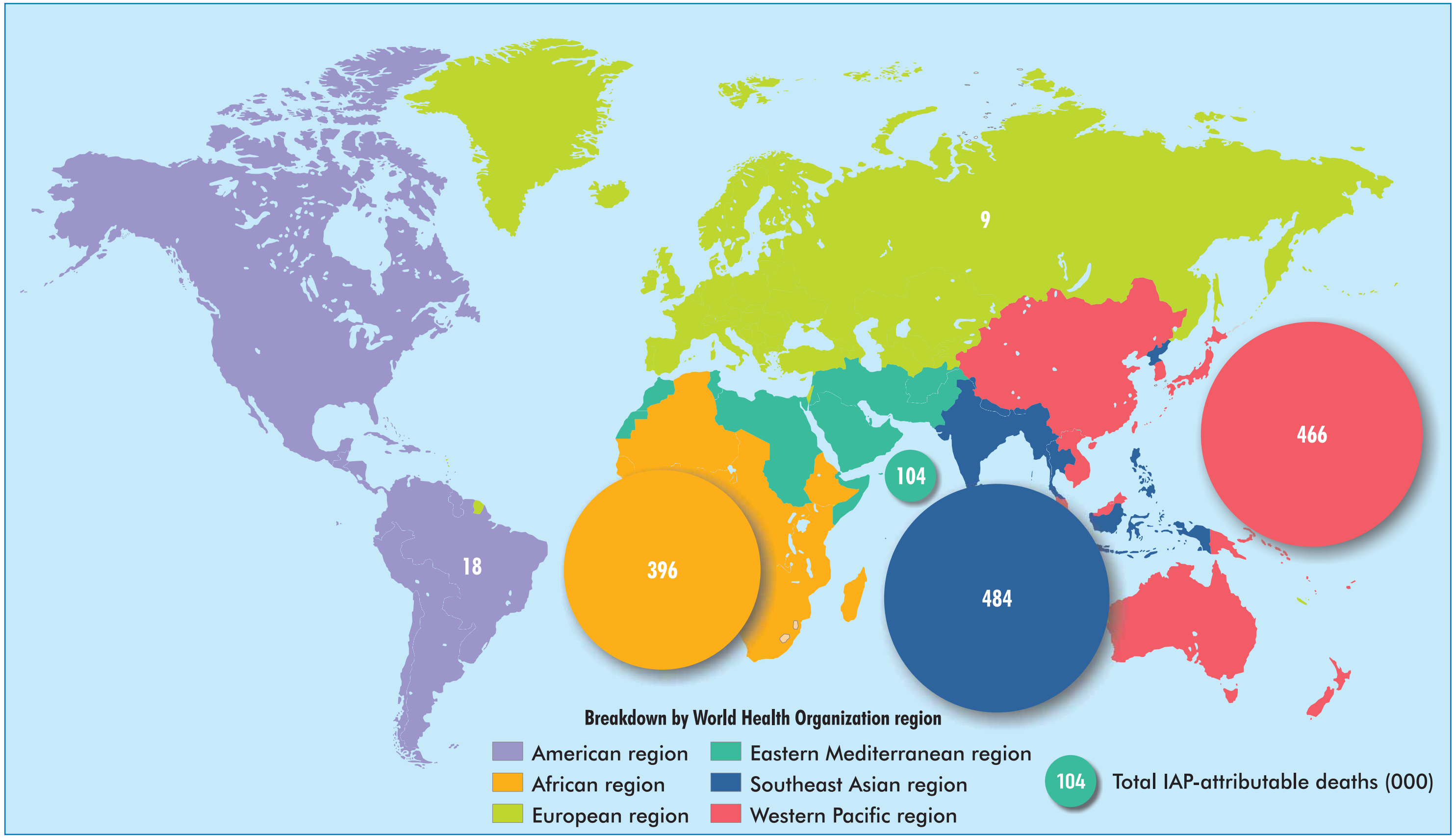
Fuelwood, roots, agricultural residues and animal dung all produce high emissions of carbon monoxide, hydrocarbons and particulate matter (Smith *et al.,* 2000). Hydrocarbon emissions are highest from the burning of dung for fuel, while particulate emissions are highest from agricultural residues. Women and children suffer most from indoor air pollution because they are traditionally responsible for cooking and other household chores, which involve spending hours by the cooking fire exposed to smoke. Young children are particularly susceptible to disease, which accounts for their predominance in the statistics for premature deaths due to the use of biomass for cooking.

Figure 15.3: **Annual Deaths Worldwide by Cause**



* IEA estimate based on WHO figure for all solid fuels.
Source: WHO Statistical Information System, available at www.who.int/whosis.

Figure 15.4: **Deaths per Year Caused by Indoor Air Pollution, by WHO Region**



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Note: Countries are grouped according to WHO regions. Deaths include those, mainly in China, attributable to the use of coal.

Source: WHO (2006).

The effects of exposure to indoor air pollution depend on the source of pollution (fuel and stove type), how pollution is dispersed (housing and ventilation) and how much of their time household members spend indoors. The type of fuel used and individuals' participation in food preparation have consistently been the most important indicators. The prevalence of indoor air pollution is significantly higher where income is below $1 per day per capita (WHO, 2004). As well as being much more dependent on biomass, poor households rely on low-quality cooking equipment and live in poorly ventilated housing, exacerbating the negative health impact, as there is incomplete combustion and non-dissipation of smoke.

It is estimated that indoor air pollution causes about 36% of lower respiratory infections and 22% of chronic respiratory disease (UNEP, 2006). A child exposed to indoor air pollution is two to three times more likely to catch pneumonia, which is one of the world's leading killers of young children. In addition, there is evidence to link indoor smoke to low birth weight, infant mortality, tuberculosis, cataracts and asthma. As well as direct effects on health, indoor air pollution worsens the suffering and shortens the lives of those with both communicable diseases such as malaria, tuberculosis and HIV/AIDS, and chronic diseases, notably cardiovascular diseases and chronic respiratory diseases, which are by far the world's worst killers. Four out of five deaths due to chronic diseases are in low- and middle-income countries (WHO, 2005).

