Smoke – the Killer in the Kitchen

Indoor Air Pollution in Developing Countries

Hugh Warwick and Alison Doig

ITDG PUBLISHING

Published by ITDG Publishing
103-105 Southampton Row,
London WC1B 4HL, UK
www.itdgpublishing.org.uk

First published in 2004

ISBN 1 85339 588 9

A catalogue record for this book is available from the British Library.

ITDG Publishing is the publishing arm of the Intermediate Technology Development Group. Our mission is to build the skills and capacity of people in developing countries through the dissemination of information in all forms, enabling them to improve the quality of their lives and that of future generations.

Typeset by FiSH Books, London
Printed in Great Britain by Latimer Trend, Plymouth

Front cover: Children stoking a traditional fireplace, Nepal
Credit: ITDG

Contents

Acknowledgements

ITDG would like to thank Hugh Warwick for his tremendous research and for his patience in producing this report. Our great appreciation goes to Liz Bates, Nigel Bruce and Eva Rehfuess for their continued support and invaluable advice given to the report team. Thanks also go to Majid Ezzati, Grant Ballard-Tremeer, Jyoti Parikh, Kirk Smith, Karen Westley, Kurt Hoffman, Sarah Kline and John Magrath for their comments, contributions and general assistance in compiling this work. Special thanks go to the ITDG country project teams in Kenya, Nepal and Sudan for their inspiring work with communities to reduce smoke pollution in many homes and passing their experience on to many more.

Acronyms

ALRI	Acute lower respiratory infection
COPD	Chronic obstructive pulmonary disease
DALYs	Disability-adjusted life years
DFID	Department for International Development
ESMAP	Energy Sector Management Assistance Programme
HECA	Healthy Environments for Children Alliance
HEDON	Household Energy Network
LDC	Less developed countries
LPG	Liquid petroleum gas
MDG	Millennium Development Goals
PRSP	Poverty Reduction Strategy Paper
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Aid
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WSSD	World Summit on Sustainable Development

Executive summary

'The burden of biomass fuel use is a major aspect of most poor women's lives. It absorbs large amounts of time in heavy work, it can have negative effects on health, and, although this problem has been recognised for 30 years, very little has been done about it.'[17]

Of the four greatest risks of death and disease in the world's poorest countries[1] – being underweight; unsafe sex; unsafe water, sanitation and hygiene; and smoke from solid fuel – the international community has mobilized resources to combat the first three. It is nothing short of an international scandal that the fourth has been largely ignored. This report calls for global action to fight the killer in the kitchen – smoke from cook stoves.

The killer in the kitchen

More than a third of humanity, 2.4 billion people, burn biomass (wood, crop residues, charcoal and dung) for cooking and heating. When coal is included a total of 3 billion people – half the world's population – cook with solid fuel.

The smoke from burning these fuels turns kitchens in the world's poorest countries into death traps. Indoor air pollution from the burning of solid fuels kills over 1.6 million people, predominately women and children, each year. This is more than three people per minute. It is a death toll almost as great as that caused by unsafe water and sanitation, and greater than that caused by malaria. Smoke in the home is one of the world's leading child killers, claiming nearly one million children's lives each year.

Women and children hit hardest

The use of poorly ventilated, inefficient stoves 'can have the same adverse health impacts as smoking two packs of cigarettes a day'.

United Nations Development Programme

Indoor air pollution is not an indiscriminate killer. It is the poor who rely on the lower grades of fuel and have least access to cleaner technologies. Specifically, indoor air pollution affects women and small children far more than any other sector of society. Women typically spend three to seven hours per day by the fire, exposed to smoke, often with young children nearby.

Over half of all people cooking on biomass live in India and China. However the proportion of the population cooking on biomass is highest in sub-Saharan Africa, rising to over 90% of the population in many countries. This is a chronic problem for people living in rural areas of developing countries, but not exclusively – there is a growing problem in the cities as well.

A problem set to get worse

On current trends an extra 200 million people worldwide will rely on biomass for their cooking and heating needs by 2030, according to the International Energy Agency. In parts of Central Asia where gas and electricity used to be available people are reverting back to using biomass as their main fuel source. In Tajikistan since 1991 the incidence of acute respiratory infection, the world's greatest child killer, has risen by 35% largely as a result of burning wood indoors.

The effects of smoke on health

In the cities of the industrialized world air pollution has long been recognized as a major health hazard. A great deal of time and effort is put into measures that will reduce exposure to air pollution. Yet in poor people's homes throughout the developing world levels of exposure to pollutants are often 100 times greater than recommended maximums.

Illnesses caused by indoor air pollution include acute lower respiratory infection. A child is two to three times more likely to contract acute lower respiratory infection if exposed to indoor air pollution. Women who cook on biomass are up to four times more likely to suffer from chronic obstructive pulmonary disease, such as chronic bronchitis. Lung cancer in women in China has been directly linked to use of coal burning stoves. In addition there is evidence to link indoor air pollution to asthma, tuberculosis, low birth weight and infant mortality and cataracts.

Reducing lethal levels of smoke

Billions of people would lead a healthier life if their exposure to lethal levels of smoke were reduced. Public awareness of the health risks of smoke is a crucial first step. The most effective way to reduce

smoke in the home is to switch to a cleaner fuel, such as liquid petroleum gas (LPG), kerosene or biogas.

However, the vast majority of people at risk are too poor to change to a cleaner fuel, or have no access to modern fuels. In these homes, the answer will be to reduce exposure, for example by using well designed chimney stoves, or smoke hoods which can reduce indoor air pollution by up to 80%.

Though simple, low-cost solutions are available, a technical fix alone is not the answer. Cooking is a deeply cultural and domestic task and communities themselves, particularly the women, must be directly involved in developing solutions that suit their circumstances.

Realizing the need for action

The international community is slowly gearing up to tackle indoor air pollution, with new initiatives from the World Health Organization and the launch of the United States Environmental Protection Agency-led Partnership on Indoor Air Pollution and the United Nations Development Programme's LPG Challenge. Organizations such as the Shell Foundation and a number of non-governmental organizations, including ITDG, are working directly with poor communities to find solutions and scale up their efforts. However, compared with action on the other main risks of death, there has been extremely limited funding and insufficient high-level international political backing for such initiatives.

How to stop this killer

Reducing the exposure of approximately half the world's population to smoke will take concerted political will, international co-ordination, government action and targeted funding. It will require energy, environment, health, shelter and development sectors to work together in partnership.

For relatively little outlay, massive health benefits and savings in life could be achieved. Solutions are already available. The total cost of providing three billion people with access to healthy indoor air would be in the region of US$2.5 billion annually over the next 12 years. To kick-start an effective market in distributing low-cost smoke solutions, it is estimated that government spending and international development aid would be in the region of 20% of this total, around $500 million a year – less than one per cent of total western aid spending.

What is urgently required is a global campaign that matches the level of this chronic problem, in line with the international community's response to hunger, HIV/AIDS, dirty water, poor sanitation and malaria.

Around two-thirds of women with lung cancer in China and India are non-smokers.[15]

A Global Action Plan

ITDG calls on the United Nations to instigate a **Global Action Plan** to address this neglected killer. The first step would be for the UN Secretary General to convene urgently a high level international conference to set in motion action plans with the necessary resources.

The conference should agree the following four-part strategy:

- **Millennium Development Goals** – a specific reference to and action on preventing and reducing child mortality through reducing risk from indoor air pollution.
- **A global partnership** – which puts the global political weight and resources into the existing Partnership for Clean Indoor Air, bringing together the leading international players from the health, development, energy, shelter and environment sectors to work towards a global solution and to prepare strategic plans to tackle indoor air pollution.
- **Sustainable finance** – that establishes the extra and sustainable resources from traditional and non-traditional donors needed to bring clean air to millions of homes.
- **National task forces** – that bring together the key national and local level stakeholders to enable them to address the problem with international support.

Contact details:
For further information contact:
Intermediate Technology Development Group
Schumacher Centre for Technology Development
Bourton Hall
Bourton-on-Dunsmore
Warwickshire
CV23 9QZ
UK
e-mail: itdg@itdg.org.uk
Tel: +44 – 01926 634400
Fax: +44 – 01926 634401
www.itdg.org

Smoke – the killer in the kitchen

Poverty condemns half of humanity to cook with solid fuels on inefficient stoves. Smoke in homes from these cook stoves is the fourth greatest risk factor for death and disease in the world's poorest countries, and is linked to 1.6 million deaths per year. Yet the international community has largely neglected it. Women and children are most at risk from the killer in the kitchen, as they spend considerable time around the cooking fire. Reducing indoor air pollution across the developing world would contribute significantly to achieving the internationally agreed Millennium Development Goals, in particular the aim to reduce child mortality by two-thirds by 2015.

More than a third of humanity, 2.4 billion people, use biomass (wood, crop residues, charcoal and dung) for cooking and heating.[3] Of these, approximately 800 million depend solely on crop residues and dung.[4] It is a technology that has changed little since the Stone Age. When coal is included a total of 3 billion people – approximately half the world's population – cook with solid fuel.[5]

The smoke from burning these fuels in the home is one of the four leading causes of death and disease in the world's poorest countries.[7] The indoor air pollution from the burning of solid fuels is linked to the deaths of over 1.6 million people, predominately women and children, each year. This is more than three people per minute.[6] It is a death toll almost as great as that caused by dirty water and poor sanitation, and greater than malaria.

Smoke in the home is one of the world's leading child killers, claiming nearly one million children's lives each year. Illness caused by smoke kills more children annually than malaria or HIV/AIDS.

The most recent figures from the World Health Organization (WHO) show that in developing countries where mortality is high, the four greatest risks leading to death, disease and injury are being underweight, unsafe sex, unsafe water, sanitation and hygiene and smoke from solid fuel.

Three of these risks are the subject of wide-ranging campaigns and programmes, albeit massively under funded. Being underweight, unsafe sex, and unsafe water and sanitation are well known as the principal causes of death and disease.[7] It is an international scandal that relatively little is known and done about the impacts of indoor air pollution.

The World Health Report 2002 carries a breakdown of the causes of death and disease around the world. Figure 1 indicates the total number of deaths in the world attributable to these leading health risks, and also shows the impact of ill health and disability (measured in DALYs) in the world's poorest countries where mortality is highest.

ITDG/Dr Nigel Bruce

A woman cooking on an open fire in Sudan.

Disability-adjusted life years (DALYs)

The WHO and World Bank measure health risks according to a disability-adjusted life years (DALYs) formula. DALYs estimate life years lost from disease and injuries and the subsequent disability over the remaining years. It is a measure that allows comparison of health interventions across various life threatening diseases.

