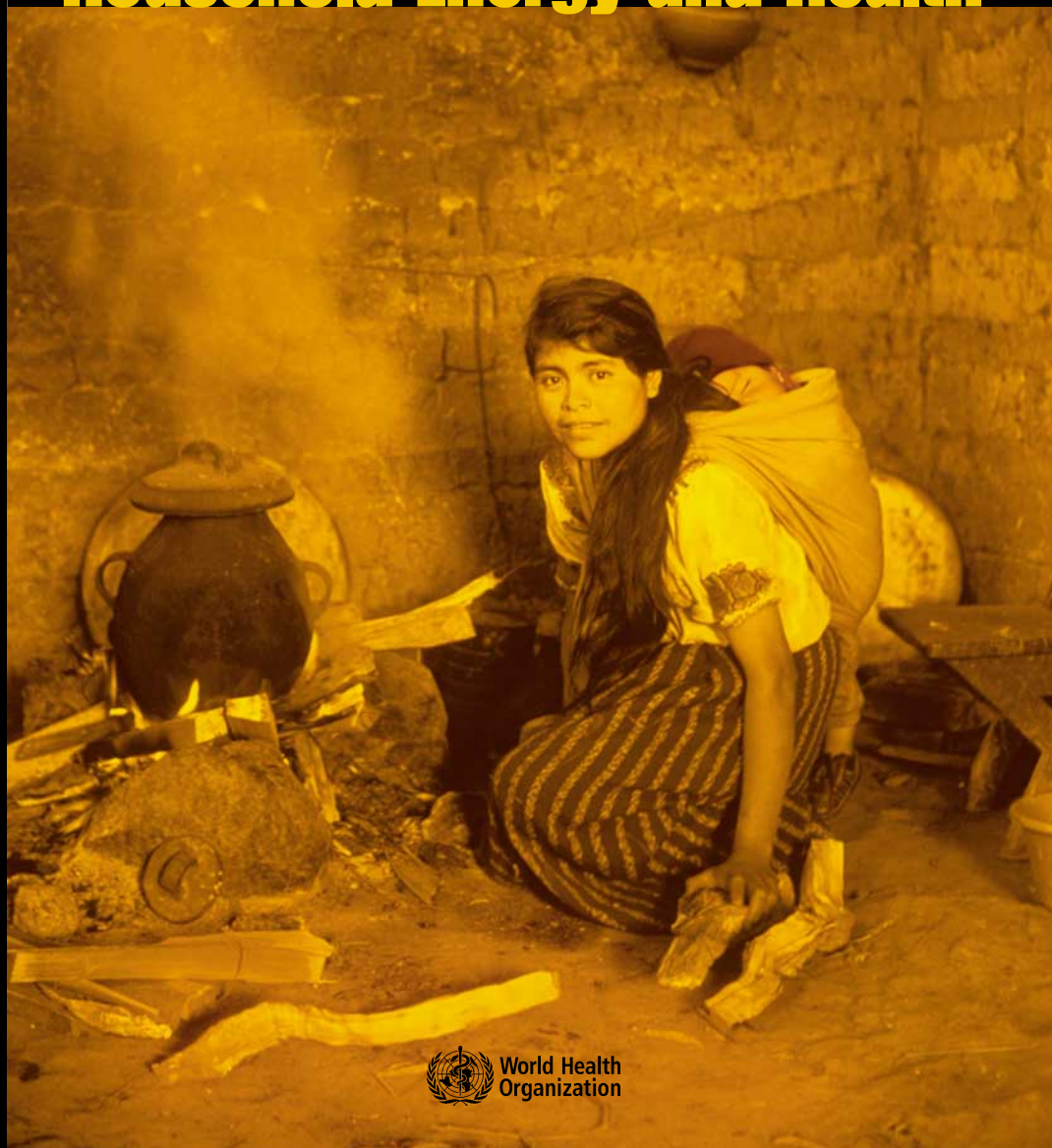
World Health Organization

Fuel for Life

Household Energy and Health



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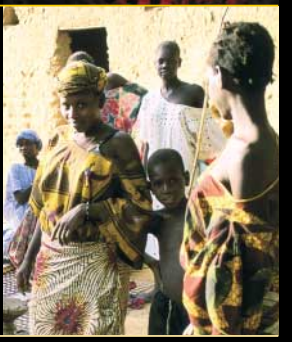

Foreword

Energy is essential to meet our most basic needs: cooking, boiling water, lighting and heating. It is also a prerequisite for good health – a reality that has been largely ignored by the world community.

More than three billion people still burn wood, dung, coal and other traditional fuels inside their homes. The resulting indoor air pollution is responsible for more than 1.5 million deaths a year – mostly of young children and their mothers. Millions more suffer every day with difficulty in breathing, stinging eyes and chronic respiratory disease. Moreover, indoor air pollution and inefficient household energy practices are a significant obstacle to the achievement of the Millennium Development Goals.

Fuel for life, food for thought. With this publication we draw attention to a serious neglected public health problem. Effective solutions exist and the economic case for taking practical solutions to scale is just as strong as the humanitarian case. Making cleaner fuels and improved stoves available to millions of poor people in developing countries will reduce child mortality and improve women's health. In addition to the health gains, household energy programmes can help lift families out of poverty and accelerate development progress.

We hope that *Fuel for life* will inspire and prompt vigorous action to close the household energy gap.

Dr LEE Jong-wook
Director-General
World Health Organization

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section 1

Household Energy, Indoor Air Pollution and Health

Household energy: three billion left behind

"The health of the people is really the foundation upon which all their happiness and all their powers as a state depend."

Benjamin Disraeli,
British statesman and writer (1804–1881)

Cooking as an enjoyable pastime and passion for a privileged minority – on an electric range or a gas stove in a stylish kitchen in New York, Paris or Tokyo. Cooking as a chore and threat to the lives of the great majority – on an open fire in a shabby hut in rural Africa, south Asia or Latin America.

Worldwide, more than three billion people depend on solid fuels, including biomass (wood, dung and agricultural residues) and coal, to meet their most basic energy needs: cooking, boiling water and heating (Figure 1). Opening the door to their homes makes for a hazy welcome: thick grey smoke fills the air, making breathing unbearable and bringing tears to the eyes. The inefficient burning of solid fuels on an open fire or traditional stove indoors creates a dangerous cocktail of hundreds of pollutants, primarily carbon monoxide and small particles, but also nitrogen oxides, benzene, butadiene, formaldehyde, polyaromatic hydrocarbons and many other health-damaging chemicals. Day in day out, and for hours at a time, women and their small children breathe in amounts of smoke equivalent to consuming two packs of cigarettes per day. Where coal is used, additional contaminants such as sulfur, arsenic and fluorine may also be present in the air.

Yet, these families are faced with an impossible dilemma: don't cook with solid fuels, or don't eat a cooked meal. Being poor condemns half of humanity to dependence on polluting household energy practices. With increasing prosperity, cleaner, more efficient and more convenient fuels are replacing, step-by-step, traditional biomass fuels and coal. Climbing up the energy ladder tends to occur gradually as most low- and middle-income households use a combination of fuels to meet their cooking needs (Figure 2).

The problem of indoor air pollution has been around since the Stone Age, yet international development agendas still fail to recognize that missing out on clean energy equals missing out on life.

Figure 1: Energy poverty in people's homes
Percentage of population using solid fuels (Millennium Development Goal indicator 29), 2003 or latest available data

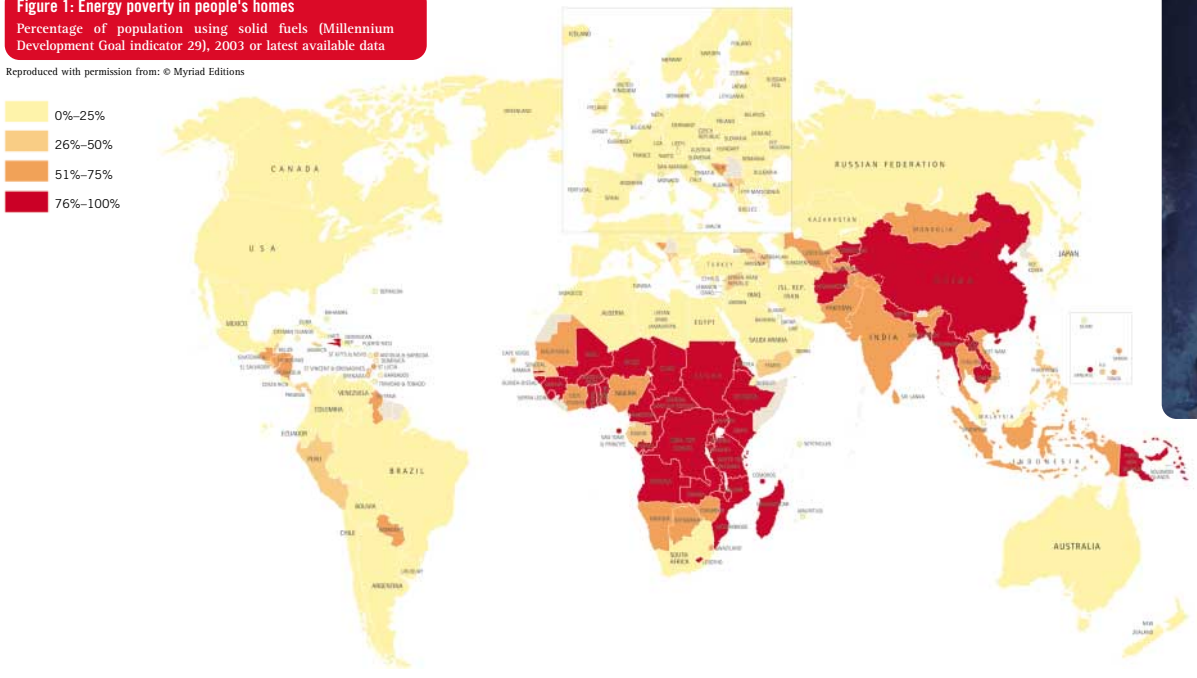
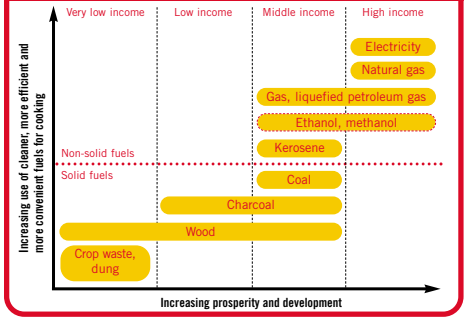


Figure 2: The energy ladder: household energy and development inextricably linked



Health at the heart of the matter

Black soot covers the walls of the dwelling. It is the pollutants in this black soot, as well as many invisible pollutants in the air, that women and children breathe in for many hours every day. Small particles (with a diameter of up to 10 microns (PM_{10})) are the most widely used indicator of the health hazard of indoor air pollution. Fine particles (with a diameter of up to 2.5 microns ($PM_{2.5}$)) are able to penetrate deep into the lungs and appear to have the greatest health-damaging potential. It is known that these particles can cause inflammation of the airways and lungs and impair the immune response, yet the precise mechanism by which exposure to indoor air pollution translates into disease is still unknown.