Environment

Inefficient and unsustainable cooking practices can have serious implications for the environment, such as land degradation and local and regional air pollution. There is some localised deforestation, but depletion of forest cover on a large scale has not been found to be attributable to demand for fuelwood (Arnold *et al.,* 2003). Fuelwood is more often gathered from the roadside and trees outside forests, rather than from natural forests. Clearing of land for agricultural development and timber are the main causes of deforestation in developing countries. Studies at the regional level indicate that as much as two-thirds of fuelwood for cooking worldwide comes from non-forest sources such as agricultural land and roadsides. Charcoal, on the other hand, is usually produced from forest resources. Unsustainable production of charcoal in response to urban demand, particularly in sub-Saharan Africa, places a strain on biomass resources. Charcoal production is often inefficient and can lead to localised deforestation and land degradation around urban centres.[9] Scarcity of wood typically leads to greater use of agricultural residues and animal dung for

9. As a result of charcoal production for urban and peri-urban households, biomass resources have been devastated in a 200 to 300 kilometre radius around Luanda, Angola (IEA, 2006).

cooking. When dung and residues are used for fuel rather than left in the fields or ploughed back into fields, soil fertility is reduced and propensity to soil erosion is increased.

Figure 15.5 shows the supply and demand balance of wood resources in East Africa. Red areas represent the risk of environmental impact due to overexploitation. In these areas, the supply of biomass energy resources is insufficient to meet the demand. The red deficit areas in Tanzania, along the border with Kenya, are the result of high consumption of fuelwood and charcoal, stemming from high population density and low levels of production of woody biomass.

The Burden of Fuel Collection

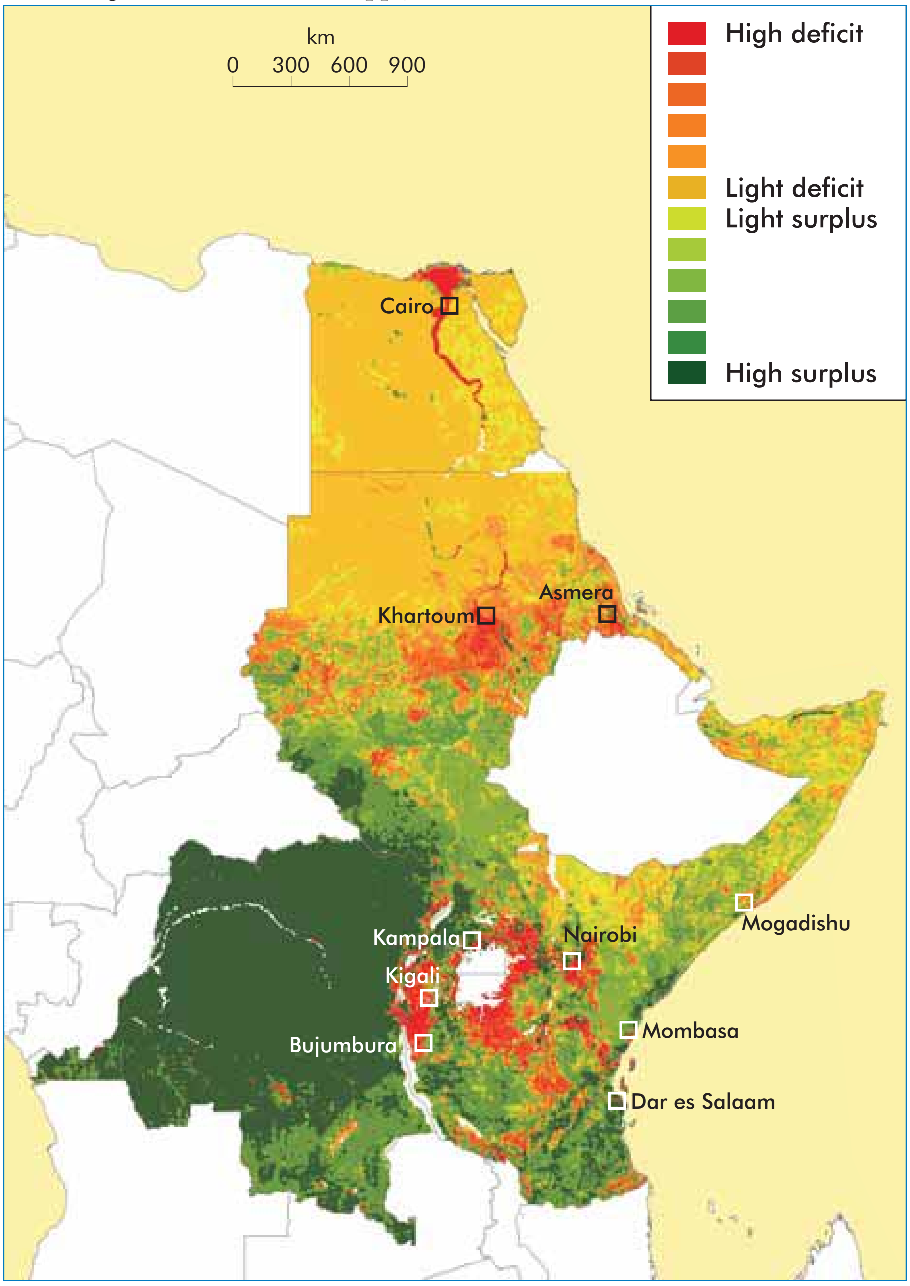
In developing regions reliant on biomass, women and children are responsible for fuel collection, a time-consuming and exhausting task. The average fuelwood load in sub-Saharan Africa is around 20 kg but loads of 38 kg (Rwelamira, 1999) have also been recorded. Women can suffer serious long-term physical damage from strenuous work without sufficient recuperation. This risk, as well as the risk of falls, bites or assault, rises steeply the further from home women have to walk, for example because of conversion of land to agricultural uses.