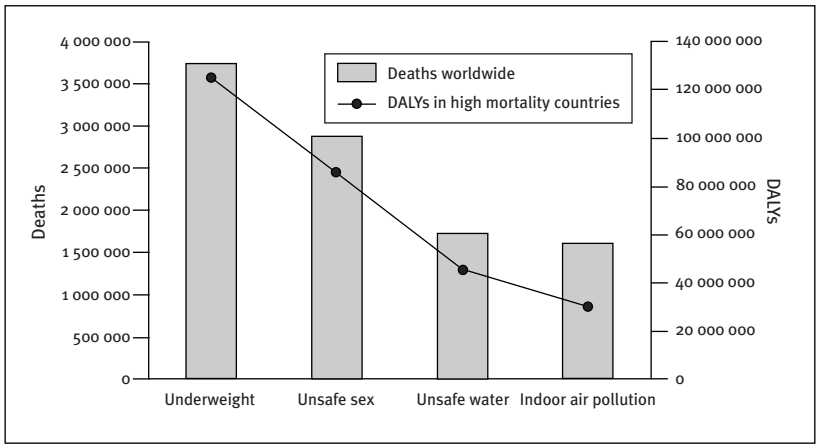


Figure 1: World Health Report's estimates of death and ill-health (DALYs) from leading risk factors in the year 2000.[7]

The main victims of death from exposure to indoor air pollution are women and children. Children aged under five account for 56 per cent of total deaths from indoor air pollution. The main cause of children's death from indoor air pollution is acute lower respiratory infections (ALRI). At 2.1 million deaths a year, ALRI is the world's leading killer of children under five. More than 50 per cent of these deaths are caused by indoor air pollution, lack of adequate heating and other precarious living conditions.[4]

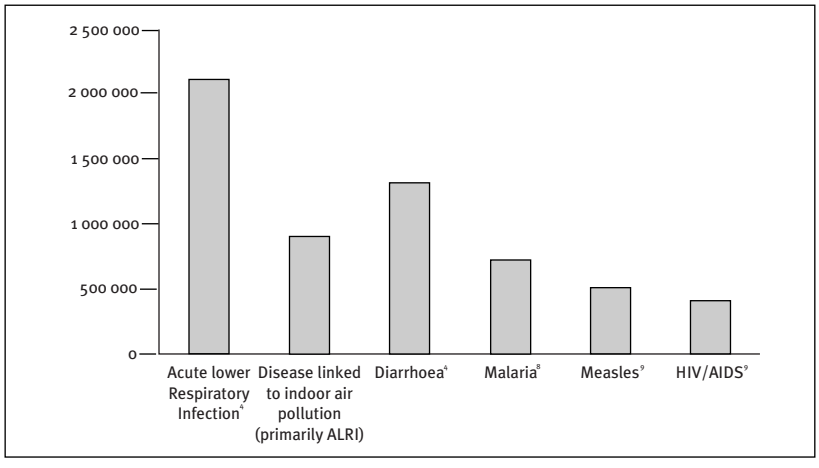


Figure 2: Deaths in the under-fives by various causes.[10]

Recently the UN General Assembly restated their aim to control malaria. It is interesting to parallel the scale of the problems presented by malaria and indoor air pollution. Twenty per cent of the world's population are at risk from malaria; almost 50% are at risk from indoor air pollution. Malaria kills about one million people per year; indoor air pollution kills over 1.6 million.[6,11,7] Quite rightly there is a major international campaign to fight malaria. This report argues for a similar worldwide campaign for healthy indoor air.

A crisis affecting mainly poor women and children

Indoor air pollution is nothing new. As the smoke-stained walls and ceilings of caves occupied by prehistoric man attest, smoke has been a fact of life for millennia. Living without smoke is inconceivable for many people in developing countries. The vast majority of staple foods, 95%, need cooking before they can be eaten.[11] Cooking needs energy.

This is not an indiscriminate killer. Indoor air pollution is strongly related to poverty. It is the poor who rely on the lower grades of fuel and have least access to cleaner technologies.

Indoor air pollution affects women and small children far more than it affects any other sector of society. In developing countries cooking is the preserve of women. This means that of all family members they have the greatest exposure to indoor air pollution.[13] Women typically spend between three and seven hours per day by the fire, longer when fires are also used for heating the home.

Children under the age of five are also particularly at risk because they spend most of their time with their mothers; often very young ones are strapped to their mother's body. The impact this length of exposure has on small children is exacerbated by a number of factors. Children's airways are smaller, therefore more susceptible to inflammation. Their lungs are not fully developed until they are teenagers, so they breathe faster. Also, their immune systems are not fully developed – a process that may be further delayed by malnutrition. These facts mean that children absorb pollutants more readily than adults and also retain them in their system for longer.[14]

Cultural practices may promote the exposure of the elderly and the sick to high levels of indoor air pollution if they end up spending extended periods of time close to the fire.[15]

Women carry a double burden

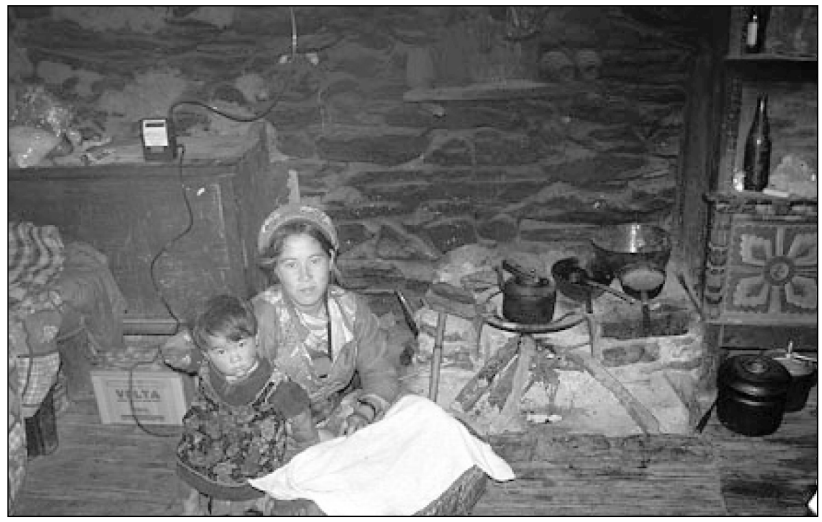
The impact on women is more than just from the smoke. In most societies it is also the women's responsibility to provide the biomass fuel. The time cost alone, in rural areas, can be extreme. Estimates range from two to twenty hours per week spent collecting fuel, and the distances covered over difficult terrain can be considerable. In Nepal, for example, women can walk over 20 km per journey in search of wood. This level of work not only reduces the amount of time women can spend on other activities, such as earning money or resting, but it contributes to a range of additional threats to health and well-being. Women are vulnerable to back problems from carrying heavy loads, frequently in the order of 20 kg, and they are more at risk of violence – rape, beating, injury and snakebites. Girls are often removed from school to assist in wood collection.[16]

A DFID-sponsored study concludes: 'The burden of biomass fuel use is a major aspect of most poor women's lives. It absorbs large amounts of time in heavy work, it can have negative effects on health, and, although this problem has been recognized for 30 years, very little has been done about it.'[17]

But it is also clear that women are not passive victims of biomass use. Women have developed strategies to cope with shortages of fuel, including shortening cooking times, changing food processing techniques, cooking fewer meals and changing the types of food eaten. They are essentially managers of the natural resource of biomass.[17]

As biomass in rural areas is collected at no financial cost, mainly by women and children, it falls outside national energy accounts. It is therefore essentially invisible as an issue. Decision makers need to be aware of the extent of women's effort. But women's input of their own time and energy is, like biomass, invisible in energy statistics and therefore remains low on the agenda.[18]

A great deal can be learnt from the decisions women make regarding biomass, and these lessons should be incorporated into any proposed effort to reduce indoor air pollution.



Smoke affects the lower status members of the community – women and children.

Smoke and the Millennium Development Goals

The international community has pledged to reduce poverty by 2015 through what have been called the Millennium Development Goals (MDGs). The MDGs have set targets for a reduction in poverty, improvements in health and education, and protection of the environment, and are commonly accepted as a framework for measuring progress towards poverty alleviation.

The MDGs concentrate the efforts of the world community on achieving significant, measurable improvements in people's lives. They establish yardsticks for measuring progress towards poverty reduction in developing countries, and have become the focus of much of the overseas aid funding of rich countries and multilateral institutions.

Reducing the level of indoor air pollution is included in MDG7, ensuring environmental sustainability, as an indicator to monitor the proportion of people using solid fuels.

'If people do not have fuel for lighting, they must sit in the dark; if they do not have fuel for cooking, quite simply, they starve.'[12]

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

United Nations Millennium Declaration[22]

Measuring the proportion of people relying on solid fuel may turn out to be a very blunt instrument for monitoring indoor air pollution. Though cooking with a cleaner fuel is by far the least polluting option, switching to higher quality fuel is out of reach for the vast majority of people at risk. Poverty will continue to condemn many households to cook on traditional fuel. In the short to medium term, the most feasible option for these homes is to get smoke safely out of the house.

What is required within the Millennium Development Goals is a more realistic method of measuring progress towards reducing indoor air pollution that takes into account the realities of poor people's economic choices and ways of reducing levels of smoke in their homes.

Nevertheless reducing levels of indoor air pollution could contribute to the achievement of most of the MDGs. Most significantly, MDG 4 has a target to reduce by two-thirds the under-five mortality rate between 1990 and 2015.

Millennium Development Goals

In September 2000 the member states of the United Nations unanimously adopted the Millennium Declaration that set in place the Millennium Development Goals of reducing poverty by 2015. The goals are:

MDG 1: Eradicate extreme poverty and hunger
MDG 2: Achieve universal primary education
MDG 3: Promote gender equality and empower women
MDG 4: Reduce child mortality
MDG 5: Improve maternal health
MDG 6: Combat HIV/AIDS, malaria and other diseases
MDG 7: Ensure environmental sustainability
MDG 8: Develop a global partnership for development

The UK's Department for International Development (DFID) acknowledges that energy plays a crucial role in underpinning efforts to achieve the MDG. 'Lack of access to adequate, affordable, reliable, safe and environmentally benign energy is a severe constraint on development.'[11]

At the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002 there was acknowledgement that the vicious cycle of energy poverty needs to be broken in order to achieve the Millennium Development Goals for reducing world poverty. A lack of access to clean and affordable energy can, and should, be considered a core dimension of poverty.[19]

Reducing exposure to indoor air pollution will help meet seven of the goals

MDG 1 – Healthier families mean a healthier workforce, and therefore a greater potential for undertaking income-generating activities from farming to small industry.

MDG 2 – Girls often have to spend considerable time collecting fuel for cooking – time that could be better spent in school.

MDG 3 - Women are the primary targets of intervention. Any improvement in the conditions in which women live and work promotes gender equality and empowerment. Interventions that have reduced indoor air pollution have been shown to increase women's social capital and provide opportunities to develop new skills and increase income levels.

MDGs 4 and 5 – The two groups of people most affected by indoor smoke are women and children under the age of five. Interventions that reduce exposure will improve the health of mothers and children.

MDG 6 – The improved conditions within the home provided by interventions to reduce indoor air pollution would help to mitigate the effects of HIV/AIDS and other illness. More efficient use of fuel means that less needs to be collected, reducing the work burden. Also, the reduction of exposure to smoke will reduce the more vulnerable person's risk of illness.

