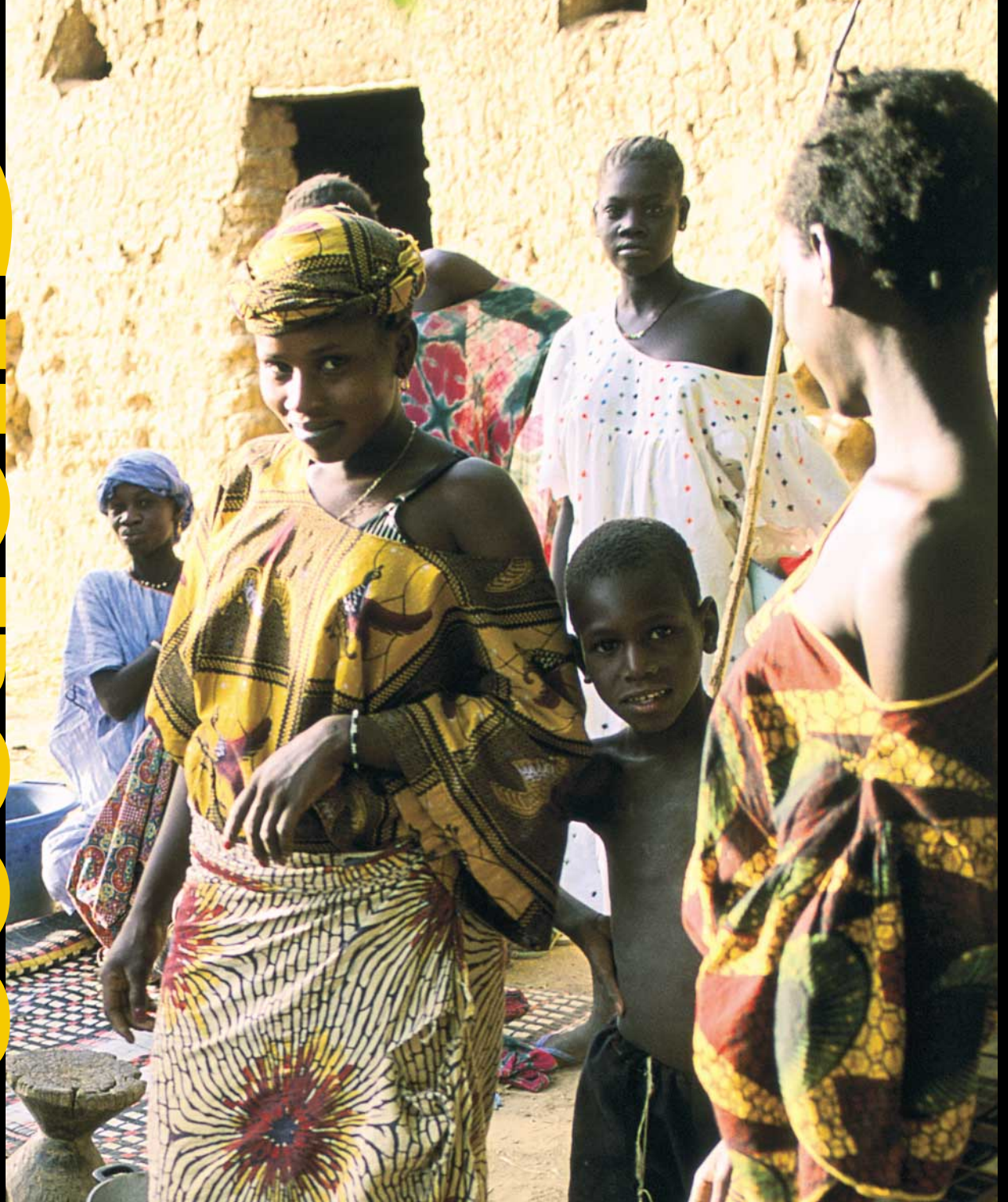
section 3



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.

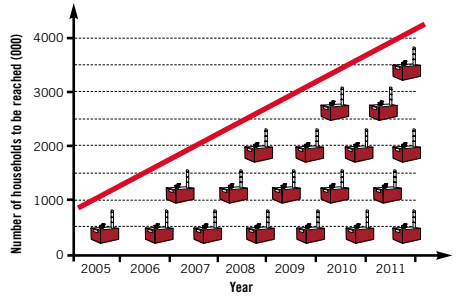
Lack of safe drinking-water and adequate sanitation is responsible for 1.7 million deaths from diarrhoea every year, mostly of young children. Indoor smoke is to blame for 1.5 million deaths from respiratory illness every year. Again, young children bear the brunt of the burden. Why not join forces to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