Figure 15.6 shows the distance travelled for fuelwood collection in rural areas of Tanzania. The average distance is highest in the central region of Singida, at over ten kilometres per day, followed by the western regions near Lake Tanganyika, where it is greater than five kilometres per day. Collection time has a significant opportunity cost, limiting the opportunity for women and children to improve their education and engage in income-generating activities. Many children, especially girls, are withdrawn from school to attend to domestic chores related to biomass use, reducing their literacy and restricting their economic opportunities. Modern energy services promote economic development by enhancing the productivity of labour and capital. More efficient technologies provide higher-quality energy services at lower costs and free up household time, especially that of women and children, for more productive purposes.[10]

There are important development benefits to be gained from expanding access to modern energy services. The UN Millennium Project (2005) has emphasised that close links exist between energy and all eight of the Millennium Development Goals (MDGs). Modern energy services help reduce

10. See also WEO-2004 and Victor (2005) for further discussion of the link between energy and economic development.

Figure 15.5: **Woodfuel Supply and Demand Balance in East Africa**



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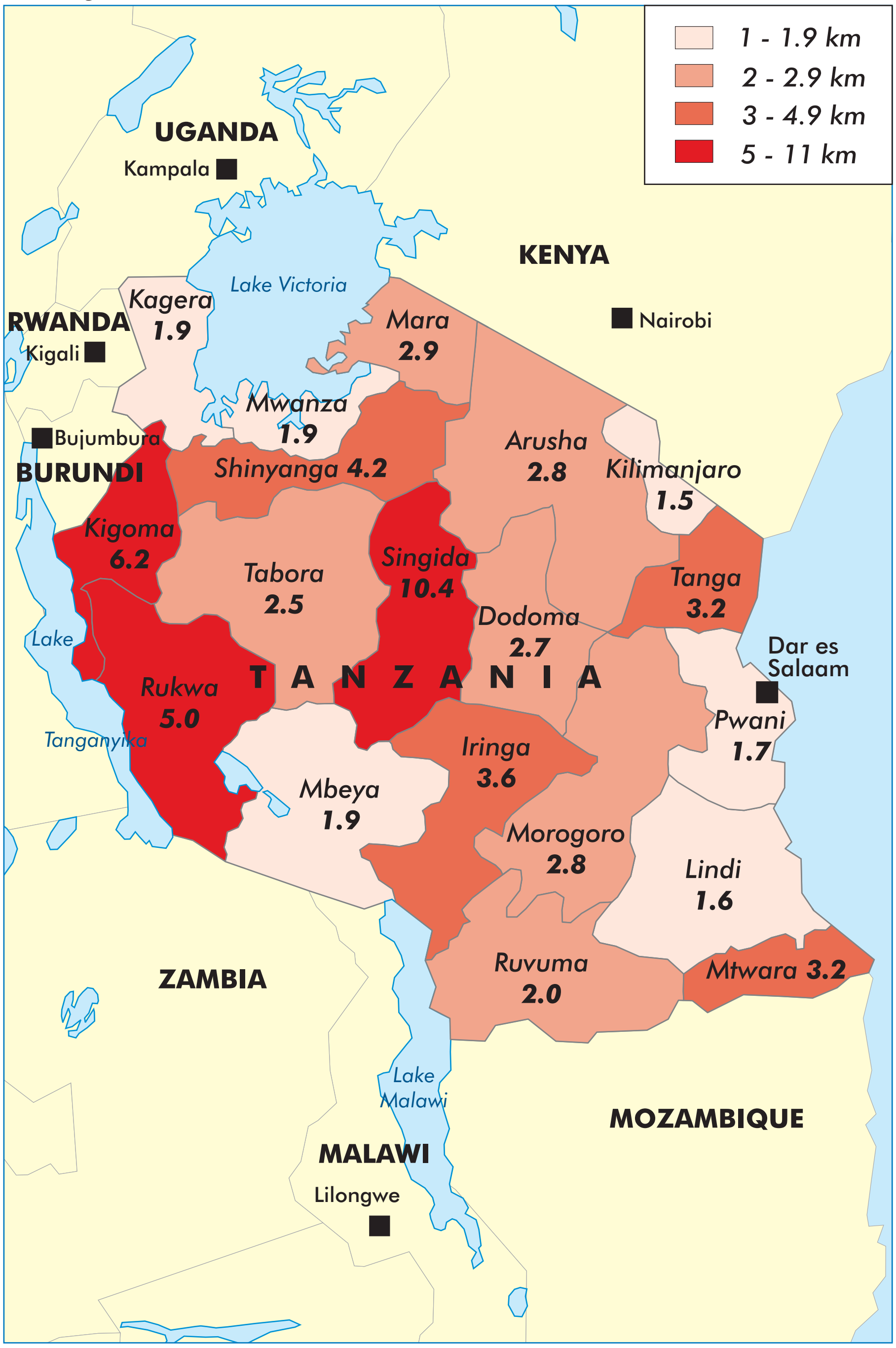
Note: Based on the estimated consumption of fuelwood and charcoal, and production of woody biomass within cells of approximately 10x10 km (5 arc-minutes), applying the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology.
Source: Drigo, R. based on FAO (2006).

Figure 15.6: **Distance Travelled to Collect Fuelwood in Rural Tanzania**



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Source: *Household Budget Survey 2000/01*, National Bureau of Statistics, Tanzania.

poverty (MDG 1) and can play a critical role in improving educational opportunities for children, empowering women and promoting gender equality (MDGs 2 and 3). The availability of adequate clean energy is important in reducing child mortality (MDG 4). Reducing the carrying of heavy loads of fuelwood improves maternal health (MDG 5). Inefficient combustion of fuelwood exacerbates respiratory illnesses and other diseases (MDG 6). Fuel substitution and improved stove efficiencies would help alleviate the environmental damage of biomass use (MDG 7). Finally, widespread substitution of modern energy for traditional biomass can be a rallying point for global partnerships (MDG 8).

Outlook for Household Biomass Use in Developing Countries

Without strong new policies to expand access to cleaner fuels and technologies, the number of people in developing countries relying on traditional biomass as their main fuel for cooking will continue to increase as the global population increases. In the Reference Scenario, in which no new policies are introduced, the number rises from 2.5 billion in 2004 to 2.6 billion in 2015 and to 2.7 billion in 2030 (Table 15.2). Residential biomass demand in developing countries is projected to rise from 771 Mtoe in 2004 to 818 Mtoe in 2030. These projections take into account the fuel substitution and the market penetration of more efficient technologies that would occur as a result of rising per-capita incomes, fuel availability and other factors.