MDG 7 – Some of the interventions to reduce indoor air pollution can result in the more efficient use of wood fuel and therefore contribute to a lessening in greenhouse gas emissions and the conservation of forest areas – thereby contributing to environmental sustainability.[20] Surprisingly, even switching from inefficient use of biomass to fossil fuel (kerosene or LPG) can reduce climate impact, as it can conserve forestry and emit less greenhouse gas than inefficiently burned biofuels.[21]

Smoke's increasing cloud across the globe

It is in the world's poorest regions that smoke is a major threat, including China, India and sub-Saharan Africa. On current trends, 200 million more people will rely on these polluting fuels by 2030. Women and children are exposed for up to seven hours a day to pollution concentrations 100 times and more above accepted safety levels. There is ample medical evidence that smoke from burning biomass fuels leads to killer diseases, such as penumonia, chronic bronchitis and lung cancer.

Smoke is a chronic problem in rural areas of developing countries. Most people who depend on biomass fuels live in the countryside where wood and agricultural residues are readily available.

However, there is a growing problem in cities as well, as many people moving from rural areas to urban settlements continue to use traditional fuels. There is a complex relationship between indoor and outdoor pollution in urban areas. In cities, indoor air pollution can be due partly to external pollution sources such as vehicle emissions. In turn, the outdoor air pollution in parts of cities can consist largely of the emissions from fires in people's homes.

On current trends, the number of people relying on biomass for cooking and heating is set to rise by 200 million, to 2.6 billion, by 2030. The majority of the rise will be in South Asia and sub-Saharan Africa. The actual percentage of the world's population relying on biomass is projected to decline, but the rate of decline will not keep up with population growth.[31]

It is not just countries that have never had access to more modern forms of energy that are suffering. Countries whose economies are in transition, for example Tajikistan and the Kyrgyz Republic, have, in rural areas, conditions that are rapidly becoming similar to those in developing countries.

Political change and economic downturn have resulted in the collapse of much of the infrastructure. People have lost access to the power grid and cleaner household fuels such as liquid petroleum gas (LPG). Rural populations are

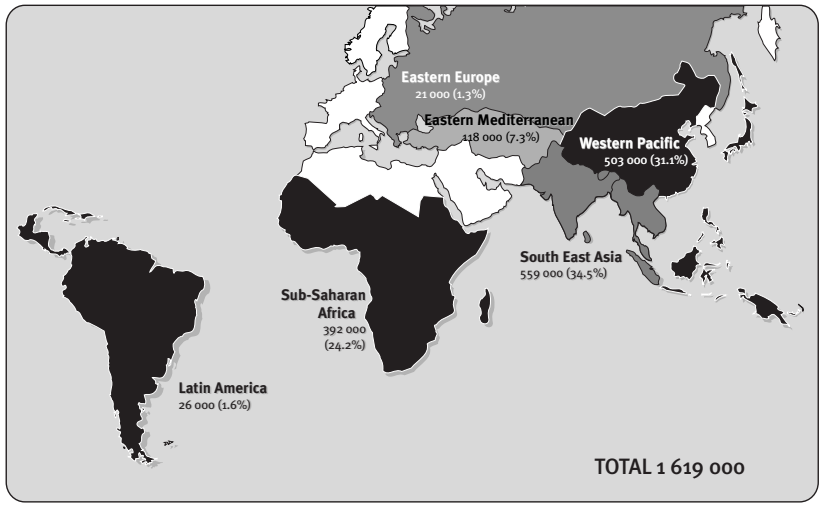


Figure 3: Map showing distribution of deaths from indoor smoke from solid fuels (2000). Source: The World Health Report 2002

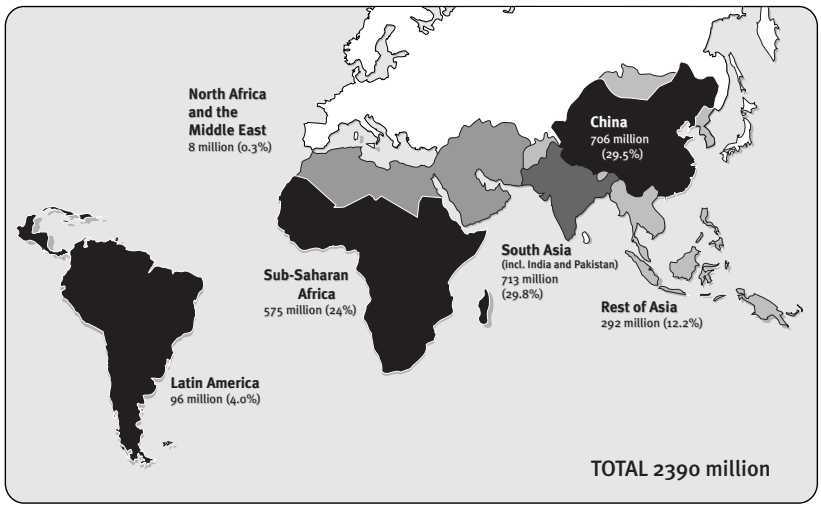


Figure 4: Map showing distribution of people depending on biomass fuels (2000). Source: IEA, World Energy Outlook, 2002

reverting to the use of wood, dung, crop residues and low-quality coal for fuel. There are concerns that, as the tradition of using such energy sources has been interrupted for several decades of subsidized access to cleaner fuels, there will be a deterioration in health due to indoor air pollution.[23]

The most striking example of this is in Tajikistan where the coverage of gas and electricity has reduced. People are now reverting back to using biomass. The impact of this is all too familiar – between 1991 and 2000 there has been a dramatic 35% increase in cases of acute respiratory infection, 'largely as a result of burning wood indoors'.[24]

Why has so little been done?

Given that half of humanity is at risk from burning solid fuels and that in the world's poorest countries indoor air pollution is the fourth greatest risk factor for death and disease, it would be expected that there would have been significant action to address this crisis. But this is not the case.

Indoor air pollution persists as a problem because of many interacting factors; not least are:

- **Largely not understood or ignored**

Until very recently there was insufficient evidence to link indoor air pollution and ill health or death. However, there are now a growing number of health studies clearly demonstrating this link, which has recently been quantified for the first time by the WHO. An increasing number of international health professionals are recognizing that indoor air pollution is a problem.

- **Cure not prevention**

Responses to childhood acute lower respiratory infection (ALRI) so far have focused on treatment rather than on removing one of the major causes of the illness – smoke in the home. Over the past decade, the United Nation's Children's Fund (UNICEF) has been monitoring the progress of the aims of the World Summit for Children (1990 to 2000). One aim was to reduce by one-third deaths due to ALRI in children under five. This target has not been hit. The main method used to prevent ALRI deaths was treatment by the selective use of antibiotics, but the findings showed that in half the 80 countries reviewed, fewer than 50% of the children with ALRI were taken to the health care provider.[25]

Demonstrating the link between indoor air pollution and ill health in Tamil Nadu, India[39]

The Indira Gandhi Institute of Development has carried out a detailed survey of the household energy use and health of 5028 households in 30 villages in Tamil Nadu. In about ten per cent of these households the research team monitored the direct exposure to smoke of the family members.

The survey showed that in 96% of the households in the survey, biomass fuels were the main cooking source. Direct exposure to smoke of the cook in each household was very high, with exposure to particulate matter ranging from 500 to 2000 $\mu g/m^3$ during cooking periods (noting that typical standards for maximum exposure to particulates are about 50 to 100 $\mu g/m^3$). In addition, concentrations of particulates in areas adjacent to the cooking area were also extremely high, which is important considering that children and older people are likely to be in the home during these periods.

Incidence of respiratory illness was measured, showing that prevalence of obstructive disorders amongst women cooks using biofuels was around 22%. Incidence of cough, phlegm, breathlessness, wheezing and eye irritation are also significantly higher in households using biomass fuels compared to those using LPG.

- **Low status of women**

Smoke mainly affects those perceived to be the lower status members of a community – women and children. Their work and contribution to society and the economy is rarely calculated in national economic planning. Therefore, the poverty alleviation benefits of improved, clean cooking have not been fully recognized.

- **Focus on environment not health**

There has been a great deal of work done on improving stove design, with the goals of energy efficiency and fuel saving, lifting the burden of women's time and effort, and with the environmental motive of saving forests. It is only in the last few years that attention has turned to the issue of indoor air pollution.

- **Other pressing problems**

Policy makers are slowly beginning to recognize smoke as a problem, but it has the disadvantage of being viewed as less significant than more acute issues, such as food, HIV/AIDS, water and sanitation and malaria. However, the impact of indoor air pollution can be as acute and dramatic as malaria. A young child getting pneumonia, for example, and having no access to hospital, will be as acutely in need of help to prevent death as if they had malaria.

Guatemalan study

Professor Kirk Smith from the University of California is leading a team embarking on the most thorough analysis of the impacts of biomass generated indoor air pollution yet conducted. The four-year, US$2 million Guatemalan programme started in 2002 and hopes to learn whether reducing indoor air pollution will decrease the incidence of pneumonia among young children.

Working in the highlands of Guatemala the international team are conducting a randomized intervention trial that will increase confidence in indoor air pollution risk estimates.

There are 500 households taking part in the trial. Each is randomly assigned to receive either an improved stove (a *plancha*) or to continue to use a three-stone fire and receive no intervention (these households receive a stove at the end of the experiment). The *plancha* is a relatively expensive wood-burning stove constructed from brick and concrete blocks, with a three pot-holed steel top plate and a metal chimney. It was developed locally and is well accepted.

Each week, trained field workers visit all the households taking part in the study and ask questions about the health of the children. Sick children are referred to the study physicians for clinical assessment. While the principal focus is on the incidence of ALRI/pneumonia, they are also recording other important health outcomes, including diarrhoea, nutritional status, scalds/burns along with child growth and development.

Time-activity patterns of the householders are monitored, as well as quality of life indicators, to establish whether the new stoves affect cooking practices and other household routines. Asthma, the incidence of low birth weight as well as women's respiratory and cardiac health are also monitored.

Levels of exposure to indoor air pollution are assessed periodically. While monitoring small particles is the best indicator, the measuring devices are cumbersome and noisy, so carbon monoxide is measured as a proxy using a small tube attached to the child's clothing for 48-hour intervals. Particulates are measured directly in a sub sample with state of the art machinery. Additionally, outdoor pollution levels are measured to quantify any relationships with indoor pollution.[34,35]

How smoke kills and injures

Smoke is the result of the incomplete combustion of fuel. The composition of smoke produced by cooking stoves varies with factors such as fuel quality or stove design. One of the most detailed reviews of indoor air pollution was led by Professor Kirk Smith from the University of California:

> 'Biomass fuel smoke contains significant quantities of several pollutants for which many countries have set outdoor air quality standards – for example, carbon monoxide, particles, hydrocarbons, and nitrogen oxides. In addition, the aerosol contains many organic compounds considered to be toxic or carcinogenic, such as formaldehyde, benzene, and polyaromatic hydrocarbons.'[29]

It is instructive to see what a kilogram of wood will generate. On a typical three-stone wood-fired stove about 18% of the energy goes into the pot, 8% into the smoke and 74% is waste heat.[26] But it is the pollutants that are of more concern. A kilogram of burning wood can produce significantly harmful levels of gases, particles and dangerous compounds.