Burning solid fuels produces extremely high levels of indoor air pollution: typical 24-hour levels of PM_{10} in biomass-using homes in Africa, Asia or Latin America range from 300 to 3000 micrograms per cubic metre (μg/m³). Peaks during cooking may be as high as 10 000 μg/m³. By comparison, the United States Environmental Protection Agency has set the standard for annual mean PM_{10} levels in *outdoor* air at 50 μg/m³; the annual mean PM_{10} limit agreed by the European Union is 40 μg/m³. As cooking takes place every day of the year, most people using solid fuels are exposed to levels of small particles many times higher than accepted annual limits for outdoor air pollution (Figure 3). The more time people spend in these highly polluted environments, the more dramatic the consequences for health. Women and children, indoors and in the vicinity of the hearth for many hours a day, are most at risk from harmful indoor air pollution.

Since the mid-1980s, epidemiological studies have been investigating the impacts of exposure to indoor air pollution on health. The results of these studies have recently been reviewed by WHO (Table 1). Inhaling indoor smoke doubles the risk of pneumonia and other acute infections of the lower respiratory tract among children under five years of age. Women exposed to indoor smoke are three times more likely to suffer from chronic obstructive pulmonary disease (COPD), such as chronic bronchitis or emphysema, than women who cook with electricity, gas or other cleaner fuels. And coal use doubles the risk of lung cancer, particularly among women.

Moreover, some studies have linked exposure to indoor smoke to asthma; cataracts; tuberculosis; adverse pregnancy outcomes, in particular low birth weight; ischaemic heart disease; interstitial lung disease, and nasopharyngeal and laryngeal cancers. New research is needed to shed light on how exposure to indoor smoke contributes to this long list of health problems (see also Box 1).

Figure 3: Smoky streets, smoky homes
Typical 24-hour mean levels of small particles (PM_{10}) in micrograms per cubic metre (μg/m³), early 2000s

USEPA, US Environmental Protection Agency.

Table 1: Health impacts of indoor air pollution

Health outcome	Evidence[1]	Population	Relative risk[2]	Relative risk (95% confidence interval)[3]	
Acute infections of the lower respiratory tract	Strong	Children aged 0–4 years	2.3	1.9–2.7	SUFFICIENT
Chronic obstructive pulmonary disease	Strong	Women aged ≥ 30 years	3.2	2.3–4.8	SUFFICIENT
	Moderate I	Men aged ≥ 30 years	1.8	1.0–3.2	SUFFICIENT
Lung cancer (coal)	Strong	Women aged ≥ 30 years	1.9	1.1–3.5	SUFFICIENT
	Moderate I	Men aged ≥ 30 years	1.5	1.0–2.5	SUFFICIENT
Lung cancer (biomass)	Moderate II	Women aged ≥ 30 years	1.5	1.0–2.1	INSUFFICIENT
Asthma	Moderate II	Children aged 5–14 years	1.6	1.0–2.5	INSUFFICIENT
	Moderate II	Adults aged ≥ 15 years	1.2	1.0–1.5	INSUFFICIENT
Cataracts	Moderate II	Adults aged ≥ 15 years	1.3	1.0–1.7	INSUFFICIENT
Tuberculosis	Moderate II	Adults aged ≥ 15 years	1.5	1.0–2.4	INSUFFICIENT

[1] *Strong evidence: Many studies of solid fuel use in developing countries, supported by evidence from studies of active and passive smoking, urban air pollution and biochemical or laboratory studies.*
Moderate evidence: At least three studies of solid fuel use in developing countries, supported by evidence from studies on active smoking and on animals.
Moderate I: strong evidence for specific age/sex groups. Moderate II: limited evidence.
[2] *The relative risk indicates how many times more likely the disease is to occur in people exposed to indoor air pollution than in unexposed people.*
[3] *The confidence interval represents an uncertainty range. Wide intervals indicate lower precision; narrow intervals indicate greater precision.*

Box 1: Better household energy practices to mitigate the HIV/AIDS crisis?

Winning the battle against HIV/AIDS calls for effective prevention and treatment. But it also requires that people maintain their energy levels and physical fitness. Household energy plays a crucial role in keeping patients and their caregivers going: It is indispensable for cooking safe, nutritious meals and for boiling water to ensure its safety for drinking. It is essential for preparing hot compresses, heating water for bathing and sterilizing utensils for patients. And it provides warmth for those who are ill and suffering.

In Africa, wood tends to be scarce where collected and expensive where purchased. The incomplete combustion of biomass fuels indoors produces dense smoke, a major contributor to respiratory problems – even more so among immunocompromised HIV/AIDS patients. Therefore, more efficient, cleaner household energy practices can help families affected by HIV/AIDS as well as those not affected by the disease to live a healthier life.

Adapted from:
Gebert N. *Mainstreaming HIV/AIDS: Participation or exclusion? Actors in the context of HIV/AIDS and project-induced measures (GTZ) for the optimized utilization of subsistence resources.* German Technical Cooperation Programme for Biomass Energy Conservation in Southern Africa (GTZ ProBEC), in press. Available at: http://www.probec.org

The killer in the kitchen

"Are we to decide the importance of issues by asking how fashionable or glamorous they are? Or by asking how seriously they affect how many?"

Nelson Mandela,
South African statesman and winner
of the Nobel Prize for Peace (1918–)

Malaria, tuberculosis, HIV/AIDS and many other diseases compete for newspaper headlines – and the attention of the public. How should decision-makers prioritize one health problem against another?

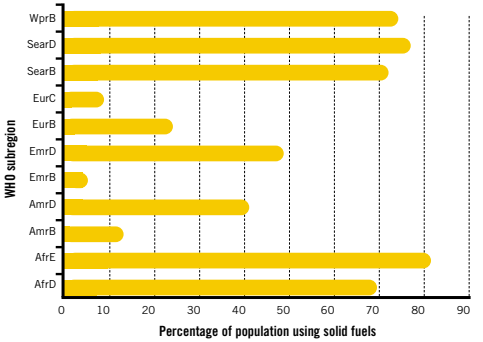
The burden of disease combines years of life lost due to death with the years of life lost due to disability in a single measure that applies across diseases and health risks. WHO investigates the contribution of a range of risk factors, such as malnutrition, smoking and lack of physical activity, to the burden of disease. The results for the year 2000 unveiled cooking as a dangerous undertaking and indoor air pollution from burning solid fuel as one of the top ten global health risks. The "kitchen killer" turned out to be responsible for 1.6 million deaths and 2.7% of the global burden of disease. In poor developing countries, only malnutrition, unsafe sex and lack of clean water and adequate sanitation were greater health threats than indoor air pollution.

This wake-up call placed indoor air pollution on the international public health agenda for the first time. Yet, the most recent and more accurate estimates show practically no change. Globally, 1.5 million people died from diseases caused by indoor air pollution in the year 2002. This figure includes children who died from pneumonia and adults who died from chronic respiratory disease and lung cancer – only those diseases for which current evidence for a link with indoor air pollution is sufficient (see Table 1). What if indoor smoke also turns out to contribute to low birth weight and tuberculosis?

Reliance on polluting solid fuels (Figure 4) and inefficient household energy practices varies widely around the world, as does the death toll due to indoor smoke (Figure 5). In 2002, Sub-Saharan Africa and South-East Asia led with 396 000 and 483 000 deaths due to indoor smoke, respectively. Widespread use of biomass and coal in China plays a key role in chronic respiratory diseases among adults, and was responsible for a large share of the 466 000 deaths in the Western Pacific in 2002. Although the majority of the population in Latin America and the Caribbean, the Eastern Mediterranean and Europe use gas and other cleaner fuels for cooking, the health burden disproportionately falls on the poorest countries in these regions, and on the poorest members of society among whom solid fuel use is still common (see Figure 6 and Trapped by energy poverty).

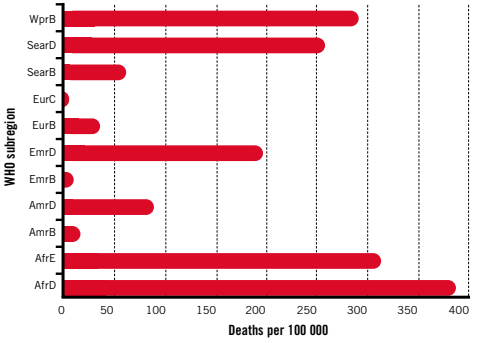
Indoor air pollution continues to ravage rural communities and poor urban dwellers. And it continues to be largely ignored by the world community.

Figure 4: Widespread solid fuel use ...
Percentage of population using solid fuels, by WHO subregion[1], 2003 or latest available data



[1] *WHO distinguishes between the following geographical regions: African Region (Afr); Region of the Americas (Amr); Eastern Mediterranean Region (Emr); European Region (Eur); South-East Asia Region (Sear); Western Pacific Region (Wpr). WHO also differentiates between the following mortality strata: very low child, very low adult (A); low child, low adult (B); low child, high adult (C); high child, high adult (D); high child, very high adult (E).*

Figure 5: ... translates into respiratory deaths
Deaths attributable to indoor air pollution per 100 000 population, by WHO subregion[1], 2002



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section 2

Household Energy and the Millennium Development Goals

Energizing the Millennium Development Goals

"We will spare no effort to free our fellow men, women and children from the abject and dehumanizing conditions of extreme poverty, to which more than a billion of them are currently subjected."

United Nations Millennium Declaration

In September 2000, the largest-ever gathering of Heads of State committed themselves to making the right to development a reality for everyone. The Millennium Declaration promotes a comprehensive approach that tackles a broad range of problems simultaneously. By 2015, the world aims to have achieved eight goals for combating poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women.

There is no Millennium Development Goal on energy. Yet, energy poverty is one of the many manifestations of poverty and a prevailing feature of deprived rural and urban households in developing countries (Figure 6). Lack of energy, in particular lack of access to modern cooking fuels and electricity, already represents a bottleneck, holding back progress towards achieving the goals. Rather than squeezing through the bottleneck, the United Nations Millennium Project proposes to confront the energy issue directly (see The need for a quantum leap). Improved energy services can reduce child mortality rates, improve maternal health, reduce the time and transport burden on women and young girls, and lessen the pressure on fragile ecosystems (Table 2).