Household sizes by region have been incorporated into the projections, but the rural/urban split has not been estimated through to 2030. Almost all of the growth in population will, in fact, be in urban areas, but the categorisation

Table 15.2: **People Relying on Traditional Biomass** (million)

	2004	2015	2030
Sub-Saharan Africa	575	627	720
North Africa	4	5	5
India	740	777	782
China	480	453	394
Indonesia	156	171	180
Rest of Asia	489	521	561
Brazil	23	26	27
Rest of Latin America	60	60	58
Total	**2 528**	**2 640**	**2 727**

between rural and urban is arbitrary in the statistics of many countries and growth could be in small towns and villages as much as in mega-cities. In line with historical trends, per-capita biomass consumption in each region is assumed to remain constant at 2004 levels over the *Outlook* period (for example, 0.35 toe for sub-Saharan Africa). On the basis of past experience, the share of people relying on traditional biomass technologies will decline faster in towns than in rural areas.

Most of the projected increase in the number of people relying on traditional biomass will occur in Asia and sub-Saharan Africa. In many of these countries, per-capita incomes are not expected to increase enough for people to be able to switch away from traditional biomass to any significant degree. In China, however, the number of people relying on biomass will decline. It will increase only slightly in Brazil, thanks to strong national programmes (Box 15.1). In Indonesia, the rate of growth in the number of people relying on biomass will decline, but there will still be an absolute increase in 2030 over 2004. In the developing world as a whole, the share of the population still relying on biomass is projected to have dropped by 2030 from 52% to 42%.

Box 15.1: **The Brazilian Experience with LPG**

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

During the period 1973-2001, retail LPG prices were set at the same level in all regions and the average level of the subsidy amounted to 18% of the retail price. In May 2001, end-user prices were liberalised, as part of a process of deregulating the petroleum sector. At the same time, the government introduced an *Auxilio-Gas* ("gas assistance") programme to enable qualifying low-income households to purchase LPG. Qualifying families were those with incomes less than half the minimum wage (an average daily per-capita income of $0.34 a day in 2003). The total programme cost in 2002 was about half that of price subsidisation. This programme now forms part of the *Bolsa Familia*, by far the largest conditional cash transfer programme in the developing world (Managing for Development Results, 2006). Recent LPG price increases, however, appear to have led to a reversal of the trend towards lower residential biomass consumption (Figure 15.10).

Improving the Way Biomass is Used

For many households, switching away from traditional biomass is not feasible in the short term. Improving the way biomass is supplied and used for cooking is, therefore, an important way of reducing its harmful effects. This can be achieved either through transformation of biomass into less polluting forms or through improved stoves and better ventilation.

Charcoal and agricultural residue briquettes have a higher energy content than fuelwood and so reduce the amount of fuel needed. Although charcoal is often produced using traditional techniques, with low transformation efficiencies, there is some evidence that fuelwood supply in developing countries can be adequate, even in densely populated areas, if resources are well managed. Even less polluting than briquettes are modern biomass fuels such as ethanol gel, plant oils and biogas (discussed in the next section).

A second approach is to improve the efficiency of biomass use through provision of improved stoves and enhanced ventilation. Adding chimneys to stoves is the most effective improvement to be made from the point of view of health. Increasing household ventilation is also a very cost-effective measure. Other technologies include "retained heat" cookers, fan stoves and "rocket" stoves. Improved stoves are not prohibitively expensive, ranging from $2 in Ethiopia to $10-$15 for rocket stoves in Guatemala. Improved biomass stoves save from 10% to 50% of biomass consumption for the same cooking service provided (REN21, 2005) and can reduce indoor air pollution by up to one-half. A study of indoor air pollution levels in Bangladesh confirms that kitchen design and ventilation play a key role in reducing emissions. Particulate levels in houses using wood, but with good ventilation, were found to be lower even than those in houses using LPG (Dasgupta *et al.*, 2004).

Today, about 560 million households rely on traditional biomass for cooking. Since the 1980s, hundreds of millions of improved stoves have been distributed worldwide, with varying degrees of success. China's Ministry of Agriculture estimated that, in 1998, 185 million out of 236 million rural households had improved biomass or coal stoves (Sinton *et al.*, 2004). In India, an estimated 34 million stoves have been distributed, while in Africa 5 million improved biomass stoves are in use (REN21, 2005). The number of improved stoves actually still in operation in all regions may be significantly less than the number distributed.

Modern Cooking Fuels and Stoves

In the long run, and even today in areas where sustainable biomass use is not possible, a modern cooking fuel solution is the most appropriate way to reduce the health risks and time-loss suffered by women and children. There are a range of fuels that can substitute for, or supplement the use of, biomass in the household energy mix. Each modern fuel has distinct characteristics and costs, as shown in Table 15.3. Some are already widely available.

Table 15.3: **Costs and Characteristics of Selected Fuels**

	Capital cost*	Fuel cost	Notes
Biogas	$100-1 000	0	Commercially available; direct fuel cost is zero (requires water and dung or leafy biomass material, usually collected in non-commercial form); more economic at village scale; an important option for some rural areas, in China and other parts of Asia; less favoured in Africa, where villages are more dispersed; formed by anaerobic digestion.
Plant oils	$38-45	$0.45-$0.60 per litre	Deployment phase; functions like a kerosene pressure stove; safer than kerosene or LPG; burns oils such as coconut, palm, rapeseed, castor and jatropha; renewable resource which can be locally produced.
DME	$45-60	$0.25-$0.35 per kg	Demonstration phase; similar to LPG; dimethyl ether (DME) is today manufactured in small-scale facilities by dehydration of methanol derived from natural gas or coal. DME can also be produced from biomass. The construction of large plants for making methanol and DME from coal has recently been announced in China (Box 15.2), where most production is used for blending with LPG.
Ethanol gel	$2-20	$0.30-$0.70 per litre	Deployment phase; viable particularly in areas with large sugar cane plantations that produce ethanol; safe and clean biomass cooking fuel, being promoted in several African and south Asian countries.
Kerosene	$30-40	$0.50-$0.60 per litre	Commercially available; produces more emissions than LPG and carries a higher risk of injury; available as a liquid or gas; in liquid form, easier to transport and distribute and can be purchased in any quantity.
LPG	$45-60	$0.55-$0.70 per kg	Commercially available, more widely in urban areas than rural; issues of affordability and distribution limit use in rural areas; disadvantages of LPG for low-income households are its relatively large start-up cost and refill cost.