Significant information about how much smoke people are exposed to can be gained from measuring the pattern of emissions from cooking fires in the home. This is shown clearly in the work of environmental health researcher Majid Ezatti in rural Kenya. Figure 6 indicates the high intensity emissions that commonly occur when using biomass fuels. The mean PM_{10} measurement near the fire was 1250 µg/m^3 – yet levels actually peaked at over 50 000 µg/m^3.[27]

Emissions in the kitchen can vary from day to day and from season to season, due to the moisture content and density of the fuel, the amount of airflow, the type of food being cooked and any changes in the stove or fuel used.[27]

Exposure in poor homes far exceeds accepted safety levels

It is not as if the world is unaware of the impact of smoke-based pollution. Ample evidence has been collected of the impact of relatively low levels of particulate pollution on health in the industrialized world. There is now evidence showing that levels of pollution previously considered to be safe are having adverse effects.[29] This is why the European Commission is introducing new targets to further lower levels of particulate pollution. Council Directive 1999/30/EC states that a PM_{10} 24-hour limit value of 50 µg/m^3 should not be exceeded more than 35 times per year by 1 January 2005 and no more than seven times per year by 1 January 2010 in the member states. Also, a PM_{10} annual limit value should not exceed 40µg/m^3 by 1 January 2005 and 20 µg/m^3 by 1 January 2010.[30]

Again, it should be borne in mind that the levels experienced by women and small children in developing countries for up to seven hours every day are frequently

Table 1: Pollutants generated from burning one kilogram of wood.[26]

Pollutant	Typical concentrations*	Typical standards set to protect health	Number of times in excess of guidelines
Carbon monoxide (ppm†)	129	8.6	15
Particles (µg/m^3)	3300	100	33
Benzene (µg/m^3)	800	2	400
1-3 Butadiene (µg/m^3)	150	3	50
Formaldehyde (µg/m^3)	700	100	7

* From burning 1 kg of wood in a traditional stove in a 40 m^3 kitchen with 15 air changes per hour.
† parts per million.

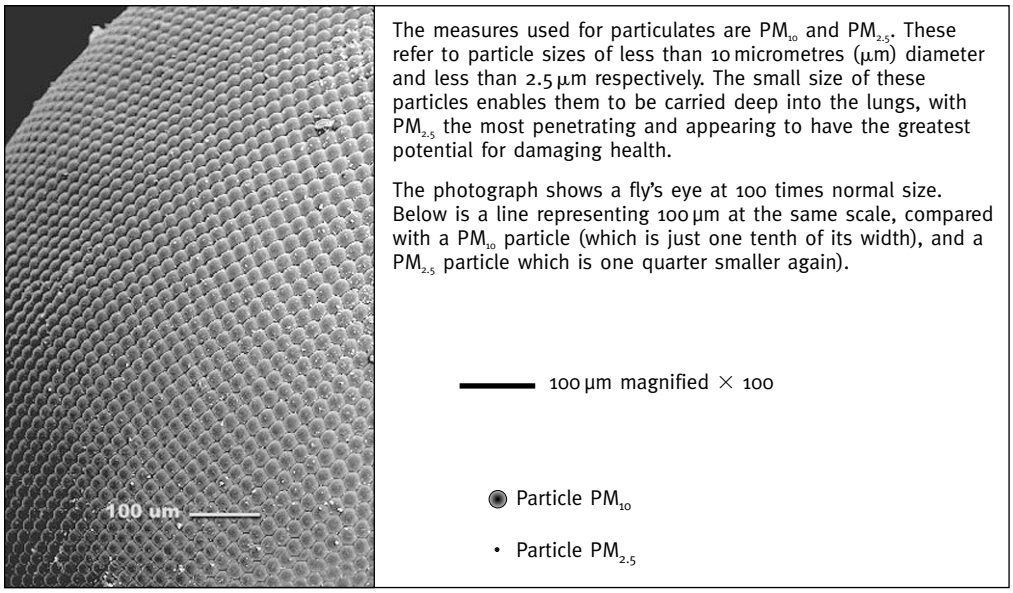


Figure 5: Measuring particulates PM_{10} and $PM_{2.5}$.

in excess of one hundred times these levels.

There are sophisticated devices placed on streets in many of Europe's cities monitoring levels of pollution, including the levels of particulates. There is a great deal of certainty about the levels experienced by people living in the relatively particle-free environments of North American and European cities, yet there is a dearth of information about levels experienced in the kitchens of developing countries.[31]

It is valuable to compare these figures with the latest results from a European wide investigation of outdoor air pollution. The APHEIS (Air Pollution and Health: a European Information System) study surveyed the levels of air pollution of 19 cities and also monitored the health of the 32 million inhabitants of these cities. The conclusions of this health

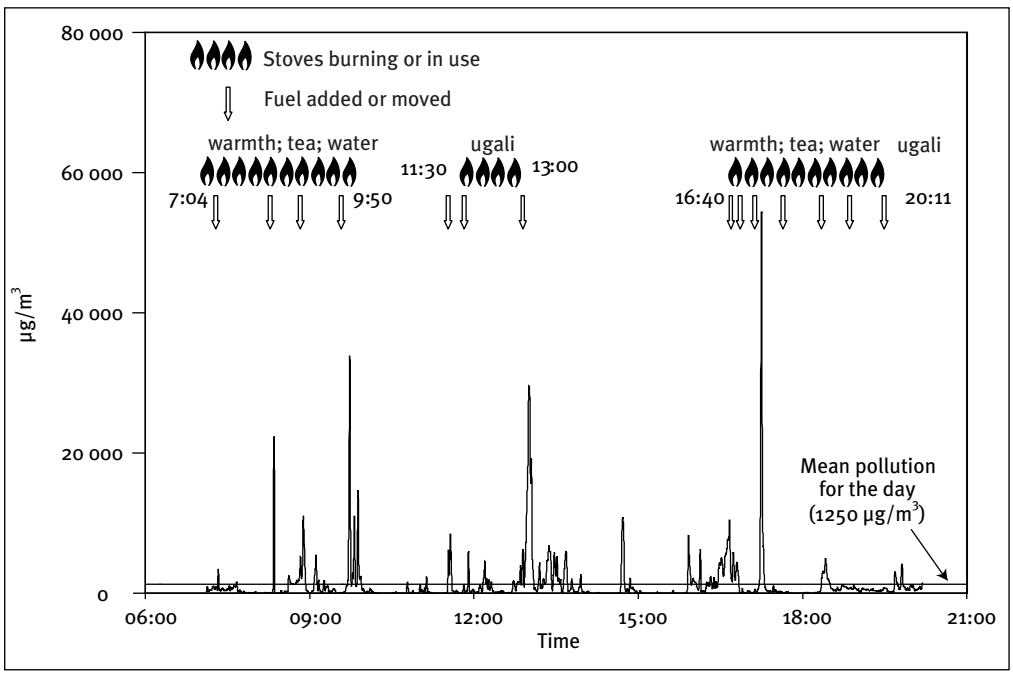


Figure 6: Day-long monitoring of pollution and cooking activities showing PM_{10} concentration (at a distance and height of 0.5 m) in a household that used a three-stone stove inside. The lower horizontal line indicates the mean pollution for the day. Ugali is the staple maize or sorghum flour meal. It requires active stirring from the cook during preparation, therefore keeping her close to the fire.[27]

impact assessment were that 5547 deaths (with a range of 3368 to 7744) could be prevented annually if long-term exposure to outdoor concentrations of PM_{10} were reduced by 5 mg/m^3.[30]

Researching how smoke affects health

The health impacts of ambient particulate pollution in industrialized countries have been researched thoroughly and have given rise to the guidelines in Figure 7. But these results are only applicable to the relatively small range of exposures examined, mostly less than 200 µg/m^3. The exposure-response relationship at concentrations of thousands of µg/m^3 is relatively unknown. Yet these are the levels experienced indoors in developing countries where around 80% of global exposure to particulate pollution occurs.[32]

An on-going study in Guatemala is the most likely to give a clear answer to the links between exposure and disease, as well as the impact that interventions can have (see page 7). It is a collaboration between the University of California in Berkeley, the University of Liverpool and del Valle University in Guatemala, and is the largest study of its kind.

In addition, the Shell Foundation are sponsoring a substantial project, called 'Standard Monitoring Packages for Household Energy and Health Field Projects', to develop a package of standardized monitoring methods for indoor air pollution. This package will allow those working in the field to monitor both exposure levels and health impacts effectively, and to compare results internationally.[33]

Health effects of indoor air pollution

There is a substantial body of evidence clearly showing that exposure to smoke in the home is a huge health hazard. As with most medical knowledge there are difficulties in drawing exact conclusions as to what levels of exposure to smoke will cause what levels of disease, as there are so many other factors which contribute to ill health. However the evidence is clear that smoke in the home is a major risk.

Acute lower respiratory infection (ALRI)

The WHO estimates that, in terms of DALYs, 35.7% of all acute lower respiratory infections are caused by exposure to solid fuel smoke.[7]

Acute lower respiratory infection, such as pneumonia, is the world's greatest killer of children under the age of five. It accounts for around 2.1 million deaths annually in this age group. More than 50% of deaths due to ALRI are caused by

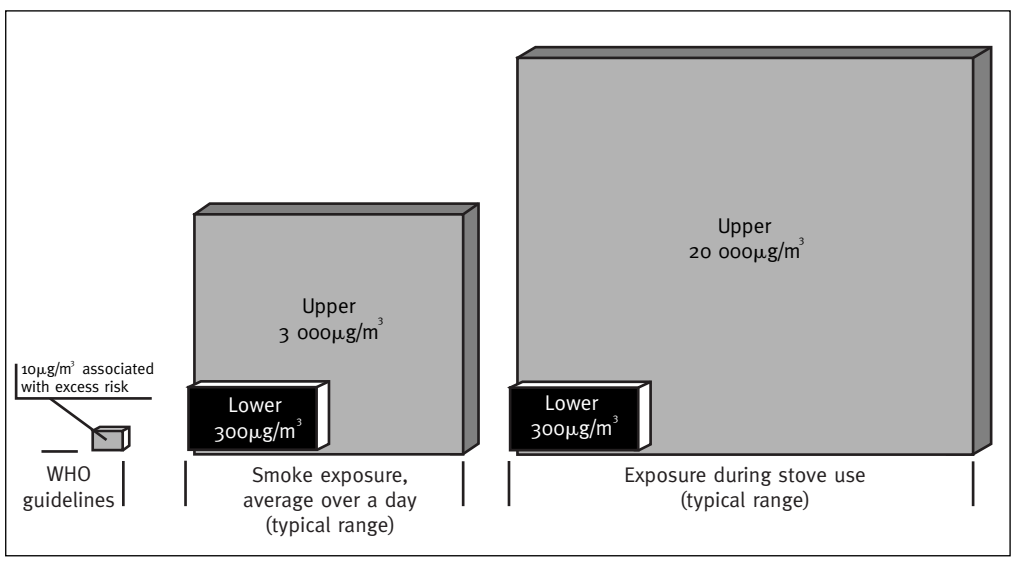


Figure 7: Comparison of typical levels of PM_{10} in developing country homes with WHO guidelines.[15]

indoor air pollution, lack of adequate heating and other precarious living conditions.[4]

Evidence from a series of studies in developing countries indicates that young children living in homes using solid fuel have two to three times more risk of suffering from ALRI than unexposed children. This figure is reached after other factors, such as socio-economic status, have been taken into consideration.[36]

Indoor air pollution can increase the incidence of ALRI by affecting the body's defence systems. For example, the ability to filter and remove particles in the upper airways and the immune system can be compromised.[29]

In the early part of the twentieth century ALRI, in the form of pneumonia, was a major cause of death in industrialized countries. Its decline as a major killer began with improvements in housing and nutrition before the advent of vaccines and antibiotics.[29]

Chronic obstructive pulmonary disease (COPD)

In industrialized countries, tobacco smoking accounts for over 80% of chronic obstructive pulmonary disease – the progressive and incompletely reversible obstruction of the airflow, such as chronic bronchitis.