Halving the number of people without effective access to modern cooking fuels by 2015 and making improved cooking stoves widely available represents a stepping stone towards achieving the Millennium Development Goals.

Figure 6: Poverty and energy poverty go hand in hand

Percentage of population using solid fuels in some of the world's largest countries, by income quintiles in urban (top) and rural (bottom) locations, 2003

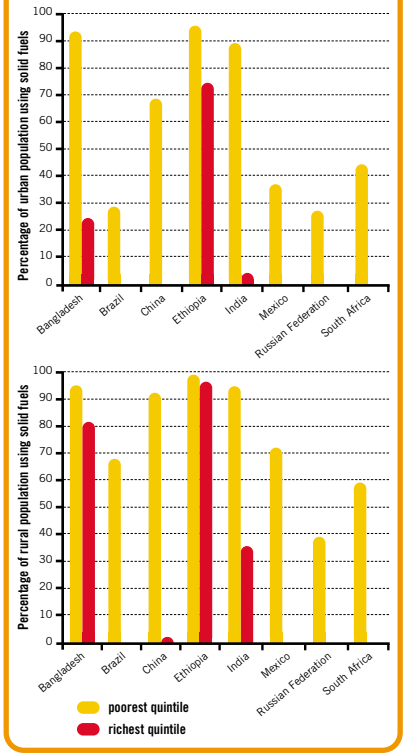


Table 2: Cracking the energy code

Millennium Development Goals	Contribution of improved household energy practices
Goal 1: Eradicate extreme poverty and hunger	• Saving time spent being ill or having to care for sick children will cut health care expenses and increase earning capacities. • Where fuels are purchased, increasing fuel efficiency and thus cutting down on the quantity of fuel needed will ease constraints on already tight household budgets. • Improved household energy technologies and practices will open up opportunities for income generation. • Access to electricity will provide a source of light for economic activities in the evening and a source of energy for operating, for example, a sewing-machine or refrigerator.
Goal 2: Achieve universal primary education	• With less time lost in collecting fuel and due to ill health, children will have more time available for school attendance and homework. • Better lighting will allow children to study outside of daylight hours and without putting their eyesight at risk.
Goal 3: Promote gender equality and empower women	• Alleviating the drudgery of fuel collection and reducing cooking time will free women's time for productive endeavours, education and child care. • Reducing the time and distance that women and girls need to travel to collect fuel will reduce the risk of assault and injury, particularly in conflict situations. • Involving women in household energy decisions will promote gender equality and raise women's prestige.
Goal 4: Reduce child mortality	• Reducing indoor air pollution will prevent child morbidity and mortality from pneumonia. • Protecting the developing embryo from indoor air pollution can help avert stillbirth, perinatal mortality and low birth weight. • Getting rid of open fires and kerosene wick lamps in the home can prevent infants and toddlers being burned and scalded.
Goal 5: Improve maternal health	• Curbing indoor air pollution will alleviate chronic respiratory problems among women. • A less polluted home can improve the health of new mothers who spend time close to the fire after having given birth. • A more accessible source of fuel can reduce women's labour burdens and associated health risks, such as prolapse due to carrying heavy loads.
Goal 6: Combat HIV/AIDS, malaria and other diseases	• Lowering levels of indoor air pollution levels can help prevent 1.6 million deaths from tuberculosis annually.
Goal 7: Ensure environmental sustainability	• Where biomass is scarce, easing the reliance on wood for fuel through more efficient cooking practices will lessen pressures on forests. • Moving up the energy ladder and using improved stoves can increase energy efficiency and decrease greenhouse gas emissions.
Goal 8: Develop a global partnership for development	• Recognition in development agendas and by partnerships of the fundamental role that household energy plays in economic and social development will help achieve the Millennium Development Goals by 2015.

Trapped by energy poverty

Extreme poverty remains a daily reality for more than 1 billion people who survive on less than 1$ per day[1]. Being poor means getting up hungry in the morning, anxious where to find enough food to make it through to the evening (Box 2). Being poor means being forced to accept any work there is and being denied a good school education. Being poor means living in an overcrowded smoky dwelling that lacks sufficient water for drinking, hand-washing and personal hygiene. Being poor means not having the freedom to make choices.

Millennium Development Goal 1, to eradicate extreme poverty and hunger, represents the essence of the Millennium Declaration. Dependence on polluting inefficient household energy practices stops people from breaking out of the vicious cycle of poverty.

Good health is crucial as household livelihoods rely on the health of family members. Being ill as a result of indoor smoke or having to care for sick children reduces earnings and leads to additional expenses for health care and medication. Broken bones, backache and snake bites endured during fuel collection add to the problem. Reports from war zones and refugee camps provide sad testimony of girls and women being assaulted when they leave the relative safety of their homes to collect fuel.

Where fuel is purchased, for example in urban slums in Africa and Asia, spending money on large quantities of inefficient fuels places severe constraints on household budgets. Poor households tend to spend a larger percentage of their income on energy than well-off households (Figure 7). Where fuel is collected, women and children lose many hours a week searching for wood branches and twigs (Figure 8). Fuel collection is not necessarily a daily task, as the duration and frequency of collection varies depending on the availability of wood for use as a fuel. In rural India, for example, daily fuel collection time ranges from only 20 minutes per day in Andhra Pradesh to more than one hour per day in Rajasthan, which is mostly covered by desert. Cooking, serving foods and washing the soot-laden pots adds to this time burden, eating up about three hours of women's time every day.

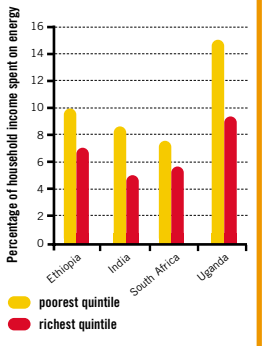
Alleviating the drudgery of collecting fuel far from home and easing the task of cooking through ownership of more efficient devices can free women's time for productive endeavours, education, child care and relaxation. With less time wasted on collecting wood and being ill, children will have more time available to attend school, do their homework and enjoy childhood. Finally, involving women in household energy decisions promotes gender equality and empowers women. Owning a less-polluting stove raises a woman's prestige – both by being a sign of wealth and, indirectly, through providing a soot-free kitchen environment.

Box 2: Too little wood for too many people: household energy and hunger

Where wood supplies are scarce, unsustainable harvesting of fuel endangers agricultural production and threatens a stable supply of crops. Deforestation and ensuing erosion damage formerly fertile fields; this is particularly true where trees are felled for charcoal production to supply urbanizing areas of Africa with fuel. Resorting to dung as a lower-grade fuel interrupts the normal composting process and diverts the dung from being used as a natural soil fertilizer. In the absence of any chemical fertilizers, this will ultimately reduce field productivity.

For these reasons, improving household energy practices will also boost agricultural productivity and food security. By restoring natural soil fertility, they reduce expenditure on chemical fertilizers. Higher fuel efficiency frees women's time for growing food and tending animals.

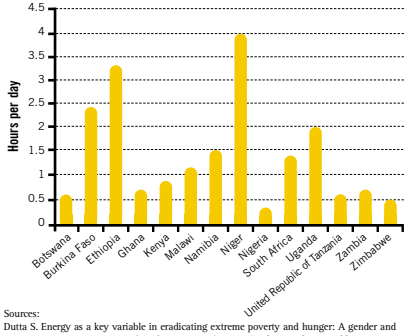
Figure 7: Energy – a major expenditure for poor households



Adapted with permission from:
International Energy Agency, OECD. *World Energy Outlook 2002*. Paris, International Energy Agency and OECD, 2002. Table 13.1.

Figure 8: Time ticking away

Daily hours that women spend collecting fuel in different African geographical settings, by country, 1990–2003



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Dutta S. Energy as a key variable in eradicating extreme poverty and hunger: A gender and energy perspective on empirical evidence on MDG 1. In: *Gender as a key variable in energy interventions*. Draft background paper for ENERGIA/DfID/KaR Research Project R8346. 2005. Available at: http://www.energia.org/
Hutton G, Rehfuess E, Tediosi F, Weiss S. *Evaluation of the costs and benefits of household energy and health interventions at global and regional levels*. Geneva, World Health Organization, in press.

[1] *$ Purchasing power parities (PPPs): These conversion rates equalize the purchasing power of different currencies by eliminating the differences in price levels between countries.*

Women and children overlooked

"Her three children were blinking at me in the darkness from behind her skirt. The woman was extremely ill and had a racking cough, and I remember the blackness inside the home and the stench of wood smoke which was overpowering."

Hilary Benn,
currently Secretary of State for International Development,
United Kingdom, reminiscing about a visit to Northern Ethiopia

Over 10 million children aged under five years die every year – 99% of them in developing countries. "To reduce by two-thirds the under-five mortality rate between 1990 and 2015" may be the most ambitious of the Millennium Development Goals.

Globally, pneumonia remains the single most important child killer and is responsible for 2 million deaths every year (Figure 9). Newborns and infants are often carried on their mother's back while she is cooking, or kept close to the warm hearth. Consequently, they spend many hours breathing polluted air during their first year of life when their developing airways and their immature immune systems make them particularly vulnerable. Indoor smoke is one of the underlying causes and to blame for nearly 800 000 child deaths annually. These deaths are not equally distributed throughout the world: more than one third of the child deaths due to indoor smoke, that is 358 000 deaths, occur on the African continent, and another 288 000 child deaths occur in South-East Asia (Figure 10).

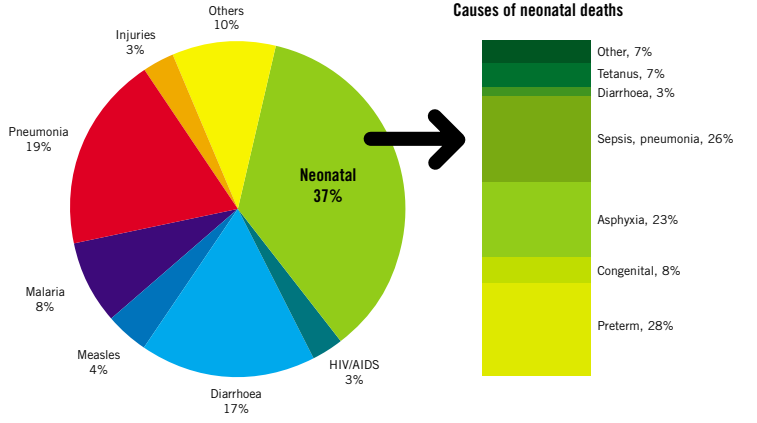
In most societies, women are in charge of cooking. Day after day, and often throughout the course of a lifetime, they spend many hours in the vicinity of the fire or stove. The acrid smoke depositing soot in their lungs is responsible for 511 000 of the 1.3 million deaths due to COPD among women worldwide per year. In contrast, only 173 000 of a total of 1.4 million deaths from COPD among men are due to indoor smoke (Figure 11). Inefficient household energy practices may be of particular significance to the health of pregnant women: carrying heavy loads during fuel collection may bring about prolapse during pregnancy, and exposure of the developing embryo to harmful pollutants may lead to low birth weight as well as stillbirth.