* Cost of digester for biogas; cost of stove and cylinder for all other fuels.

In view of their ability to reduce indoor air pollution levels substantially and their short-term potential for expansion, a number of fuels are well-placed to make major contributions to improving the household energy situation in developing countries. LPG is already quite well established in some countries. Ethanol gel is also potentially very important, particularly in sugar-producing countries, because of its low cost. Biogas has considerable potential in many rural communities, though the capital costs are not directly comparable to those of liquid fuels.

Box 15.2: **Household Coal and Alternatives in China**

China differs from most other developing countries because of the predominance of coal use for cooking and heating. China has the world's third-largest proven reserves of coal (BP, 2006). This coal can contain large quantities of arsenic, lead, mercury, other poisonous metals and fluorine. Burned in unventilated stoves, these pollutants pose a serious health threat. In addition to the health impacts associated with smoke from biomass described earlier, with coal there is evidence of a strong correlation with lung cancer in women (WHO, 2006).

The Chinese government is taking steps to increase access to fuels such as biogas and DME. The National Development and Reform Commission has recently recommended that policies supporting DME be strengthened and that standards be established. The cost of DME production from coal can be much lower than the cost of imported LPG. It can be mixed with LPG in any proportion but, with blends of up to 20%, no LPG stove modification is necessary. Plans have been announced for expanding DME production from coal in China to more than 3 million tonnes per year by 2010. This could provide cooking fuel to at least 40 million people.

Quantifying the Potential Impact of Modern Cooking Fuels and Stoves

The UN Millennium Project has adopted a target of reducing by 50% the number of households using biomass as their primary cooking fuel by 2015.[11] The cost of achieving this target is assessed below, as well as the potential effects

11. The UN Millennium Project recommendation related to energy for cooking is the following: *Enable the use of modern fuels for 50% of those who at present use traditional biomass for cooking. In addition, support (a) efforts to develop and adopt the use of improved cookstoves, (b) measures to reduce the adverse health impacts from cooking with biomass, and (c) measures to increase sustainable biomass production* (UN Millennium Project *et al.*, 2005).

on global oil demand and related emissions. The costs and other implications of expanding access to cleaner, more efficient fuels and technologies for all households by 2030 are also described.

LPG is used as a proxy for modern fuels in this analysis. However, especially in the period 2015 to 2030, other options include ethanol gel, plant oils, biogas and DME. The appropriate choice will vary by country, by region and over time.[12] Some communities will prefer the cleaner, more efficient use of biomass energy. Biogas might be an especially attractive option for India and some regions in both east and southeast Asia, because of their abundant biomass resources. Other modern biomass fuels and LPG might be a more appropriate option for Africa, Latin America and parts of east Asia. DME is likely to become an important complement to LPG in China in the near term and its use might spread to other regions if it offers clear cost advantages over LPG.

There will still be significant biomass use in developing countries in 2030. This could be a positive development, as stressed earlier in the chapter, as long as improved cooking stoves are adopted. Nevertheless, large-scale substitution of traditional biomass by alternative fuels will need to take place as well. The objective in this section is to illustrate the scale of the task. Meeting the 2015 target would mean 1.3 billion people switching to LPG as their primary fuel, while universal access in 2030 would call for 2.7 billion people to switch (Table 15.4).

Table 15.4: **Additional Number of People Needing to Gain Access to Modern Fuels** (millions)

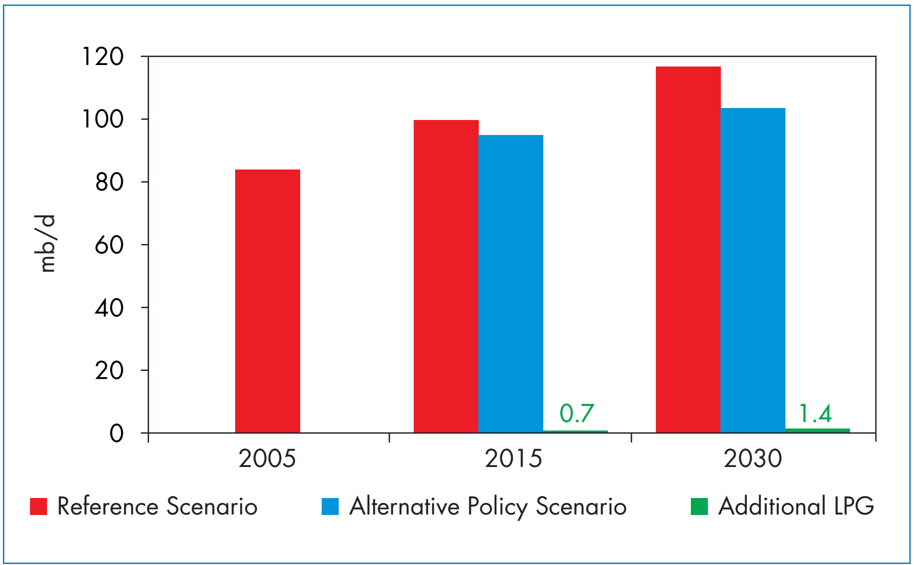
	Between 2004 and 2015	**Between 2015 and 2030**
Sub-Saharan Africa	314	406
North Africa	2	3
India	389	394
China	226	168
Indonesia	85	94
Rest of Asia	261	300
Brazil	13	14
Rest of Latin America	30	28
Total	**1 320**	**1 407**

12. For example, the Indonesian government is commencing a programme to replace kerosene with LPG in urban households and to replace biomass with coal briquettes in some rural areas.