However in the developing world this disease also occurs in areas where tobacco smoking is rare.[15] A woman who cooks over a biomass fire has between two and four times more chance of suffering from COPD than a woman who remains unexposed.[36] The WHO estimates that 22% of all COPD is caused by exposure to indoor smoke from biomass fires.[7]

Lung cancer

The most important cause of lung cancer is tobacco smoke. But in developing countries, women who do not smoke form an unexpectedly high proportion of lung cancer patients. For example, around two-thirds of women with lung cancer in China and India are non-smokers.[13] It is now clearly demonstrated that cooking with open coal stoves in China causes lung cancer in the women who use them.[36]

So far a clear link between lung cancer and wood smoke exposure has yet to be demonstrated. And while the rates of lung cancer in rural areas where there is a lot of exposure to wood smoke are low, this could be due to a variety of factors. As biomass smoke contains known carcinogens, such as benzoapyrene, 1,2 butadiene and benzene, it would not be possible to dismiss the lung cancer risks of exposure.[37,15]

If exposure to all carcinogens in wood smoke parallels exposure to particulates, then cooking with traditional biomass stoves is equivalent to smoking several cigarettes per day. And it has been estimated that in some homes women who cook for three hours per day are exposed to similar amounts of benzoapyrene as if they had smoked two packs of cigarettes.[38]

Pulmonary tuberculosis

There have been three studies published that suggest that people in homes using wood for cooking are at 2.5 times more risk of active tuberculosis.[37] This increase in risk may result from a reduced resistance to infection as exposure to smoke interferes with the proper functioning of the lungs.[15] Studies on animals have shown declining immune function with exposure to wood smoke.[36]

Low birth weight and infant mortality

Low birth weight is a key factor in infant mortality and morbidity. Exposure to tobacco smoke is known to be a significant contributor to decreased birth weight. Active smoking is associated with a mean reduction in birth weight of up to 200 grams and passive smoking has a smaller effect, estimated at between 20 and 120 grams.[40] Can any parallels be drawn with the impact of indoor air pollution?

There are thousands of substances emitted in both tobacco smoke and wood smoke. However, analysis of cigarette smoke isolates just a few dozen as particularly important to health. The

The United Nations Development Programme (UNDP) states that the use of poorly ventilated, inefficient stoves 'can have the same adverse health impacts as smoking two packs of cigarettes a day'.[2]

'Many older women go blind or have bad eyesight... it has a lot to do with all the smoke from fires, which they cook over.'

Umana Tesfasellasie, Oxfam project officer, Eritrea[41]

chemical most responsible for retarding intrauterine growth is believed to be carbon monoxide (CO). Carbon monoxide results from the incomplete combustion of biomass and fossil fuels. When inhaled it combines with the haemoglobin in the blood to form carboxyhaemoglobin (COHb) – a molecule that does not readily release oxygen to the body, or the foetus.[40] This is the main reason for the warnings published on cigarette packets in the UK linking smoking with harm to the unborn child.

The combustion of wood and other biomass is qualitatively similar to burning tobacco. Studies have shown that exposure to biofuels can result in COHb levels ranging from those seen in passive smoking up to those experienced in heavy active smoking. However, there is very limited data published on the effects of burning biomass on foetal growth.

The most rigorous study comes from Guatemala. It concluded that, when a number of other factors, such as socio-economic status are taken into consideration, women who use wood fuel have babies weighing an average of 63 g less than those who use cleaner fuels. This places the level of impact at least on a par with passive smoking. This is the first study of its kind, and more research is needed to support these findings.[40]

Cataracts

One of the most frequently reported complaints about exposure to smoke is that it affects the eyes of the cooks.[46] While the majority of complaints are about red, watering eyes and other relatively superficial irritations, there is growing evidence that indoor air pollution causes cataracts. Hospital-based studies in India have shown an increased incidence of cortical, nuclear and mixed cataracts. Studies on the eyes of rats have shown that wood smoke, like cigarette smoke, causes damage to the lens.[15]

Asthma

Asthma in poor rural communities in developing countries has not been studied in much detail. In industrialized countries, the influence of air pollution remains complex – and sometimes inconsistent. However there is evidence that wood smoke pollution may be a trigger for asthma or exacerbate it when combined with tobacco smoke and other ambient pollutants.[37]

Risks to women from fuel collection

Throughout the developing world it is women who provide fuel for the home and actually carry out most tasks that require energy at home. The average amount of time spent each day collecting fuel is between one half and two hours. Where it is scarce fuel wood collection can take much longer. Other than the opportunity costs associated with this time burden, there are significant risks linked with this activity.

Transporting large loads of wood exposes women to injuries such as fractures and miscarriages from falls and carrying weight when pregnant. In areas of war and civil unrest women will be exposed to violence and injury from landmines and other unexploded ordnance as they collect fuel.

The Great Smog

Indoor concentrations of particulate pollution in developing countries are typically in the region of 300–3000 mg/m^3 and may reach 30 000 mg/m^3 or more during periods of cooking.[4] When the smoke-laden fog – the Great Smog – enveloped London in December 1952 it exacted a death toll of an estimated 4000. Mortality from bronchitis and pneumonia increased sevenfold due to the smog. For six days, from 5–10 December, the people of London were exposed to levels of particulate pollution comparable to that experienced by women and children in developing countries for up to seven hours a day, every day. This smog event was a key factor in the creation of the UK's Clean Air Act in 1956 that for the first time controlled domestic smoke emissions.[28]

The UK's Clean Air Act shows that when faced with a dire public health crisis government can act quickly and decisively. Similar swift and purposeful action is required on a global scale if indoor air pollution is be tackled.

Reducing exposure to indoor air pollution

The solution to indoor air pollution is relatively simple: either stop smoke getting into the home or remove it from the home. The healthiest option is to cook with a cleaner fuel. However, for the foreseeable future, many poor people will have little option but to cook on low-grade fuels. The best option for them is to safely remove the smoke from the kitchen. Experience shows that there is no 'one size fits all' technical fix. A lasting solution depends upon the active participation of those at risk, poor women.

As poor people's incomes increase they tend to switch to cleaner fuels for cooking and heating. In time, as poverty levels are reduced, lethal levels of indoor air pollution will fall. But poor people cannot afford to wait for a rising tide of prosperity to clean up the air in their homes, and the international community has an obligation to ensure life is made more tolerable for today's generation. There are actions that can be taken in the short term, that will ensure long term benefit for those at risk.

In a review of ways of reducing smoke levels, undertaken for the WHO and the United States Aid (USAID), alternatives were considered according to three areas. These comprise: interventions at the source of smoke; interventions directed towards the living environment; and interventions aimed at the user.

Cooking on a cleaner fuel

The most effective means of reducing indoor air pollution is to switch to cleaner fuel that produces significantly lower emissions. While this may not currently be an option for many people due to high costs, lack of access to the fuel and other barriers, for those who are able the switch fuels, the benefits are great.

In many urban areas cleaner fuels, such as kerosene and LPG, cost less per unit of fuel than biomass. However, there is often a larger cash investment needed to purchase the fuels and the stoves. For example LPG must be bought each week or month by the bottle, but poor people usually purchase fuel daily in small quantities. Making fuel available in smaller quantities would benefit poorer customers. Mechanisms such as micro-

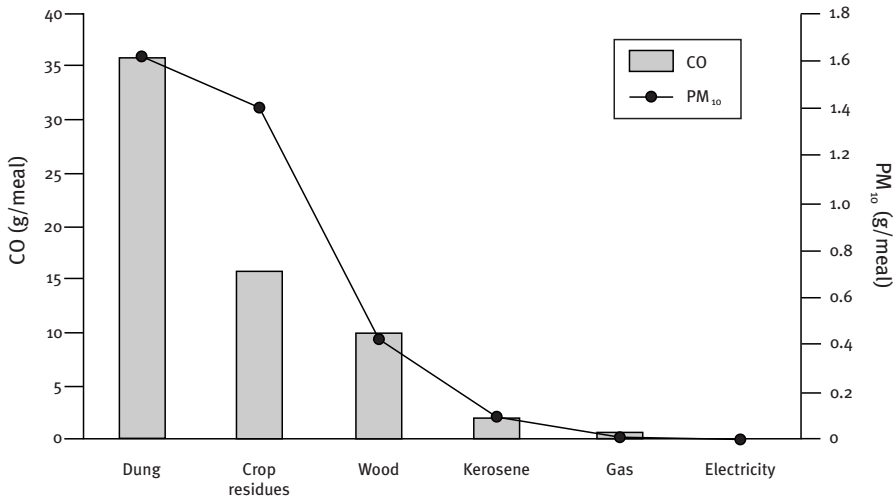
Source of smoke	Living environment	User
Improved cooking devices Chimneyless improved biomass stoves Improved stoves with chimneys **Alternative fuel–cooker combinations** Briquettes and pellets Charcoal Kerosene LPG Biogas Producer gas Solar cookers (thermal) Other low smoke fuels Electricity **Reduced need for fire** Efficient housing Solar water heating	**Improved ventilation** Hoods/fireplaces Windows/ventilation holes **Kitchen design and placement of stove** Shelters/cooking huts Stove at waist height	**Reduced exposure through operation of source** Fuel drying Use of pot lids Good maintenance Sound operation **Reductions by avoiding smoke** Keeping children out of smoke

Table 2: Potential interventions for the reduction of exposure to indoor air pollution.[53]

Figure 8: Emissions along the energy ladder.[29]

The energy ladder

The energy ladder is a scale which rates the quality of household fuels. At the lower end of the ladder are the traditional biomass fuels: dried animal dung; scavenged twigs and grass; through to crop residues, wood and charcoal. Moving up the ladder, coal is next, followed by kerosene, bottled and piped gas, biogas (from digesting animal dung) and electricity. Gaseous fuels are the cleanest burning household fuel. In general, as households climb the ladder there is an associated increase in the sophistication of the cooking technology, its cleanliness, efficiency and its cost.[29] Cooking with electricity is too costly for poor households.



credit loans or subsidies may also help to reduce the cost of fuel switching.[42]

In rural areas there is less incentive to switch fuels, as biomass is gathered at no financial cost to the user. Cost issues aside, there are other concerns about fuel switching. Many of the poorest members of society in developing countries make their living from collecting and selling biomass fuel. The result of a wholesale shift from biomass fuel could be the removal of a vital source of income for some of the most vulnerable people in society.[43]

The United Nations Development Programme's LPG Challenge aims at overcoming the barriers for rural communities to access LPG in countries where it is readily available in urban areas.