Users of solid fuels in developing countries tend to be poor and, especially in rural areas, are unlikely to live in the vicinity of health care facilities. Their ability to afford medical treatment and to seek medical care for themselves and their sick children is limited. Consequently, trying to reduce the number of deaths from pneumonia through treatment may not benefit the poorest of the poor. And, even if a child is successfully treated for pneumonia, he or she will have to return to a home where high levels of indoor air pollution prevail in combination with other threats to health, such as overcrowding and an inadequate diet.

In contrast, switching to cleaner fuels and increasing fuel efficiency through better stoves can reduce health risks for all family members. Beyond curbing respiratory problems, a more secure household energy situation enables water to be boiled and thus helps reduce the incidence of water-borne diseases. It can also increase the number of hot meals consumed per day and thus improve food safety and nutrition. A closed, raised stove prevents infants and toddlers falling into the fire or knocking over pots of hot liquid and being burned or scalded.

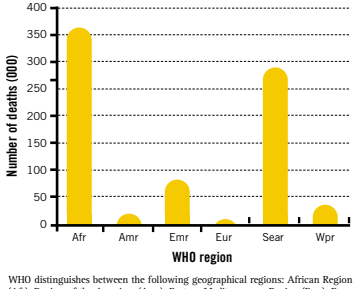
Closing the household energy gap can therefore be a springboard for achieving the health-related Millennium Development Goals.

Figure 9: Pneumonia is a major child killer
Percentage of deaths in children under five years of age, by cause, 2000–2003



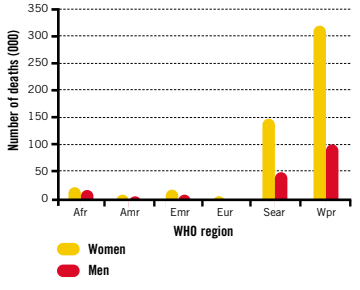
Undernutrition is an underlying cause of 53% of deaths among children under five years of age.

Figure 10: African and South-East Asian children suffer disproportionately
Deaths in children aged under five years from pneumonia and other acute infections of the lower respiratory tract due to indoor air pollution, by WHO region, 2002



WHO distinguishes between the following geographical regions: African Region (Afr); Region of the Americas (Amr); Eastern Mediterranean Region (Emr); European Region (Eur); South-East Asia Region (Sear); Western Pacific Region (Wpr).

Figure 11: Women most at risk
Deaths from chronic obstructive pulmonary disease due to indoor air pollution, by gender and WHO region, 2002



WHO distinguishes between the following geographical regions: African Region (Afr); Region of the Americas (Amr); Eastern Mediterranean Region (Emr); European Region (Eur); South-East Asia Region (Sear); Western Pacific Region (Wpr).

Stripping our forests, heating our planet

"Over the last 50 years, humans have changed ... ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre and fuel ... The degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals."

Millennium Ecosystem Assessment, 2005

Human survival and prosperity are critically dependent on the environment. Complex ecosystems ensure a continuous supply of food and fresh water and provide wood and other natural resources for our use. They regulate our climate and protect us from floods and other natural disasters. Ecosystems have shown a remarkable capacity to accommodate more and more of our needs, yet, this very foundation of our existence is now threatened by population growth and the unsustainable use of natural resources.

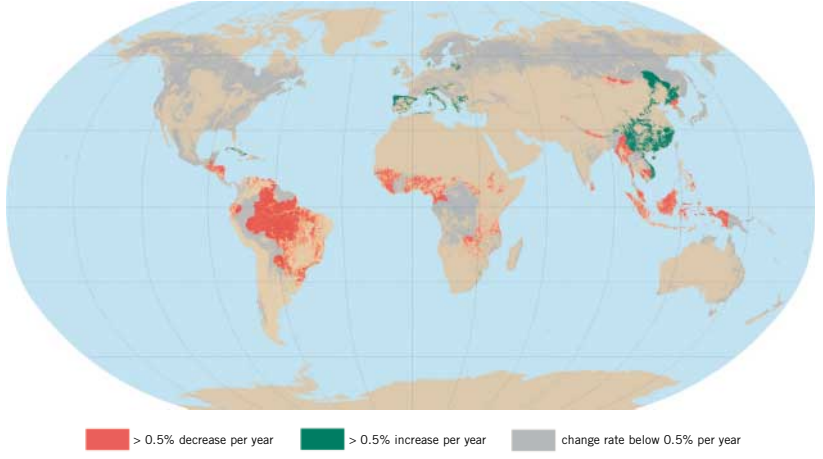
2.4 billion people burn biomass fuels on a daily basis to boil water and to cook food. As a result 2 million tonnes of biomass are going up in smoke every day. This may not pose a problem where the growth of new trees outpaces human demand. Yet, where wood is scarce and the population is dense, wood collection can put considerable pressure on forests. During the 1990s, forest plantations rendered unproductive due to illegal cutting of wood for fuel were a common sight in China and provided the main motivation for the establishment of the Chinese National Improved Stoves Programme (see Rolling out household energy programmes: learning from the past). In geographical hotspots in parts of Latin America and South-East Asia, alarming rates of deforestation are leading to land degradation and desertification. Many countries in sub-Saharan Africa have witnessed the depletion of more than three quarters of their forest cover (Figure 12).

As plants, soils and oceans struggle to absorb rising emissions, carbon dioxide (CO_2) is building up in the atmosphere. This greenhouse gas is beginning to change our climate, leading to increased temperatures, changes in rainfall patterns and more frequent extreme weather events. The use of biomass fuels and coal for cooking and heating accounts for between 10% and 15% of global energy use. Yet household use of these fuels does not feature prominently in discussions on global warming and climate change. Moreover, because they are classified as renewable sources of energy, it is mistakenly assumed that biomass fuels are always harvested and used in a sustainable way.

The burning of biomass fuels in poor homes in the developing world does not convert all fuel carbon into CO_2 and water. Open fires and traditional stoves tend to be highly inefficient and lose a large percentage of the fuel energy as so-called products of incomplete combustion. These include the potent greenhouse gas methane (CH_4), which stays in the atmosphere for decades. When combining the emissions of CO_2 and other greenhouse gases in a single index, wood, crop residues and dung score much higher than fossil fuels, such as kerosene and liquefied petroleum gas (LPG) (Figure 13). This holds true, even where biomass fuels are renewably harvested. Notably, to deliver the same amount of energy, dung used in a biogas digestor produces only 1% of the greenhouse gas emissions of those produced by dung burnt in a traditional stove (see Box 6).

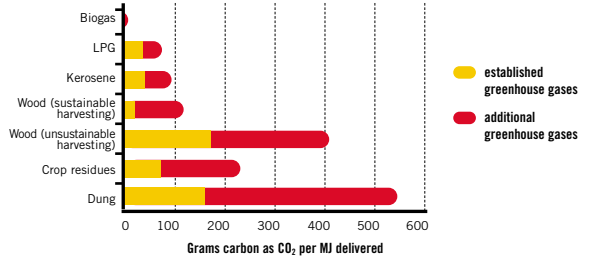
Introducing household energy practices that, in addition to decreasing levels of indoor smoke, save fuel and reduce greenhouse gas emissions can make an important contribution to achieving Millennium Development Goal 7. This is why the proportion of the population using solid fuels is one of the indicators used to assess progress towards reversing the loss of environmental resources (see Figure 1).

Figure 12: World's forests on the decline
Percentage change in forest cover per year, 2000–2005



Reproduced with permission from:
Food and Agricultural Organization. *Global Forest Resources Assessment 2005*. Available at: http://www.fao.org/forestry/fra2005

Figure 13: Household energy and global warming



20-year greenhouse gas emissions in grams carbon as CO_2 emitted per megajoule (MJ)
- based on established greenhouse gases, carbon dioxide (CO_2), methane (CH_4) and nitrogen dioxide (N_2O);
- based on established and additional greenhouse gases, carbon monoxide (CO) and non-methane hydrocarbons (NMHC).

Emissions from different fuel/stove combinations in India were systematically assessed using a standardized cooking test.

Adapted with permission from:
Smith KR, et al. Greenhouse implications of household stoves: an analysis for India. *Annual Review of Energy and the Environment*, 2000, 25:741–763

The need for a quantum leap

Energy enables basic human needs to be met: cooking food, providing light and hauling water from a well. Energy underlies all economic activity, such as growing crops, selling agricultural products in a shop and delivering them to consumers.

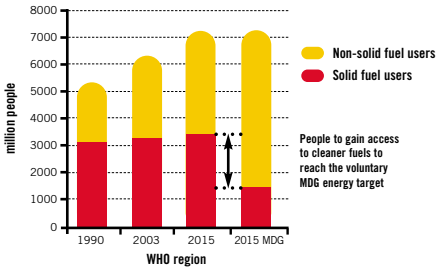
The United Nations Millennium Project highlights the role of energy services, in particular, modern cooking fuels, as a prerequisite for development (see Energizing the Millennium Development Goals). It calls on countries to adopt the following energy target to pave the way for achieving the Millennium Development Goals: "By 2015, to reduce the number of people without effective access to modern cooking fuels by 50%, and make improved cooking stoves widely available". For this target to become a reality, 1.7 billion people will need to gain access to LPG, natural gas, biogas and other modern fuels (Figure 14). In other words, every day, between now and 2015, these energy services will need to be extended to 485 000 people. Reaching the target would still leave 1.5 billion people cooking with solid fuels.

An ever-changing world adds to the challenge. Globally, 840 000 more people were using cleaner fuels in 2003 than in 1990, corresponding to a drop in solid fuel use from 58% to 52% of the population. Yet, because of population growth, the actual number of people using solid fuels has not gone down but rather gone up by 170 000. Energy poverty goes hand in hand with lack of energy infrastructure, such as a distribution network for LPG or an electricity grid. And lack of energy infrastructure is a common feature of isolated rural communities and rapidly growing urban slums. Achieving the energy target requires outpacing population growth and reaching those hardest to reach.