Implications for Oil Demand

LPG is generated as a by-product of both oil refining and natural gas production. The incremental world oil and gas demand which would result from widespread take-up of LPG is negligible. Assuming average consumption of LPG of 22 kg per person per year[13] and assuming all of this LPG was derived from oil rather than natural gas, providing 1.3 billion additional people with LPG by 2015 would increase oil demand by 0.7 mb/d, or 0.69% of the 99 mb/d projected in the Reference Scenario (Figure 15.7). The increase would be 0.72% in the Alternative Policy Scenario. If all households currently using biomass switched to LPG by 2030, the rise in oil demand would be 1.4 mb/d. Such a figure is but a tiny fraction of the fuel lost through the flaring of natural gas.[14] These are upper bounds because, as noted earlier, LPG is just one of several energy carriers that could be pursued as substitutes for traditional biomass, whereas these calculations have taken LPG as a proxy for them all.

Figure 15.7: **Additional LPG Demand Associated with Switching Compared with World Oil Demand**



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13. A weighted average based on WHO data for developing country households currently using LPG.
14. Around 60% of global LPG supply comes from natural gas processing.

Implications for Greenhouse Gas Emissions

The overall effect on greenhouse-gas emissions of switching from biomass to LPG is very difficult to quantify because it depends on many factors, including the particular fuels involved, the types of stoves used and whether the biomass is being replaced by new planting. Both biomass and non-biomass fuels emit CO_2 and other greenhouse gases. If burnt biomass is not replaced by new growth, a net addition of CO_2 to the atmosphere occurs. Also, inefficient biomass combustion produces some gases which have an even more powerful greenhouse effect than CO_2. Although biomass used with traditional stoves can be carbon-neutral (if CO_2 emissions from the combustion process are offset by absorption during regrowth), the process is not emissions-neutral unless the biomass fuel is burnt efficiently and completely (UNEP, 2006). Although the overall impact on emissions of switching to modern fuels can be either positive or negative, improved stoves and greater conversion efficiency would result in unambiguous emissions reductions from all fuels.

Costs and Financial Implications

Switching to LPG involves capital expenditure for the stove and cylinder and recurring expenditure for the fuel itself. Costs per household vary somewhat by region according to differences in household size. The capital expenditure for the equipment (stoves and cylinders) is assumed to be $50 per household (UN Millennium Project *et al.*, 2005).[15] On that basis, the total stove and cylinder cost would be $13.6 billion in the period to 2015 (Table 15.5), or $1.5 billion per year, and $14.5 billion in the period 2015-2030. Spending needs would be highest in India.

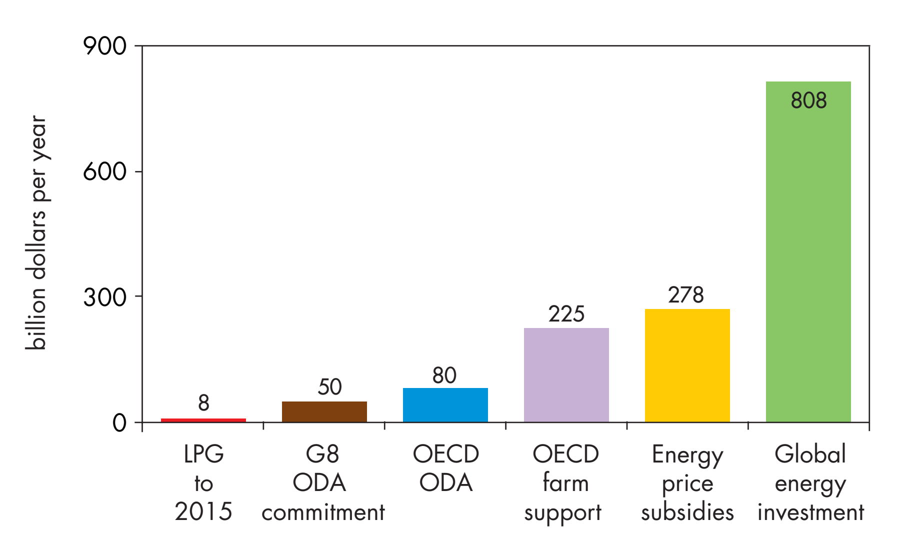
Fuel costs are estimated to be $0.55 per kilogram of LPG, based on 2005 consumer prices in a sample of developing countries. Combined with start-up capital costs, the total bill (capital *plus* fuel costs) for households switching to LPG would then be $8 billion per year in the period to 2015 and $18 billion per year from now to 2030. Although these costs are not negligible, they are small compared with allocations of resources elsewhere in the world economy (Figure 15.8). For example, the annualised capital and operating costs through to 2030 represent 10.6% of what OECD countries spent on Official Development Assistance (ODA) in 2004, 3% of the estimated $278 billion that developing and transition economies spent on energy price subsidies in 2005 (Chapter 11) and 1% of the $808 billion that will need to be spent annually on global energy infrastructure in the Reference Scenario (Chapter 2).

15. The UNDP/WLPGA LP Gas Challenge estimates $45 to $60 for a stove, a cylinder and 6kg of gas.

Table 15.5: **Purchase Cost of LPG Stoves and Cylinders by Region**
($ billion)

	50% target in 2015	2015-2030	100% provision in 2030
Sub-Saharan Africa	3.0	3.9	6.9
North Africa	0.02	0.02	0.04
India	3.9	3.9	7.8
China	2.5	1.8	4.3
Indonesia	0.9	1.0	2.0
Rest of Asia	2.9	3.3	6.2
Brazil	0.1	0.1	0.3
Rest of Latin America	0.3	0.3	0.6
Total	**13.6**	**14.5**	**28.1**

Figure 15.8: **Comparison of Average Annual Cost of LPG Fuel and Technology, 2007-2015, with Other Annual Allocations of Resources**
($ billion)



Sources: G8 ODA Commitment – additional ODA per year by 2010; OECD ODA – www.oecd.org/dac; OECD Farm Support – OECD (2006a); Energy Price Subsidies – total for developing countries and transition economies (Chapter 11); Global Energy Investment – total requirement in the Reference Scenario (Chapter 2).