Cleaner fuel and climate change

There may be concerns about the climate change impact of switching to a non-renewable, petroleum-based fuel. Professor Kirk Smith, from the University of California, tackled this argument in a paper entitled 'In Praise of Petroleum',[45] published in *Science* in December 2002. He argues that if the two billion or so people currently reliant on biomass were to shift to LPG, emissions of greenhouse gases would increase by less than 2%. Professor Smith goes on to illustrate how the smallest of increases in efficiency in the world car fleet could counter this rise. If an improvement of just 0.5% per year (5.1% over 10 years, not much more than one mile per gallon) were made, this would free up annually sufficient fuel energy for the cooking needs of all the two billion currently burning biomass.

Over-consumption of fossil fuels is primarily a problem for the industrialized world. As Professor Smith puts it:

> 'Rather than excluding petroleum, some of this one-time gift from nature ought actually to be reserved to help fulfill our obligation to bring the health and welfare of all people to a reasonable level: an essential goal of sustainable development, no matter how defined.'[45]

'Kerosene and LPG actually produce fewer greenhouse emissions per unit of energy service than biomass fuels used in traditional ways.'

UNDP World Energy Assessment[21]

Ghana LPG[44]

Promotion of LPG started in Ghana in 1990 to reduce the wastage caused by flaring constituent gases at the refinery, and to reduce dependence on charcoal and fuel wood. The Ministry of Energy took the lead in promotion and price control of LPG use for cooking. The programme involved: public awareness raising to increase demand for LPG; door-to-door delivery; reduced cost cylinders; encouragement of LPG use in schools and hospitals; promotion of LPG with commercial food vendors.

Elements of the traditional cook stove were used in the design of the locally promoted LPG stove. Between 1989 and 1997 cylinder sales increased from 80 000 to 600 000 per year, with 22.7% of households in the capital city, Accra, using LPG. Promotion of LPG to lower income households and in rural areas has not been so successful, however.

The UNDP LPG Challenge is now planning to work with local stakeholders in Ghana to overcome the barriers for LPG promotion in rural areas, and to encourage private companies to sell to rural customers.[69]

Using solid biomass fuel can, in fact, produce higher greenhouse gas emissions per meal than fossil fuels, kerosene and LPG,[26] even where the biomass fuel is harvested sustainably. This is due to inefficient combustion of the biomass fuel, which releases products of incomplete combustion, including methane, which have a greater greenhouse potential than carbon dioxide. In some situations, therefore, fuel switching to fossil fuels may be recommended to reduce greenhouse gas emissions.

Biogas from dung and other waste

Biogas is extremely effective, as it converts a renewable material (dung and other organic waste materials) into a gaseous, clean fuel. While biogas is being introduced in parts of Asia very successfully – there are over 120 000 bio-gasifiers in Nepal alone – the culture in much of Africa makes it harder to introduce there. Further research and development of renewable, clean cooking fuels will be essential for longer term cooking options.

ITDG/Simon Dunnet

A household biogas plant in Nepal.

Getting smoke out of the house

The biomass trap

While switching to a cleaner fuel is the most effective means of reducing indoor air pollution, abject poverty will mean many hundreds of millions of people worldwide will have no access to fossil fuels for a very long time to come. They will be trapped into using biomass as their primary fuel. The barriers to accessing clean fuels are many, for example:

- For extremely low-income households the up-front costs of purchasing new cooking technologies, as well as the on-going cost of fuel, are beyond their means.
- Where biomass is collected free of charge, even though it takes a considerable amount of time to collect, using limited cash income to purchase cooking fuel is not given priority in many very low-income households.
- In extremely remote areas it is very difficult to provide a reliable supply of fuel, and transport costs will increase the price of fuel supply.
- Many developing countries do not yet have sufficient infrastructure to distribute LPG or kerosene on a wide scale.

Where biomass fuels will remain the dominant domestic fuel, it is essential to maintain a reliable and sustainable supply of fuel wood. Fuel wood collection for use in rural areas is not a significant cause of deforestation as women generally collect dead wood and twigs and rarely chop down trees.[26] However, in environmentally stressed areas, fuel wood collection has a significant impact. Where deforestation has occurred, often due to either commercial logging or land clearance for agriculture, there is a need to provide sustainable fuel wood sources for rural populations.

In many countries trees are often felled unsustainably to provide fuel wood and charcoal to supply urban demand. Urgent policies and measures are required here to curtail the loss of forestry. Many people make a living, legally and illegally, in the supply of fuel to cities in the developing world. It will be essential to maintain these livelihoods, while restoring forest resources.

For those trapped into using biomass as their main domestic fuel, options for reducing exposure to indoor air pollution will entail safe ways of getting smoke out of the home.

Smoke hoods, eaves and windows

For the foreseeable future billions of people will continue to use biomass as their main fuel. Therefore it is essential that efforts to reduce exposure to indoor air pollution be directed at the reality people face now. Smoke will continue to be produced, so it needs to be removed from the house.

Substantial reductions to smoke exposure have been obtained with relatively simple methods. For example, an ITDG project in Kenya reduced particulate and carbon monoxide pollution in homes by nearly 80% through the use of smoke hoods and improved ventilation in the home.

Smoke hoods work on the same principle as flues and chimneys, but have the advantage of being freestanding and independent of the stove.[47] Smoke hoods have been shown to achieve substantial reductions (80% in some homes) in respirable particulates and carbon monoxide.

By enlarging the eaves spaces in a traditional house, substantial benefits can be achieved. For example, in the Kenya project respirable particulates were reduced by 60%. The number of houses showing very high levels of smoke pollution was also reduced significantly.[46]

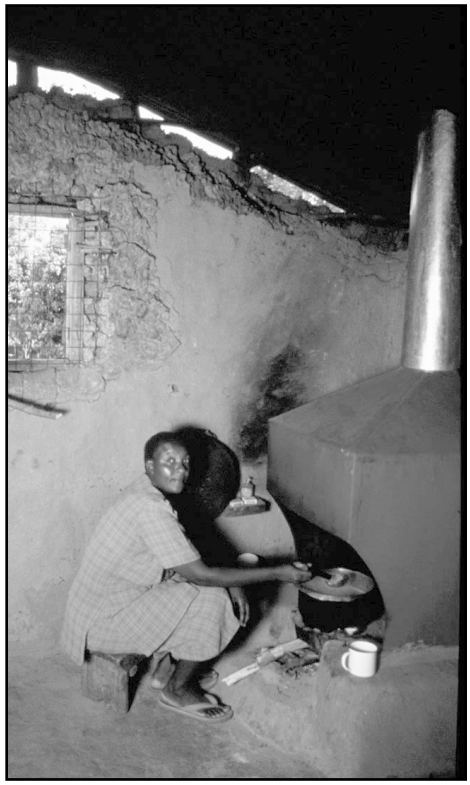
However, the enlargement of windows in the same project seemed to have little impact on indoor air pollution, although windows are required in houses with smoke hoods to allow an air flow through the house.[46] The enlarged windows did have benefits, such as improving lighting in the houses, but did not add significantly to the reduction of smoke.

Kenyan study[46]

The ITDG Smoke Project was launched in 1998. Working with 50 households in rural Kenyan communities, the project aimed to reduce exposure to indoor air pollution. The participatory approach adopted for this work meant that the project workers arrived willing to listen to the needs of the households rather than to impose specific interventions.

The interventions chosen were: smoke hoods; increased ventilation through windows and eaves; and more efficient combustion through improved stoves.

- Smoke extraction through smoke hoods was selected in favour of chimney stoves, based in part on the successful operation of smoke hoods in a previous project and on the failure of the chimney stoves installed during a government scheme.
- Increasing the amount of ventilation involved installing a window or cutting eaves spaces into the wall at roof height.
- The Upesi stove has been shown to reduce fuel use by about 40% compared with traditional three-stone fires. Households that have used them state that the kitchens are cleaner, children are safer from accidents and there is a considerable saving in the use of fuel wood.



ITDG/Dr Nigel Bruve

A West Kenya kitchen with smoke hood, large eaves space and windows.

An important component of this programme was the exchange visits that allowed local dissemination of ideas. Initial reluctance on the part of many cooks turned to enthusiasm once they had seen the interventions in place in other people's kitchens.

The results showed substantial reductions in particulate matter and carbon monoxide levels in the households after the installation of interventions. The most effective intervention was the use of smoke hoods, which reduced particulate pollution by an average of 75% and carbon monoxide in the room by 78%. The personal exposure experienced by the women in the study was reduced to about one third.

Additionally there were some very positive impacts on poverty. Community members observed that they felt healthier; there was more time to engage in economic activities when the stoves were used; and local artisans increased their income from the manufacture of interventions. There were significant improvements for women, above and beyond their health. Participating women were found to have increased confidence and improved status in the community.

These changes are not without their problems, with some reports that houses were now cooler, concerns about privacy and security which were overcome by using wire mesh over openings, and some financial problems for households who were contributing to the costs of the programme.

This was the first stage of a programme of work with the target communities. The on-going work is now aimed at achieving wider use of the interventions through public awareness, developing local markets for the interventions and establishing local financing mechanisms to help households afford the necessary changes in their homes.

Responses to interventions in the Kenya study

'I can now do my studies in the kitchen,' one boy, Sironga Masur, told the team. 'I never used to study with the fire on due to choking smoke.'

'Now I can have a breath of fresh air. No more tearing, no more red eyes, bye-bye to headaches.'

'You no longer suffocate while in the kitchen cooking.'

Cutting smoke volumes

Improved biomass stoves

Improved stoves were primarily designed to increase energy efficiency. The Upesi stove, for example, has been promoted throughout Kenya and can reduce fuel use by about 40%.[46] These stoves were developed with good reason. Reducing fuel requirements will ease demand on forestry, lessen the burden on women collecting fuel, and in urban areas cut expenditure on fuel.

Some improved stoves can also help reduce emissions of smoke. Studies have shown a small decrease from certain improved stoves, although many stoves in fact increase emissions if air flow to the fuel is restricted.[53]

If an improved stove incorporates a flue or chimney, one would anticipate smoke would be reduced. There are some very effective chimney stoves, which have been designed to remove smoke from the house, and tested in the home to show a significant reduction in smoke. Good examples are the rocket stove[48] and Ecostove,[49] which are increasingly being used in Central America.