A way to escape energy poverty, a way to escape poverty. According to the International Energy Agency (IEA), we can only halve poverty by 2015 if the number of people relying on traditional biomass for cooking and heating is reduced to less than 1.85 billion. According to the IEA's reference scenario, however, this number will increase to 2.55 billion in 2015 (Figure 15). Electricity is unlikely to become an important cooking fuel in most developing countries in the foreseeable future. Yet, access to electricity has a profound impact on people's lives, and represents a necessary precondition to moving up the development ladder. Nevertheless the number of people without electricity in 2015 will remain practically unchanged and a long way from the 1 billion required to halve the proportion of people living on less than 1$ per day (Figure 15).

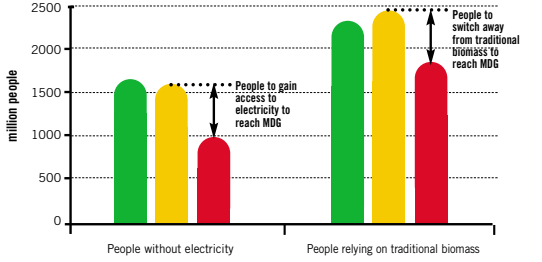
A rigorous acceleration of energy provision is needed to break the vicious cycle of energy poverty and lack of development in the world's poorest countries.

Figure 14: Trends in solid fuel use
Population using solid fuels (millions), 1990, 2003 (mid-point) and 2015



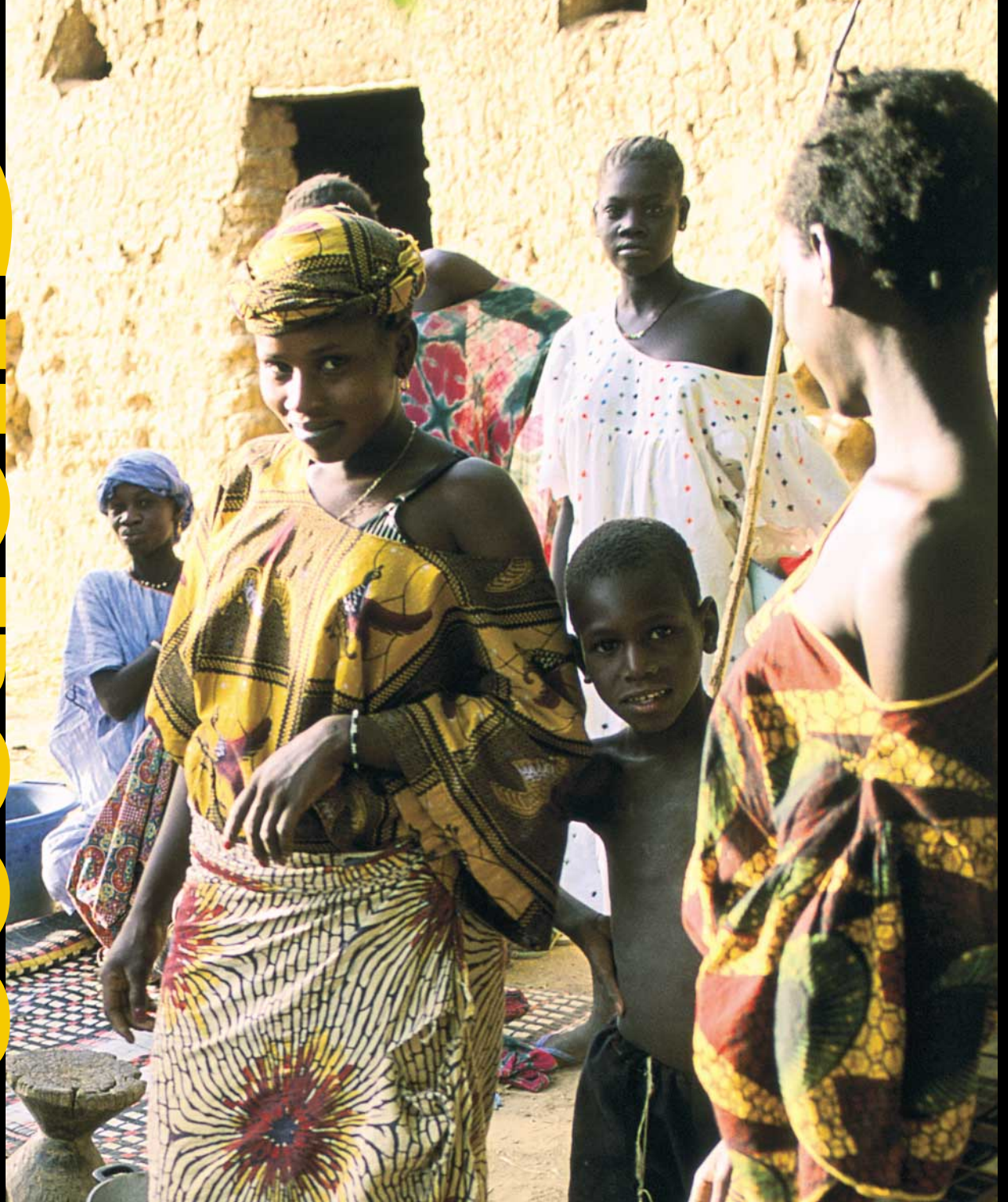
Data for 2015 are based on:
- a business-as-usual scenario that applies the observed annual increase in the number of people with access to cleaner fuels from 1990 to 2003 to the period 2003 to 2015;
- the voluntary Millennium Development Goal (MDG) target proposed by the UN Millennium Project to halve the number of people without access to modern cooking fuels between 1990 and 2015.

Figure 15: Better access to household energy can lift people out of poverty
Million people in developing countries without electricity and relying on traditional biomass, 2002 and 2015



Data for 2015 are based on:
- the International Energy Agency (IEA) reference scenario;
- the energy requirement to achieve the Millennium Development Goal (MDG) target to halve poverty.

section 3



The Way Forward

Coming clean: modern fuels, modern stoves

"All scientific work is incomplete – whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. That does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time."

Sir Austin Bradford Hill,
English epidemiologist
and statistician (1897–1991)

Practical solutions to the indoor smoke problem must reduce pollution levels substantially to curb disease. But first and foremost, interventions must meet the needs of users at least as well as the facilities they started off with. Women should be able to prepare typical dishes with ease, as well as baking bread or following other local customs. In cold regions, tackling heating requirements should be part of the planning process. Beyond meeting the users' immediate energy needs, interventions should also cut the amount of fuel needed, minimize the risk of burns and relieve the drudgery of women and children.

These interventions do exist (Table 3). Switching from wood, dung or charcoal to more efficient modern fuels, such as kerosene, LPG and biogas, brings about the largest reductions in indoor smoke. A study in rural Tamil Nadu, India, compared the levels of respirable particles between homes where cooking was done using gas or kerosene and homes using wood or animal dung. Average pollution levels of 76 $\mu g/m^3$ and 101 $\mu g/m^3$ in kitchens using kerosene and gas, respectively, contrasted with levels of 1500 to 2000 $\mu g/m^3$ in kitchens where biomass fuels were used.

In many poor rural communities, however, access to these alternatives is limited and biomass remains the most practical fuel. Here, improved stoves – provided they are adequately designed, installed and maintained – can cut back indoor smoke levels considerably. Cheap wood-burning stoves in East Africa lower pollution by 50%; *plancha* stoves in Latin America reduce indoor smoke levels by as much as 90%. These stoves reduce a family's exposure to harmful pollutants by optimizing combustion, venting smoke to the outside through a flue and chimney and, in some cases, reducing cooking times. A recent World Bank study in Bangladesh found that stove location and housing construction matter and that better ventilation of the cooking and living area may be a partial remedy. Eaves spaces, extraction through smoke hoods (Box 3) and even keeping doors open during cooking can curb levels of carbon monoxide and particulate matter substantially.

Changing behaviours also plays a role in reducing exposure to indoor smoke. Drying fuel wood before use improves combustion and lowers smoke production. Using lids on pots cuts cooking time. Young children who are kept away from the smoking hearth breathe in less of the health-damaging pollutants. Such changes are unlikely to bring about reductions as great as those from switching to a cleaner fuel or the installation of a chimney stove, but they are important supporting measures for all interventions.

Yet, one crucial link is missing: By how much do we need to lower pollution levels to make a real difference to people's health? As illustrated above, several intervention studies have documented a reduction in indoor air pollution levels, but have not made the link with health. To date, only one study has investigated the impact of an improved stove on childhood pneumonia and women's respiratory health (Box 4). Therefore, we cannot yet draw clear-cut conclusions about which interventions are most effective in saving children's and women's lives. Additional research is urgently needed to answer this question.

Table 3: Getting rid of smoke and soot

Changing the source of pollution	Improving the living environment	Modifying user behaviour
Improved cooking devices • Improved stoves without flues • Improved stoves with flues **Alternative fuel-cooker combinations** • Briquettes and pellets • Kerosene • Liquefied petroleum gas • Biogas • Natural gas, producer gas • Solar cookers • Modern biofuels (e.g. ethanol, plant oils) • Electricity **Reduced need for fire** • Retained heat cooker (haybox) • Efficient housing design and construction • Solar water heating • Pressure cooker	**Improved ventilation** • Smoke hoods • Eaves spaces • Windows **Kitchen design and placement of the stove** • Kitchen separate from house reduces exposure of family (less so for cook) • Stove at waist height reduces direct exposure of the cook leaning over fire	**Reduced exposure by changing cooking practices** • Fuel drying • Pot lids to conserve heat • Food preparation to reduce cooking time (e.g. soaking beans) • Good maintenance of stoves, chimneys and other appliances **Reduced exposure by avoiding smoke** • Keeping children away from smoke (e.g.in another room if available and safe to do so)

Box 3: A hooded solution for a Maasai community in rural Kenya

In Kenya, 96% of the population lack access to grid electricity and more than 80% of the population rely on solid fuels. Maasai women in the Kajiado region cook and heat with wood, cattle dung and crop residues. Fires are often kept smouldering throughout the day and night, leading to very high levels of indoor smoke. The Intermediate Technology Development Group/Practical Action (ITDG/Practical Action) has worked with local women to solve this problem.

Participatory approaches accompanied the solution from beginning to end. Repeated talks with the Maasai community revealed the many health and social problems associated with indoor smoke. From a range of options, the women cooks decided on a simple and affordable smoke hood as the solution that best suited their needs. Together with local artisans, ITDG/Practical Action developed and tested a hood that draws smoke straight from the fire and out through the roof. Installed into people's homes, this smoke hood cut down the concentration of respirable particles by up to 80%, from more than 4300 $\mu g/m^3$ to about 1000 $\mu g/m^3$.