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Analysis by the World Health Organization suggests that the societal benefits of such expenditure outweigh the costs by a very wide margin. The figure for the societal benefit/cost ratio of a global clean cooking initiative, as estimated by the WHO (2006), is so high that the findings on the value of such an initiative are robust under a wide range of alternative assumptions. The WHO estimates that the total benefits of meeting this UN Millennium Project-based target by 2015 through switching to LPG would average $91 billion per year (Table 15.6).

Table 15.6: **Benefits of Cleaner Cooking** ($ billion per year)

Health-care savings	0.38
Time savings due to childhood and adult illnesses prevented: school attendance days gained for children and productivity gains for children and adults	1.46
Time savings due to less time spent on fuel collection and cooking: productivity gains	43.98
Value of deaths averted among children and adults	38.73
Environmental benefits	6.07
Total benefits	**90.62**

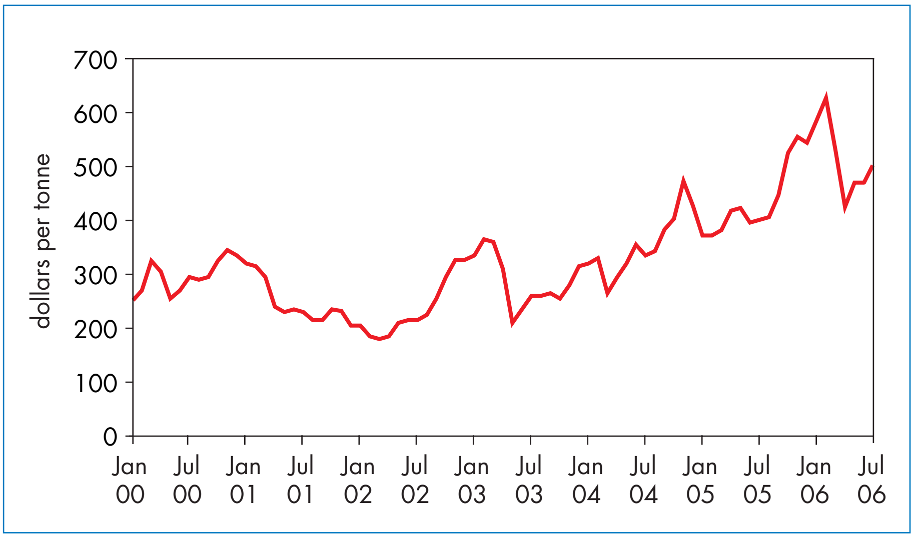
Note: Societal economic benefits of providing LPG to half the population by 2015 who would otherwise be using solid fuels for cooking in 2015.
Source: WHO (2006).

Policy Implications

Meeting the cooking-fuel target will require government action. On the supply side, it can be difficult to establish a commercially viable LPG distribution network in the face of low population density, poor roads, and low LPG uptake and consumption among those who sign up for LPG. The absence of economies of scale in catering to rural domestic consumers is one of the main factors hindering LPG access. Infrequent delivery of refill cylinders serves as a disincentive to switching to LPG. Demand-side barriers include low per-capita incomes, lack of awareness of the benefits of alternative fuels, inappropriate stove designs and simple force of habit. Moreover, even were LPG widely available, many poor households would not be able to afford the required capital investments. The start-up cost of buying a stove and paying a deposit for a fuel canister represents a serious barrier for many households.

The trend worldwide is towards removal of price subsidies, linking final consumer prices of kerosene and LPG to international market prices. These have fluctuated significantly in recent years (Figure 15.9), reflecting swings in international crude oil prices: the Saudi LPG contract price, a benchmark for international prices, has ranged from a low of $200 per tonne in 2002 to over $600 per tonne in early 2006. If fluctuations of that magnitude were reflected in domestic cooking fuel prices, poor households would find it difficult to pay for fuel or budget for future purchases.

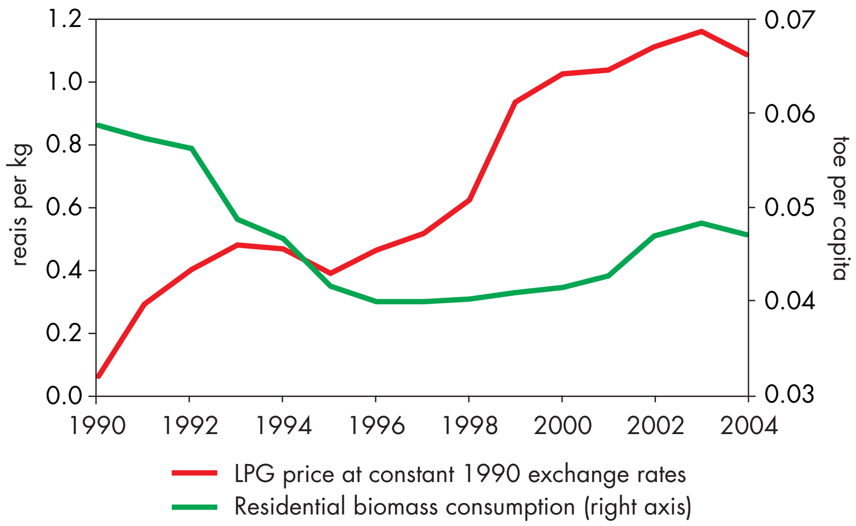
Figure 15.9: **Saudi Aramco Contract LPG Price** (butane, $ per tonne)



Notes: Saudi Aramco Contract is a benchmark LPG price. The price of propane differed only very slightly from that of butane over the period shown in the chart.
Source: LPG Australia, available at www.lpgaustralia.com.au.

Although more analysis is needed, there is evidence that the trend to switch away from traditional biomass is being reversed under the pressure of higher oil prices. In Brazil, for example, biomass consumption per capita has stopped declining and even started to increase, as many poor households switch back to fuelwood, in the face of higher LPG prices (Figure 15.10). In some poor communities in Brazil, inefficient stoves adapted to burning scraps of wood have resurfaced. As countries remove their price controls and let domestic prices rise to world levels, they are likely to face the same predicament.