However, there are also potential problems with many chimney stoves. Flues may not perform well if they are not installed properly, they can be poorly designed and can be fragile. Chimneys are expensive and may be ineffective if the smoke returns through doors and windows.[47] They can also block up quickly with soot and require regular cleaning.

These points indicate that improved stove must be more rigorously designed and monitored to demonstrate a significant impact on IAP in the home.

Reducing the need for fire

Hay boxes

A very simple technology can reduce the need for fuel for cooking – this is the fireless cooker, or a 'hay box'. This acts like a slow cooker, and is good for making soups, rice or stews. The food is heated to boiling, then placed in a box filled with insulating material, such as hay or crumpled newspaper.[50] The food continues to cook slowly. The development organization Winrock found that the hay box was very popular with the women's groups they worked with in Nairobi, where hay boxes are proving as popular as improved stoves.[51]

The success of the Ecostove in Nicaragua[49]

After diarrhoea, acute respiratory illness is the greatest cause of death in young children in Nicaragua. In both rural and urban parts of the country, three-stone fires are still commonly used. In urban Managua and smaller towns, a new stove is making inroads to replace the traditional stove. This is the energy efficient Ecostove, developed by the NGO Proleña, with technical support from Aprovecho.[48] The Ecostove is an innovative woodstove which is insulated, with hot emissions (smoke) vented through a chimney. The stove is sealed, preventing nearly all indoor air pollution, and reduces consumption and expenditure on wood fuel by 50%. It is common for women to increase their income by creating a small business to cook tortillas and soup to sell at their back door or from small stalls. This requires long periods by the stove. The Ecostove has been particularly beneficial to these households.

Rogerio Carneiro de Miranda

Woman cooking on an Ecostove in Nicaragua.

Solar water heaters and cookers

Solar water heaters, which absorb the heat of the sun, can fairly consistently provide water at 60°C. This has been estimated to result in a 30% reduction in the amount of fire use and therefore, potentially, a 30% reduction in exposure to air pollution. They need not be costly as effective systems can be constructed from black piping and plastic drums.[53]

As much of the need for improved cooking comes from countries with abundant sunshine, it would seem a logical step to move towards solar power, and there are some very strong advocates for this technology. However, there are also some serious concerns.

Solar cookers, which concentrate sunlight directly to cook food, have been seen as a clean alternative way of cooking. Unfortunately there has been limited success in practice. The use of solar energy means preparing a meal at midday, which does not coincide with the main family mealtime in many cultures. It also requires the cook to work out of doors, which reduces privacy while cooking and makes cleanliness difficult.[16] For solar cookers to be used more widely, they must be developed along with the users to ensure greater acceptance from the target community.

Photovoltaic solar home systems, which produce electrical power, are not capable of delivering the levels of power sufficient to cook a family meal. They are also, currently, very expensive for most poor people.

Changing patterns of behaviour

Simple changes in the way the cook behaves can reduce exposure to smoke. For example, making sure that fuel wood is dry cuts emissions. The use of a pot lid can reduce the fuel consumed during simmering by a factor of three and overall emission levels by almost a half. Keeping children away from the fire is also an obvious way of reducing their exposure – but if they are habitually carried on their mother's back, or the mother is the only childminder for toddlers, this can be very difficult.[53]

Cooking outdoors would, in many instances, reduce exposure to indoor air pollution, and in some parts of the world, for example the aborigines in Australia, this is the norm. However, for most cultures cooking indoors is normal practice.

There are some practical objections to cooking outdoors. There is a need to keep cool (when the sun is hot outside); there is the need to keep warm (when the fire is required for heating); there is a need to keep the fire sheltered from the wind as the heat is directed away from the pot; there is a need to keep the food clean from wind-blown dirt; and there is the need to keep safe (a closed kitchen keeps food safe from thieving people and dogs).[52]

There may also be cultural objections in some societies – people do not like to have others see what they are eating – and the fire is sacred, a source of life, and therefore needs to be at the heart of the household.

Heating the home

Most of the interest in the impact of indoor air pollution has concentrated on the use of stoves primarily as devices for cooking in the tropics. However, in even the hottest countries, there may be a need to heat the home, especially at night. And in a number of regions, for example the Himalayas and the Andes, space heating is essential. In northern Pakistan, for example, summer temperatures can reach 45°C yet fall to –40°C in the winter. Exposure to smoke is exacerbated enormously when members of the family spend longer by the fire during the winter. The increased need for fuel creates another burden for women. Unfortunately, stoves that are well insulated, though more efficient at cooking, will release a smaller amount of energy into the room. And the addition of chimneys will conduct heat away from the space where it is needed. These needs have not been well catered for in the development of stove technology.[16]

Some reasons why women do not cook outside

- Climate – need to keep cool (when it is blazing hot outside), need to keep warm (when heating is required) and the need to keep dry (during the rainy season). There is often switching between inside and out depending on the weather conditions.
- Gender – the kitchen is a woman's domain, where she keeps her utensils and food ordered and clean, implying the need for a private space.
- Cultural – people do not like other people seeing what they are eating. People regard the fire as sacred – and so it has to be at the heart of the household.
- Energy – cooking outdoors burns much more fuel due to the wind. The wind also blows dirt and dust on to the food.
- Safety – the need to keep safe and to stop food being stolen by other people or animals.

Where there is a need to heat the home, thermally-efficient housing can reduce, or even eliminate the need for heating, reducing the family's exposure to pollution. There are some measures, such as correct solar orientation, that cost nothing at the time of construction. Where insulation is installed, smoke must be vented from the house.[53]

Identifying appropriate solutions

Cooking is a deeply cultural and private affair, as it occurs in the home. Experience has indicated that there is no point trying to dictate a solution to a community. This is a view supported by a WHO and USAID-supported consultation on indoor air pollution and health: 'A single issue, technology-driven approach to indoor air quality is doomed to failure … Such an approach would limit the choices available to the local community and frequently demands of them changes that affect numerous aspects of their lives.' The authors argue that 'the key to success is to adopt project approaches that broaden the range of secure and sustainable choices available to the local actors and thus to enable them to devise their own solutions'.[53]

Any programme must be based on what is acceptable to the community. There is no point investing massive resources into something that will not be used. For example in Sri Lanka, early stove projects were aimed at what the 'experts' assumed was the key issue. But the emphasis on fuel-efficiency at the cost of users' priorities often resulted in low acceptance amongst households.[54] This is a common factor in the failure of many unsuccessful stoves programmes around the world.

Selecting appropriate technologies – comparing experience in Sudan, Kenya and Nepal

ITDG is working in three very different locations to develop locally appropriate solutions to indoor air pollution.[55] Participatory approaches have enabled the community to select solutions that suit their own needs. Their choice of technology, in each location, was influenced by cultural aspects, cost of both the technology and the fuel, geographical location, access to fuels and climate.

In the refugee settlement in Kassala, Sudan, the community identified LPG as an appropriate solution once microfinance was made available to cover the initial cost of the stove. The scheme is popular, and already others outside the project are using the credit system to buy stoves. Fuel costs are much lower for LPG than for charcoal and wood in Kassala, so repayments can be offset by reduced fuel costs.

In the communities around Kisumu town in Kenya, wood fuel is much cheaper than LPG or collected 'for free', so most households have elected to continue using biomass. Smoke hoods and eaves spaces are proving effective. A few households could afford to choose LPG.

In the remote, cold mountain village of Gatlang in Nepal, solutions have been more difficult to identify as energy is needed to heat the house as well as to cook the food. It is remote, making LPG or kerosene unavailable, so biomass is the only solution. Home insulation has been identified as a possible means of retaining room heat whilst reducing the need to burn fuel wood for space heating. Ways of venting the smoke are currently being developed, along with metal stoves to reduce fuel use.

Country	Location	Solutions chosen by communities[56]
Kenya	Kisumu, town	Upesi improved stove, smoke hoods, eaves space, hay boxes, LPG
Sudan	Kassala, refugee settlement	Mostly LPG
Nepal	Gatlang, remote mountain village (cold area)	Venting smoke, improving home insulation

Table 3: Solutions chosen by three different communities.

Weighing up the cost of smoke alleviation

Poor people are willing to invest in improved cooking if they see the benefit, as has been demonstrated by programmes to introduce fuel-efficient stoves. China has successfully introduced nearly 200 million fuel-efficient stoves at minimal cost. In both Sri Lanka and Kenya nearly one million improved stoves have been introduced. For minimal outlay, significant health gains can be achieved. The total cost of reaching those in need will be US$500 million a year for 12 years – less than 1% of the West's aid budget.

Lessons from stoves programmes

Many lessons have been learned from promoting improved stoves (see Appendix 1). While these programmes were not focused on reducing indoor air pollution, experience was gained on how to introduce appropriate technologies within poor communities.

The most successful stoves programme has been in China, where more than 175 million improved stoves have been introduced.[21] It has been reported to be the most cost-effective measure in rural energy conservation undertaken in the country.[57]

The success of the China programme is attributed to stove designs suited to users' needs, targeted national promotion schemes and effective local implementation, including setting up commercial rural energy companies. Direct subsidy from the government per stove was relatively low, and varied between counties, with higher subsidies in counties where need was greatest.

An interim study of this work showed that the Chinese government spent US$200 million (including the cost of administration, research and development, promotion and direct subsidies) over seven years for more than 100 million stoves.[58] Follow-up studies show that over 70% of these stoves were in frequent use. If the direct cost to the householders of installing stoves was $1 billion (100 million stoves costing on average $10 each), then, overall government spending on improved stoves was about 20% of the direct cost of installation. These programmes were not designed for smoke removal, they were aimed at fuel efficiency. However, the Chinese experience shows that this type of programme can target millions of people with limited subsidy.[59]

Other successes with fuel-efficient stoves have included programmes in Sri Lanka, which have reached over 25% of the population – over 800 000 homes – and established a self-sustaining stoves industry (see box, over page). Kenya has led the way in sub-Saharan Africa with over 780 000 stoves distributed, largely in urban areas.[21]

Appropriate stove design and implementation at a local level leading to commercial markets for stoves were key factors in each of these programmes. Experience has shown that a level of subsidy is also required to target the most poor and vulnerable sectors of society.

The improved stoves programme in India, where the government subsidized over half the cost of the stove, has resulted in mixed success. While 30 million stoves have been installed in homes, follow-up surveys have shown that only one-third of these improved stoves are still in use. Reasons for the limited success have related to centralized control of the programme and poor stove design. In some cases, users' perception were of low energy savings, no removal of smoke and high breakdown rates (see Appendix 1).[21]

Appendix 2 gives an outline of the model ITDG is developing from its many years working in household energy to disseminate technologies for reducing indoor air pollution at a community level.

Smoke reduction efforts and health spending

It is useful to compare the spending so far on reducing indoor air pollution with that on other major health concerns.