Adapted from:
ITDG/Practical Action. *Reducing indoor air pollution in rural households in Kenya: working with communities to find solutions.* The ITDG Smoke and Health Project, 1998–2001. Available at: http://www.itdg.org/docs/advocacy/smoke-project-report-kenya.pdf

Box 4: Testing the *plancha* stove in the highlands of Guatemala

The first ever randomized controlled trial of an improved chimney stove has just been completed in the province of San Marcos in Western Guatemala. Researchers from the Universidad del Valle, the University of California at Berkeley, United States, and the University of Liverpool, England, are trying to find out whether the *plancha* stove makes a real difference to the health of children and their mothers.

A new stove was installed in 250 homes in the small mountainous community of San Lorenzo; 250 so-called control homes continued to cook on an open fire. Over a two-year period, all children aged less than 18 months were assessed for pneumonia to compare the health of children living in a home with a *plancha* stove with that of children living in a home with an open fire. Every week, field workers visited the homes to identify any sick children and to refer them to the study physicians for a thorough examination. The researchers also collected information on differences between smoke levels, women's respiratory health, heart disease and childhood asthma in the homes with and without the *plancha* stove.

The Guatemala trial represents the most sophisticated intervention study undertaken to date. The health and household energy community is waiting with great interest for the results to shed light on how much an improved stove can reduce childhood pneumonia.

Adapted from:
University of California at Berkeley. *Stove intervention study in the Guatemalan highlands.* Available at: http://ehs.sph.berkeley.edu/guat/

Investing in household energy pays off

"Strong reasons make strong actions."

William Shakespeare,
English dramatist and poet
(1564–1616)

Making sound policy decisions is hard. Too many problems need to be tackled, and too many priorities compete for too little money. This holds even more true for household energy, an issue that concerns many sectors and tends to fall between the cracks of responsibilities: It is an energy problem, but it is not a traditional concern of the energy sector. It is a health problem, but the answer only partly lies within the health sector. It is an environmental problem, but the environment sector is often too isolated to put solutions into practice.

First and foremost, we need to identify those technical fixes and strategies that can effectively solve the problem (see Coming clean: modern fuels, modern stoves and Rolling out household energy programmes: learning from the past). Moreover, we should try to make the best use of scarce resources. One of the tools that can help decision-makers allocate their limited budgets is economic evaluation.

Cost-effectiveness analysis can help in judging the potential return on investment in one health intervention against another. For example, how can the Ministry of Health make the best use of US$ 1 million to reduce child mortality due to pneumonia? Cost-effectiveness analysis can help them to decide whether it is better to invest in a new vaccination programme against *Haemophilus influenza b,* one of the most common infectious agents causing pneumonia, or to scale up existing efforts to treat sick children with antibiotics. WHO has applied this approach to interventions to reduce indoor air pollution (Table 4). The results should, however, be treated with caution, as cost-effectiveness analysis only considers the benefits of these interventions from the point of view of the health sector.

Cost-benefit analysis, on the other hand, values all benefits against all costs from the point of view of society as a whole. It is thus a more suitable tool for investigating investments with many different impacts on people's lives. The Ministry of Finance may ask how it can best reduce rural poverty over a ten-year timeframe? Should the top priority be to intensify educational programmes for rural children? Or is it best to provide people with access to electricity, thus providing opportunities for evening study and additional activities to generate income?

As highlighted in this publication, household energy interventions bring about a wide range of benefits: they improve children's and women's health, save time and money, promote gender equality, reduce deforestation and curb greenhouse gas emissions. A cost-benefit analysis, recently conducted by WHO, evaluated different intervention scenarios for meeting the voluntary MDG energy target (see The need for a quantum leap). Globally, the analysis shows a payback of US$ 91 billion a year from the US$ 13 billion a year invested to halve the number of people cooking with solid fuels by providing them with access to LPG by 2015. (For ethanol, due to higher fuel prices and lower fuel efficiency, the investment increases to US$ 43 billion a year for the same economic benefit.) Making improved stoves available, by 2015, to half of those still burning biomass fuels and coal on traditional stoves, would result in a negative intervention cost of US$ 34 billion a year as the fuel cost savings due to greater stove efficiency exceed the investment costs. This generates an economic return of US$ 105 billion a year over a ten-year period (Table 5). Time gains from reduced illness, fewer deaths, less fuel collection and shorter cooking times, valued at Gross National Income (GNI) per capita, account for more than 95% of the benefits. There is debate on the appropriate valuation of time. When these time gains are conservatively valued at 30% of GNI per capita for adults and 0% of GNI for children, the economic payback decreases to US$ 31 billion a year for LPG and US$ 33 billion a year for improved stoves.

A global cost-benefit analysis is highly dependent on data quality and assumptions. To guide decision-making at the national level, an analysis should be conducted for a given country or setting. Nevertheless, the global cost-benefit analysis illustrates the enormous potential of household energy interventions and suggests that these are a worthwhile investment. It is time to roll out programmes that can make a real difference to the lives of the poor and that open up the road to the modern world.

Table 4: Improved stoves and clean fuels can be cost-effective health interventions
Cost-effectiveness ratios for interventions to reduce indoor air pollution (International $ (I$) per healthy year gained), 2002

Intervention scenarios:
[1] Providing 100% of the population with access to liquefied petroleum gas.
[2] Providing 100% of the population with improved stoves.
[3] Providing 50% of the population with liquefied petroleum gas and 45% with improved stoves.

Intervention scenario	Africa		The Americas		Eastern Mediterranean		Europe	South-East Asia		Western Pacific
	AfrD	AfrE	AmrB	AmrD	EmrB	EmrD	EurB	SearB	SearD	WprB
1	6 270	11 050	14 050	7 500	24 200	11 020	17 740	15 120	7 350	1 410
2	500	730	-	5 880	-	7 800	-	1 180	610	32 240
3	3 750	6 440	16 330	6 770	-	9 780	19 870	8 970	4 280	1 570

Table 5: Remarkable returns from investing in household energy
Benefits of household energy and health interventions (US$ million), by type of benefit, 2005

	If 50% of the population cooking with solid fuels in 2005 switch to cooking with liquefied petroleum gas by 2015	If 50% of the population cooking with solid fuels in 2005 switch to cooking with modern biofuels by 2015	If 50% of the population cooking with solid fuels in 2005 switch to cooking on an improved stove by 2015
Health care savings	384	384	65
Time savings due to childhood and adult illness prevented: school attendance days gained for children and productivity gains for children and adults	1 460	1 460	510
Time savings due to less time spent on fuel collection and cooking: productivity gains	43 980	43 980	88 100
Value of deaths averted among children and adults	38 730	38 730	13 560
Environmental benefits	6 070	5 610	2 320
Total benefits	90 624	90 164	104 555

Costs and benefits of different intervention scenarios were estimated using 2005 as the base year and a 10-year time horizon, taking into account demographic changes over this period. The analysis was conducted for 11 WHO subregions to reflect variations in (i) the availability, use and cost of different fuels and stoves; (ii) disease prevalence; (iii) health care seeking as well as quality and cost of health care; (iv) the amount of time spent on fuel collection and cooking; (v) the value of productive time based on Gross National Income per capita; and (vi) variations in environmental and climatic conditions. A 3% discount rate was applied to all costs and benefits. See *Evaluation of the costs and benefits of household energy and health interventions at global and regional levels* for a detailed description of the method and the results of a range of intervention scenarios by WHO subregion as well as of the sensitivity analysis.

Rolling out household energy programmes: learning from the past

"It is often necessary to make decisions on the basis of information sufficient for action, but insufficient to satisfy the intellect."

Immanuel Kant,
German philosopher (1724–1804)

200 million stoves rolled out in China! The Chinese National Improved Stoves Programme is one of the big household energy success stories. In the 1980s and 1990s, the Chinese government implemented the programme in a decentralized fashion, reducing bureaucratic hurdles and speeding up financial payments. A commercialization strategy helped to set up rural energy enterprises; national-level stove challenges generated healthy competition. On the one hand, the central production of critical stove components, such as parts of the combustion chamber, enforced quality control. On the other hand, the modification of general designs ensured that the stove would meet the needs of local users. The programme thus managed to shift societal norms: most biomass stoves now on sale in China are improved stoves.

The last decades have witnessed many household energy initiatives, ranging from ambitious government-run programmes, such as the Chinese programme, to small-scale community-led projects. Technologies promoted include smoke hoods (Box 3), improved stoves (Box 4 and Figure 16), kerosene, LPG (Box 5), biogas (Box 6) and solar cookers. The Indian national programme distributed more than 33 million stoves between 1983 and 2000. In Africa, more than 5 million improved stoves are now in use.

These initiatives have provided important insights into the ingredients needed to promote household energy solutions successfully:

- Social marketing can overcome the low awareness of the health risks of indoor air pollution and highlight the numerous benefits of solutions.
- Involving users, in particular women, is crucial. Too often, cooks fail to adopt, use or maintain equipment provided in intervention programmes, because it does not meet their needs.
- Local artisans, shops and markets should offer a choice of interventions. In this way, they can respond to different demands and abilities to pay.
- Micro-credit facilities and targeted subsidies can overcome financial barriers, in particular among the poorest of the poor.
- Appropriate policies in the energy, health, environment and other sectors should make sure that local projects do not operate in a vacuum (Table 6).

These lessons learnt from past programmes should guide the implementation of programmes in the future.

Box 5: How to promote new markets for liquefied petroleum gas

LPG is often perceived as an exclusively urban fuel. Yet, it is also an up-and-coming alternative in those rural areas where wood, charcoal or kerosene are already being purchased. The LPG Rural Energy Challenge is dedicated to setting up viable markets and supply chains in developing countries. In so-doing, this initiative, jointly run by the United Nations Development Programme and the World LPG Association, can draw on a few key lessons that have already been learnt:

Micro-credit schemes should emphasize that switching to LPG may ultimately cut expenditure and add to income generation. One-time subsidies on gas cookers may be an incentive for people to consider switching to a cleaner fuel and thus to become lifetime customers. Similarly, introducing smaller and more affordable gas bottles could remove barriers to adoption. LPG is very clean and fuel-efficient, yet there are concerns about the safe handling of this explosive gas. Awareness-raising among fuel sellers and consumers and tougher regulations can ensure the correct refilling and transportation of gas bottles and, most importantly, contribute to the safe use of LPG. Government leadership in developing policies for successful market expansion of LPG is essential.

Adapted from:
McDade S. Fueling development: the role of LPG in poverty reduction and growth. Energy for Sustainable Development, 2004, 8:74–81.

Box 6: The Nepal biogas programme

Biogas systems convert cattle dung and other animal or human wastes into methane. This flammable gas is a simple-to-use fuel for lighting and cooking: it burns cleanly and efficiently on a conventional low-pressure gas burner.