Figure 15.10: **Residential Biomass Consumption and LPG Retail Price in Brazil**



Source: LPG prices – Economic Commission for Latin America and the Caribbean; Residential biomass consumption – IEA databases.

There are many ways in which policy-makers and other stakeholders can help make clean fuels affordable. The LP Gas Rural Energy Challenge[16], among other initiatives, is working to this end. One approach is to encourage the development of microfinance (Box 15.3). There may also be a case for subsidising the up-front costs of buying gas stoves and cylinders, in view of the potentially large impact and relatively small overall cost of such a programme. Governments could also facilitate commercialisation of LPG by designing financial incentives and training private entrepreneurs, setting technical standards, extending credit facilities to stove-makers and providing marketing support. Another approach is to promote the use of smaller LPG cylinders. These would lower the initial deposit fee and refilling costs, encouraging more regular LPG consumption, especially in rural areas, and more widespread use of the fuel. This approach has had some success in Morocco. On the other hand, small cylinders do involve higher transaction costs and hence higher unit prices. Also, reliance on more frequent refills can become a problem if the supply system is unreliable.

16. More information is available at www.undp.org/energy/lpg.htm and www.worldlpgas.com.

Box 15.3: **The Role of Microfinance in Expanding the Use of Modern Fuels**

Microfinance institutions allow households and villages to mobilise the capital needed to make small energy investments. Notably, women's access to such financial services has increased in the past decade. Worldwide, four out of five micro-borrowers are women. Microfinance is particularly important in rural areas where farmers have no income for long periods of the year.

One of the principal barriers to the penetration of modern cooking fuels is the high initial cost of the cylinder purchase (in the case of LPG) and the stove. An option to overcome up-front costs is for a bank or financial institution to offer financing for the cylinder and appliance over a year or more. There are strong arguments for using the community as a vehicle for this financing and making it jointly and individually responsible for repayment.

Energy service companies can assist with cost barriers by providing energy to customers on a fee-for-service basis, retaining ownership of some or all of the energy equipment, pooling subsidies and investment incentives and amortising over time the balance of equipment costs in the fees charged to customers. An affordable connection fee would be collected, offsetting some equipment costs, with the remainder amortised in the charges for each refill. If the customer returns the bottle for refill, credit risk and collection costs for LPG decline significantly.

Providing improved stoves and canisters is a necessary, but not a sufficient condition for expanding the use of modern fuels. Annual fuel costs are typically several times the annualised cost of stoves and canisters. Many rural households would not be able to afford LPG, even with microfinance or subsidised capital investment. The challenge is especially daunting for those dependent on agriculture, where incomes are not only low but volatile. In such cases, efforts to tackle energy poverty would clearly need to go hand in hand with broader policies aimed at alleviating poverty more generally and promoting economic development. Clean-cooking initiatives would ideally be carried out in parallel with programmes for education, rural electrification and industrialisation, which would also enable time freed up to be productively reallocated. In general, income-support or social welfare programmes are a far more effective way of addressing poverty than subsidies to the fuels themselves.

One of the recommendations of the UN Millennium Project was that objectives regarding energy services should be placed on a par with the original Millennium Development Goals. Efforts by groups such as the LP Gas Rural Energy Challenge have had some success but, at the global level, the resources and attention devoted to improving energy use for cooking are not commensurate with the magnitude of the problem. Compared with the international response to hunger, HIV/AIDS, dirty water, poor sanitation and malaria, energy use for cooking has received extremely limited funding and high-level political backing. Even in countries where the vast majority of the population relies on traditional biomass for cooking, access to electricity has received much more attention and investment. Climate-driven programmes have also tended to bypass household energy use for cooking, since biomass-based energy sources were regarded as emissions-neutral. There are opportunities for the private sector to make up the shortfall in funding. Support to microfinance institutions could also be an effective approach, as would new financing mechanisms, such as the MDG Carbon Facility of the UNDP.[17]

Large electricity generation, transmission and distribution projects primarily benefit industry and urban populations, while most rural and poor people depend on biomass (OECD, 2006b). Effective, comprehensive policies need to include the forms of energy used by the poor – for cooking, lighting, productive appliances and transport – rather than concentrate on provision of electricity alone as an end in itself.

Detailed, accurate statistics on energy supply and consumption are essential for proper policy and market analysis. Efforts are under way to improve regular data collection through international surveys such as the Living Standards Measurement Study and the Multiple Indicators Cluster Surveys. The IEA and FAO are developing a standard joint terminology (FAO, 2004). Greater coverage, both geographical and temporal, is needed and more resources should be devoted to achieving this. Better information on markets and technologies is also needed. Although the findings of this chapter are robust, better data would allow for more detailed analysis at the local and household levels.

Governments could increase provision of training programmes to develop skills and expertise in the area of improved stoves and housing design, and to educate people about the health risks of indoor air pollution. Simple measures can be very effective, such as improving public awareness of changes that can reduce smoke levels, like drying wood thoroughly before use and shortening cooking time (by using a pot lid). Similar gains can be made from improvements in household design, such as increasing the number of window openings in the kitchen, providing gaps between roof and wall and moving the stove out of the living area.

17. The MDG Carbon Facility was founded on the basis that climate change threatens to significantly undermine efforts to achieve the Millennium Development Goals. More information is available at www.mdgcarbonfacility.org.

The benefit/cost ratio of government intervention to help poor households gain access to affordable modern energy has been found to be very high and the cost would be small compared with total aid budgets or global energy investment. Greater energy efficiency and diversity of energy sources in developing countries would provide a gain in energy security at only a very small cost in terms of the increase in world oil and gas demand.

Effective policies will need to be locally designed, since there are substantial differences between and even within countries. Regulatory reforms can improve the affordability, availability and safety of a range of cooking fuels and technologies. Governments can also support cleaner cooking by developing national databases which include information on the population to be served, potential fuels, stoves, the infrastructure and potential providers, together with cost analyses and estimates of the ability and willingness to pay, as a function of income. Long-term commitments are needed from development partners to scale up energy investments, transfer knowledge and deploy financing instruments which will leverage private capital, particularly in countries with the largest concentration of the energy-poor, such as those in sub-Saharan Africa and south Asia.