In Nepal, the Biogas Support Programme has installed more than 120 000 biogas plants over the last 13 years. About 3% of Nepalese homes now benefit from much lower levels of indoor air pollution. Moreover, 72% of the biogas plants are connected to latrines, leading to improved cleanliness and reduced health risks in the vicinity of the home. The residual slurry is a valuable organic fertilizer.

This biogas programme was the first to be recognized under the Clean Development Mechanism. It trades certified emission reductions; each operational biogas plant is worth 4.6 tonnes of CO_2 equivalent per year. This success story points to new synergies between household energy programmes and efforts to reduce climate change (see Stripping our forest, heating our planet).

Adapted from:
Netherlands Development Organization and Biogas Sector Partnership-Nepal. *The Nepal Biogas Support Programme: a successful model for rural household energy supply in developing countries. Executive summary.* 2004. More information is available at: www.snvworld.org and www.bsipnepal.org.np

Table 6: Policy instruments for effective household energy programmes

Policy instruments	Examples
Information, education and communication	• Health professionals • Community • Schools • Media
Taxes and subsidies	• Tax on fuels and appliances • Subsidy on fuels and appliances
Regulation and legislation	• Air quality standards • Design standards for appliances
Direct expenditures	• Public programme for provision of appliances • Funding of finance schemes
Research and development	• Surveys • Development and evaluation of interventions • Studies of health impacts • Research capacity development

Adapted from:
Bruce N, et al. Indoor air pollution. In: Jamison DT et al., eds. *Disease control priorities in developing countries.* 2nd ed. New York, Oxford University Press, 2006.

New household energy horizons

Household energy projects and programmes currently under way around the world have set out to reach nearly 4 million households with improved stoves by 2011 (Figure 16). These initiatives should be accompanied by careful evaluation and monitoring to answer two fundamental questions: Can the technical fix reduce indoor smoke levels, improve health and bring about other benefits? And, how can a programme reach a large number of households in a sustainable way?

To date, few household energy projects or programmes have undergone rigorous evaluation, and if they have, the results have been mixed. In India, improved stoves currently account for less than 7% of all stoves, many of them in poor working order due to improper installation and lack of maintenance. Even in Chinese households benefiting from an improved stove, levels of particles and carbon monoxide still exceed the national standard for indoor air. Consequently, despite the success of the Chinese programme, a large proportion of the rural population is still chronically exposed to high levels of harmful pollutants. These findings suggest that improved stoves are an important step towards reducing indoor smoke levels, but are probably not the ultimate means to prevent 1.5 million deaths a year. Moreover, improved stoves tend to shift the problem outdoors: by venting smoke to the outside they contribute to ambient air pollution. A large-scale switch to cleaner fuels, on the other hand, eliminates nearly 100% of the health risk (Box 7). Beyond kerosene, LPG and biogas, latest-generation biofuels may become a healthy and environmentally friendly cooking alternative in the future (Box 8).

Evaluating the impacts of projects and programmes will shed light on how to fine-tune different technical solutions to maximize their health, social and environmental benefits. Compiling knowledge from around the world will generate a menu of solutions from which decision-makers at all levels can choose. Learning from their experience will provide a recipe for putting into action successful, large-scale programmes.

And, there are new opportunities on the horizon. Frequently, the same families who breathe polluted air inside their homes also drink contaminated water and make do without even a simple latrine.

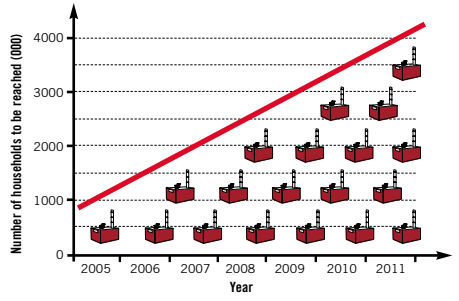
Lack of safe drinking-water and adequate sanitation is responsible for 1.7 million deaths from diarrhoea every year, mostly of young children. Indoor smoke is to blame for 1.5 million deaths from respiratory illness every year. Again, young children bear the brunt of the burden. Why not join forces to reduce diarrhoea and respiratory disease in an integrated manner?

In both cases, interventions at the household level can prevent disease and death because they are effective, inexpensive and rapidly deployable. Generating demand among users and meeting this demand with a range of solutions is a challenge for implementers of interventions to improve water quality and sanitation as well as household energy use. For both, the private sector plays a major role in developing appropriate supply chains. And poor people often need to draw on micro-credit or to benefit from targeted subsidies to be able to afford to make a change to their homes. In some locations, existing programmes to promote household water treatment could be the entry-point for sensitizing families about indoor air pollution. In others, a successful household energy programme could provide an organizational structure for introducing improvements to water supplies and sanitation.

Exploiting these synergies to tackle two priority public health issues at once has an enormous potential to save lives. And it puts people at the centre.

Figure 16: Taking improved stoves to scale

Thousands of households to be reached by selected improved stove programmes (cumulative projection), 2005–2011



Many improved stove programmes are currently under way around the world. Important implementing agencies include the German Technical Cooperation (GTZ), the Intermediate Technology Development Group/Practical Action, Winrock International, Development Alternatives and the Appropriate Rural Technology Institute. Major agencies funding these programmes include the Dutch Development Cooperation, the United Kingdom Department for International Development, the United States government, the German Ministry for Development and the Shell Foundation.

Box 7: Cleaner fuels save lives

On average, 100 million more homes using liquefied petroleum gas, biogas or modern biofuels for cooking would lead to:

- 473 million fewer men, women and children exposed to harmful indoor air pollution;
- 282 000 fewer deaths from respiratory diseases per year.

Box 8: Fuels of the future: biofuels and plant oils

"The use of plant oil as fuel may seem insignificant today. But such products can in time become just as important as kerosene and these coal-tar-products of today."

Rudolf Diesel, German inventor of the diesel engine (1858–1913)

Rising oil prices and a global move towards renewable energy sources triggered the search for biofuels, primarily as alternatives to diesel for running cars. Ethanol, usually obtained from the residues from sugar production, is the most common biofuel. Methanol or "wood alcohol", its close relative, is currently derived from natural gas but can be produced by gasifying biomass. The last few years have also witnessed experiments with a range of domestic plants, such as rape seeds, and wild oil plants, such as *Jatropha curcas*.

The development of biofuel stoves is a first step in pulling this "green gold" away from the automotive sector into the household sector. Field-testing of simple as well as more sophisticated technologies is under way in several developing countries. The first results are promising: plant oils, ethanol and methanol burn cleanly and are safe to use. Produced locally at competitive prices, they may well turn into the cooking fuels of the future.

key points

Every year, indoor air pollution from cooking with solid fuels is responsible for 1.5 million deaths.

Indoor air pollution has dramatic consequences for health. Cooking with wood, dung, coal and other solid fuels is a major risk factor for pneumonia among children and chronic respiratory disease among adults, with more than two thirds of these deaths occurring in South-East Asia and sub-Saharan Africa. Every year, the killer in the kitchen is responsible for 1.5 million deaths. Curbing indoor air pollution will put an end to this needless loss of life.

Progress since 1990 has been negligible. To halve, by 2015, the population cooking with solid fuels, 485 000 people need to gain access to cleaner fuels every day.

Progress in access to modern cooking fuels since 1990 has been negligible, as the small gains made are lagging behind population growth. To halve, by 2015, the number of people without access to such fuels, 485 000 people will need to gain access to modern energy services every day for the next 10 years. Innovative policy approaches and a rigorous acceleration of investments is needed now to save lives and enable development.

Health and productivity gains can more than pay for lifting people out of energy poverty.

Investing US$ 13 billion per year to halve, by 2015, the number of people worldwide cooking with solid fuels by providing them with access to liquefied petroleum gas shows a payback of US$ 91 billion per year. Making improved stoves available to half of those still burning biomass fuels and coal on traditional stoves would result in a negative intervention cost of US$ 34 billion a year and generate an economic return of US$ 105 billion a year over a 10-year-period. Health and productivity gains make household energy solutions potentially good value for money.

Taking household energy solutions to scale will overcome a major barrier to achieving the Millennium Development Goals.

Practical solutions to the household energy problem do exist. Liquefied petroleum gas, biogas and other cleaner fuels represent the healthiest alternative. Switching from a traditional stove to an improved stove substantially reduces indoor smoke. Improved household energy practices promote education, empower women, save the lives of children and their mothers and benefit our forests and our climate.

Carefully documenting experience with solutions will serve to maximize the health and broader benefits of large-scale programmes.

Many household energy projects and programmes are currently under way around the world. Evaluating the impacts of these initiatives will shed light on how different technical solutions could be fine-tuned to maximize their health, social and environmental benefits. Learning from their experience will provide a recipe for putting into action successful, large-scale programmes.

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Annex

Country	Total population (thousands)	Percentage of population living below $1 (PPP) per day	Percentage of population using solid fuels	Under-five mortality rate per 1000 live births	Maternal mortality rate per 100 000 live births	Carbon dioxide emissions per capita (metric tons)
Year	2003	2003 or latest available data	2003 or latest available data	2003 or latest available data	2000	2002
Afghanistan	23 897	no data	>95	257	1 900	0
Albania	3 166	2	50	21	55	0.8
Algeria	31 800	2	<5	41	140	2.9
Andorra	71	no data	<5	7	no data	no data
Angola	13 625	no data	>95	260	1 700	0.5
Antigua and Barbuda	73	no data	46	12	no data	4.7
Argentina	38 428	3	<5	20	82	3.5
Armenia	3 061	13	26	33	55	1.0
Australia	19 731	no data	<5	6	8	18.3
Austria	8 116	no data	<5	5	4	7.8
Azerbaijan	8 370	4	49	91	94	3.4
Bahamas	314	no data	<5	14	60	6.7
Bahrain	724	no data	<5	15	28	30.6
Bangladesh	146 736	36	88	69	380	0.3
Barbados	270	no data	<5	13	95	4.6
Belarus	9 895	0	19	17	35	6.0
Belgium	10 318	no data	<5	5	10	6.8
Belize	256	no data	43	39	140	3.1
Benin	6 736	no data	95	154	850	0.3
Bhutan	2 257	no data	no data	85	420	0.2
Bolivia	8 808	14	25	66	420	1.2
Bosnia and Herzegovina	4 161	no data	51	17	31	4.8
Botswana	1 785	31	65	112	100	2.3
Brazil	178 470	8	12	35	260	1.8
Brunei Darussalam	358	no data	no data	6	37	17.7
Bulgaria	7 897	5	17	15	32	5.3
Burkina Faso	13 002	45	>95	207	1 000	0.1
Burundi	6 825	55	>95	190	1 000	0.0
Cambodia	14 144	34	>95	140	450	0.0
Cameroon	16 018	17	83	166	730	0.2
Canada	31 510	no data	<5	6	6	16.5
Cape Verde	463	no data	36	35	150	0.3
Central African Republic	3 865	67	>95	180	1 100	0.1
Chad	8 598	no data	>95	200	1 100	0.0
Chile	15 806	2	<5	9	31	3.6
China	1 311 709	17	80	37	56	2.7
Colombia	44 222	8	15	21	130	1.3
Comoros	768	no data	76	73	480	0.1
Congo	3 724	no data	84	108	510	0.6
Cook Islands	18	no data	no data	21	no data	1.5
Costa Rica	4 173	2	23	10	43	1.4
Côte d'Ivoire	16 631	11	74	192	690	0.4
Croatia	4 428	2	12	7	8	4.7
Cuba	11 300	no data	21	8	33	2.1
Cyprus	802	no data	<5	5	47	8.3
Czech Republic	10 236	2	<5	4	9	11.2
Democratic People's Republic of Korea	22 664	no data	no data	55	67	6.5
Democratic Republic of the Congo	52 771	no data	>95	205	990	0.0
Denmark	5 364	no data	<5	4	5	8.9
Djibouti	703	no data	6	138	730	0.5

Annex

Country	Total population (thousands)	Percentage of population living below $1 (PPP) per day	Percentage of population using solid fuels	Under-five mortality rate per 1000 live births	Maternal mortality rate per 100 000 live births	Carbon dioxide emissions per capita (metric tons)
Year	2003	2003 or latest available data	2003 or latest available data	2003 or latest available data	2000	2002
Dominica	79	no data	21	14	no data	1.5
Dominican Republic	8 745	2	14	35	150	2.5
Ecuador	13 003	18	<5	27	130	2.0
Egypt	71 931	3	<5	39	84	2.1
El Salvador	6 515	31	33	36	150	1.0
Equatorial Guinea	494	no data	no data	146	880	0.4
Eritrea	4 141	no data	80	85	630	0.2
Estonia	1 323	2	15	9	63	11.8
Ethiopia	70 678	23	>95	169	850	0.1
Fiji	839	no data	40	20	75	1.6
Finland	5 207	no data	<5	5	6	12.0
France	60 144	no data	<5	5	17	6.2
Gabon	1 329	no data	28	91	420	2.6
Gambia	1 426	54	>95	123	540	0.2
Georgia	5 126	3	42	45	32	0.7
Germany	82 476	no data	<5	5	8	9.8
Ghana	20 922	45	88	95	540	0.4
Greece	10 976	no data	<5	5	9	8.5
Grenada	80	no data	48	23	no data	2.3
Guatemala	12 347	16	62	47	240	0.9
Guinea	8 480	no data	>95	160	740	0.1
Guinea-Bissau	1 493	no data	95	204	1 100	0.2
Guyana	765	3	59	69	170	2.2
Haiti	8 326	no data	>95	118	680	0.2
Honduras	6 941	21	57	41	110	0.9
Hungary	9 877	2	<5	8	16	5.6
Iceland	290	no data	<5	4	0	7.7
India	1 065 462	35	74	87	540	1.2
Indonesia	219 883	8	72	41	230	1.4
Iran, Islamic Republic of	68 920	2	<5	39	76	5.3
Iraq	25 175	no data	<5	125	250	3.0
Ireland	3 956	no data	<5	6	5	11.0
Israel	6 433	no data	<5	6	17	11.0
Italy	57 423	no data	<5	4	5	7.5
Jamaica	2 651	2	45	20	87	4.1
Japan	127 654	no data	<5	4	10	9.4
Jordan	5 473	2	<5	28	41	3.2
Kazakhstan	15 433	2	5	73	210	9.9
Kenya	31 987	23	81	123	1 000	0.2
Kiribati	88	no data	no data	66	no data	0.3
Kuwait	2 521	no data	<5	9	5	24.6
Kyrgyzstan	5 138	2	76	68	110	1.0
Lao People's Democratic Republic	5 657	26	>95	91	650	0.2
Latvia	2 307	2	10	12	42	2.7
Lebanon	3 653	no data	<5	31	150	4.7
Lesotho	1 802	36	83	110	550	no data
Liberia	3 367	no data	no data	235	760	0.1
Libyan Arab Jamahiriya	5 551	no data	<5	16	97	9.1
Lithuania	3 444	2	<5	11	13	3.6
Luxembourg	453	no data	<5	5	28	21.1

Country	Total population (thousands)	Percentage of population living below $1 (PPP) per day	Percentage of population using solid fuels	Under-five mortality rate per 1000 live births	Maternal mortality rate per 100 000 live births	Carbon dioxide emissions per capita (metric tons)
Year	2003	2003 or latest available data	2003 or latest available data	2003 or latest available data	2000	2002
Madagascar	17 404	61	>95	126	550	0.1
Malawi	12 105	42	>95	178	1 800	0.1
Malaysia	24 425	2	<5	7	41	6.3
Maldives	318	no data	no data	72	110	3.4
Mali	13 007	72	>95	220	1 200	0.0
Malta	394	no data	<5	6	21	7.5
Marshall Islands	53	no data	no data	61	no data	no data
Mauritania	2 893	26	65	107	1 000	1.1
Mauritius	1 221	no data	<5	18	24	2.6
Mexico	103 457	10	12	28	83	3.7
Micronesia, Federal States of	109	no data	no data	23	no data	no data
Monaco	34	no data	<5	4	no data	6.2
Mongolia	2 594	27	51	68	110	3.3
Morocco	30 566	2	5	39	220	1.4
Mozambique	18 863	38	80	147	1 000	0.1
Myanmar	49 485	no data	95	107	360	0.2
Namibia	1 987	35	63	65	300	1.1
Nauru	13	no data	no data	30	no data	10.8
Nepal	25 164	39	80	82	740	0.2
Netherlands	16 149	no data	<5	5	16	9.4
New Zealand	3 875	no data	<5	6	7	8.7
Nicaragua	5 466	45	58	38	230	0.7
Niger	11 972	61	>95	262	1 600	0.1
Nigeria	124 009	70	67	198	800	0.4
Niue	2	no data	no data	no data	no data	2.0
Norway	4 533	no data	<5	4	16	12.2
Oman	2 851	no data	<5	12	87	12.1
Pakistan	153 578	13	72	98	500	0.7
Palau	20	no data	no data	28	no data	11.9
Panama	3 120	7	33	24	160	2.0
Papua New Guinea	5 711	no data	90	93	300	0.4
Paraguay	5 878	16	58	29	170	0.7
Peru	27 167	18	33	34	410	1.0
Philippines	79 999	15	47	36	200	0.9
Poland	38 587	2	<5	7	13	7.7
Portugal	10 061	2	<5	5	5	6.0
Qatar	610	no data	<5	15	7	53.1
Republic of Korea	47 700	2	<5	5	20	9.4
Republic of Moldova	4 267	22	63	32	36	1.6
Romania	22 334	2	23	20	49	4.0
Russian Federation	143 246	2	7	21	67	9.9
Rwanda	8 387	52	>95	203	1 400	0.1
Saint Kitts and Nevis	42	no data	<5	22	no data	2.8
Saint Lucia	149	25	63	18	no data	2.4
Saint Vincent and the Grenadines	120	no data	31	27	no data	1.6
Samoa	178	no data	70	24	130	0.8
San Marino	28	no data	<5	5	no data	7.5
Sao Tome and Principe	161	no data	95	118	no data	0.6
Saudi Arabia	24 217	no data	<5	26	23	15.0
Senegal	10 095	22	41	137	690	0.4

Annex

Country	Total population (thousands)	Percentage of population living below $1 (PPP) per day	Percentage of population using solid fuels	Under-five mortality rate per 1000 live births	Maternal mortality rate per 100 000 live births	Carbon dioxide emissions per capita (metric tons)
Year	2003	2003 or latest available data	2003 or latest available data	2003 or latest available data	2000	2002
Serbia and Montenegro	10 527	no data	no data	14	11	4.4
Seychelles	81	no data	<5	15	no data	6.8
Sierra Leone	4 971	no data	92	284	2 000	0.1
Singapore	4 253	no data	<5	3	30	13.8
Slovakia	5 402	2	<5	8	3	6.8
Slovenia	1 984	2	8	4	17	7.8
Solomon Islands	477	no data	95	22	130	0.4
Somalia	9 890	no data	no data	225	1 100	no data
South Africa	45 026	11	18	66	230	7.4
Spain	41 060	no data	<5	4	4	7.3
Sri Lanka	19 065	8	67	15	92	0.5
Sudan	33 610	no data	>95	93	590	0.3
Suriname	436	no data	no data	39	110	5.1
Swaziland	1 077	8	68	153	370	0.9
Sweden	8 876	no data	<5	3	2	5.8
Switzerland	7 169	no data	<5	5	7	5.7
Syrian Arab Republic	17 800	no data	32	18	160	2.8
Tajikistan	6 245	7	75	95	100	0.7
Thailand	62 833	2	72	26	44	3.7
The former Yugoslav Republic of Macedonia	2 056	2	30	11	23	5.1
Timor-Leste	778	no data	no data	124	660	no data
Togo	4 909	no data	76	140	570	0.3
Tonga	104	no data	56	19	no data	1.1
Trinidad and Tobago	1 303	4	8	20	160	31.9
Tunisia	9 832	2	5	24	120	2.3
Turkey	71 325	2	11	39	70	3.0
Turkmenistan	4 867	10	<5	102	31	9.1
Tuvalu	11	no data	no data	51	no data	no data
Uganda	25 827	85	>95	140	880	0.1
Ukraine	48 523	2	6	20	35	6.4
United Arab Emirates	2 995	no data	<5	8	54	25.1
United Kingdom	59 251	no data	<5	6	13	9.2
United Republic of Tanzania	36 977	49	>95	165	1 500	0.1
United States of America	294 043	no data	<5	8	17	20.1
Uruguay	3 415	2	<5	14	27	1.2
Uzbekistan	26 093	14	72	69	24	4.8
Vanuatu	212	no data	79	38	130	0.4
Venezuela, Bolivarian Republic of	25 699	14	5	21	96	4.3
Viet Nam	81 377	2	70	23	130	0.8
Yemen	20 010	16	42	113	570	0.7
Zambia	10 812	64	85	182	750	0.2
Zimbabwe	12 891	56	73	126	1 100	1.0

For further information on data sources and data limitations see:
United Nations Statistics Division. *Millennium Development Goal Indicators Database.* Available at: http://millenniumindicators.un.org/unsd/mi/mi_goals.asp