Currently indoor air pollution receives a few million US dollars each year in direct funds (for example, from the Shell Foundation, DFID and the World Bank), mostly to support individual pilot projects.

Though not sufficient to meet needs, overseas development assistance provided to water and sanitation was US$1.4 billion in 2001, with total spending from all sources (developing countries, aid, private and community investment) totalling $14 billion.[60] The Global Fund to Fight AIDS, Tuberculosis and Malaria had about $1 billion per year in pledges from international donors[61] and US President George Bush recently announced $15 billion from the USA over the next five years in the fight against AIDS.

In comparison the cost of reducing indoor air pollution would be in the region of $2.5 billion annually over the next 12 years based on an average cost of $50 per home. If the Chinese experience is followed, where the government spending was equivalent to 20% of the amount spent by households on the improved technology, then government spending and international development aid would be in the region of $500m a year.

All these pressing issues – clean water and sanitation, AIDS, TB, malaria – have to be tackled at one time. Saving a child's life from smoke only to have him or her die of diarrhoea is not an option.

If ill health and death from hunger, HIV/AIDS, poor water and sanitation, malaria and indoor air pollution can all be fought together in a cost-effective way, then the benefit to health in the developing world will be tremendous.

Comparing costs of health gains

In order to compare the impact of different health programmes the term disability-adjusted life year (DALY) has become widely used. The World Bank Environment Strategy has compiled the known studies on the cost per DALY saved as due to interventions, as follows:[62]

- Hygiene and behavioural change: $20 per DALY
- Water connections in rural areas: $5 per DALY
- Malaria control: $35-75 per DALY
- Improved biomass stoves: $50-100 per DALY
- Use of kerosene and LPG stoves in rural areas: $150-200 per DALY
- Improved quality of urban air: large variations, from negative costs to $70 000 per DALY, and more for some pollution control measures. Most measures cost over $1000 per DALY.

Successful uptake of stoves in Sri Lanka: lessons to be learned

Despite persistent political instability, and the difficulties of introducing a new product to both users and producers, stove programmes in Sri Lanka have managed to reach over 25% of the households in the country. This success was due to combined initiatives of NGOs and the government. A new self-sustaining stove industry has been established within 20 years, benefiting around 250 producers and 800 000 cooks and their households. While not much more than US$1.5 million has been spent on stoves by development agencies and households since 1977, the financial benefits (mainly fuel wood savings) are valued at over $37.5 million. That does not take account of the unquantifiable but impressive quality of life, health and environmental benefits.[54]

ITDG/Jean Long

A Sri Lankan stove designed to suit local conditions.

Economic gains from reducing indoor air pollution – evidence from India

In one of the largest studies ever undertaken of the costs incurred by poor families, the Indira Ghandi Institute of Development Research looked at the rural energy and health impacts on poor rural communities in three of India's northern provinces of Rajasthan, Himachal Pradesh and Utter Pradesh.

The research looked at the health of adults, but not children. Forty five per cent of families had an income of less than 10 000 rupees a year, which is less than US 60 cents a day. The costs to poor families due to days lost collecting fuel wood, lost earnings and cost of medical treatment of adults came to 85 billion rupees ($1.84bn) per year. Days lost due to collecting fuel and illness came to 1 billion days. These figures are for a population of 226 million.[39]

In another India study, Green India 2047 by Tata Energy and Resources Institute, it was estimated that a change to cleaner fuel would increase slum dwellers' income by between 2000 and 7400 rupees ($43–161) per annum.

'Several studies to value the economic benefits of controlling air pollution have demonstrated not only its significant health benefits but also its economic feasibility: the cost of implementing policy decisions no longer appears prohibitive once it is weighed against the economic benefits of a healthy citizenry. Benefits of controlling air pollution indoors – pollution mainly due to burning firewood, dung-cakes, etc. for cooking – are even higher, and the groups that would benefit most are women and children, especially those living in slums, and those in rural areas in general.'[64]

The World Bank has proposed that health sector interventions of up to $150 per DALY saved should be considered cost-effective.[63]

The data would suggest that interventions to reduce exposure to indoor air pollution are cost-effective in reducing the burden of disease – especially when compared with the expense of measures to control urban air pollution.[37]

Estimated costs and benefits for the householder

Much of the cost for implementing solutions to indoor air pollution will be borne by the households themselves. Therefore, it is important to assess the cost to the user, (see Table 4). Some of the interventions are relatively low cost; others are a significant outlay for a poor household.

The use of subsidies and government support would have to be considered to increase access to these solutions for many very poor people. However, given the social, gender, economic (see box above) and environmental benefits of some of the solutions, in addition to the health gains, many of the solutions become an extremely attractive options for governments aiming to achieve the Millennium Development Goals.

Solution	Approximate cost	Possible reduction in indoor air pollution
Chimney stove	$10–150	0–80% depending on type, cost, condition, etc
LPG stove	Burner $30–120 Cylinder deposit $50–60 Weekly cost for fuel $1–2	Up to 90%
Smoke hood	$10–60	Up to 80%
Biogas	$300	Very clean (no data currently available)
Solar cooker	$5–50	No emissions, but may not replace all biomass cooking
Behavioural changes, e.g. use of pot lids, drying fuel, keeping children way from smoke	Less than $5	Variable (no data available)

Table 4: Typical costs for solutions to indoor air pollution[5] (derived from specific studies and therefore illustrative, not necessarily accurate for all cases).

A Global Action Plan

*The United Nations should instigate a **Global Action Plan** to address this neglected killer. The first step would be for the UN to convene urgently a high level international conference to set in motion action plans with the necessary resources.*

There is an urgent need to reduce indoor air pollution in millions of homes in Asia, Africa and Latin America. This paper calls for the United Nations Secretary General to instigate a Global Action Plan to mobilize the political will and resources to make clean air a reality in the homes of millions.

The Global Action Plan will build on and expand existing efforts and provide the strategic leadership in driving and co-ordinating national and international action. It will also be the focus for mobilizing the necessary resources from traditional and new forms of funding.

The Global Action Plan would entail the following:

High level international conference

The first step would be for the UN Secretary General's office to convene urgently a high level international conference of the major stakeholders – governments, UN agencies, bilateral and multilateral donors, private sector, research institutions and non-governmental organizations – to agree a shared vision, common approaches and set in motion strategic plans to tackle the scourge of indoor air pollution.

The conference should agree the following four-part strategy:

- **Millennium Development Goals –** a specific reference and action on preventing and reducing child mortality through reducing risk from indoor air pollution.
- **A global partnership –** which puts the global political weight and resources into the existing Partnership for Clean Indoor Air, bringing together the leading international players from the health, development, energy, shelter and environment sectors to work towards a global solution and to prepare strategic plans to tackle indoor air pollution.
- **Sustainable finance –** that establishes the extra and sustainable resources from traditional and non-traditional donors needed to bring clean air to millions of homes.
- **National task forces –** that bring together the key national and local level stakeholders to enable them to address the problem with international support.

Millennium Development Goals

Indoor air pollution is inextricable linked to poverty. Reducing indoor air pollution can contribute to many of the MDGs. But given that smoke is such a major child killer, and that efforts to tackle childhood acute lower respiratory infection are falling short of targets, there needs to be a specific reference and action on preventing deaths from indoor air pollution under MDG 4 Reducing Child Mortality.

A global partnership

Indoor air pollution is a global problem requiring a global solution. The United States Environmental Protection Agency led Partnership for Clean Indoor Air has attracted a number of key players since it was launched in Johannesburg in September 2002. The international community needs to rally round the partnership and transform it into a truly global partnership.

The international community is slowly beginning to take indoor air pollution seriously. Key organizations already active in the fight against indoor air pollution include (see Appendix 3): the WHO; the World Bank; the United Nations Development Programme (UNDP); the Global Village Energy Partnership; the

Shell Foundation; and many NGOs and community groups.

Increasing co-operation between all the key players in the energy, environment, health, shelter and development sectors is the first step towards achieving the global reach needed. This partnership of governments, UN agencies, bilateral and multilateral donors, private sector, research institutions and non-governmental organizations will need to:

- build consensus on priorities and prepare strategic plans to tackle indoor air pollution
- facilitate partner co-ordination to expand the availability of, and access to, cleaner fuels and safe methods of extracting smoke from the home
- offer technical support and share best practice across a range of sectors
- assist the development of further improved ways of reducing the risk of indoor air pollution
- support further necessary research into understanding the best way to reduce risk
- communicate and advocate the need for a greater response to indoor air pollution.

International working group

In the early stages of co-operation there needs to be a multi-stakeholder working group with the remit to develop recommendations for policy and practice on ways in which levels of indoor air pollution can be alleviated at national and local level. Working within a given time frame, the working group should:

- collate information on previous experience and identify factors which have led to success and to failure in the past
- based on this knowledge, develop policy recommendations for alleviating smoke on a wide scale at national and local level
- provide indicators of the cost of introducing these policy measures, and of the expected levels of poverty reduction and health benefit resulting from the introduction of those measures
- recommend further actions, at international, national and local level, which are needed to fill the knowledge gaps on successfully alleviating indoor air pollution.

This information will be essential for guiding national task forces and assisting them to adapt the international experience to suit local conditions.

Continuing research

An essential part of the international co-operation will be concerted efforts by the health research community, who continue to provide evidence on the risks involved in exposure to household smoke and the health benefits of household interventions to reduce exposure. This research will be needed in the drive to persuade national governments of the urgency of tackling indoor air pollution. The fact that there is ongoing research should not raise questions as to the seriousness of indoor air pollution. This research is aimed at gaining an understanding of the best ways to eradicate a very real problem.

Any global strategy to tackle indoor air pollution will need to ensure there is a global understanding of what variables are measured, and where and when. Standards need to be set to allow progress to be monitored and programme results to be compared. The Partnership for Clean Indoor Air is developing a harmonized methodology to evaluate initiatives which aim to reduce the impact of indoor air pollution.[33]

Sustainable finance

Bilateral and multilateral donors (governments, World Bank, IMF and regional development banks) and non-traditional donors need to commit the necessary level of funding without cutting their financial commitments to other essential poverty-reduction strategies.

It is estimated the funding should be in the order of US$500 million per year over

the next 12 years. This money will be required for implementing programmes in individual countries, and for research, development and co-ordination at the international level. The aim of the funding is to enable all people to reduce the health risks associated with indoor air pollution. This will include subsidies for communities most in need.

National task forces

In the first phase of the action plan there will be a need to focus on a set number of countries that will champion efforts to reduce indoor air pollution. These countries will act as pioneering centres of excellence setting up national indoor air pollution plans that are linked to national poverty reduction, health, energy, shelter and environmental plans.

Above all, there has to be action on the ground, at a national and local level, to promote healthy indoor air for all, and to remove the barriers that prevent people from living in a clean indoor environment. Operating at a national level, the task forces will bring together stakeholders (government, private sector, NGOs and communities) to take action on smoke. Each task force should be guided by the findings of the international working group, and carry out a similar scoping, costing and policy review at a national level.

Working across various government sectors, task force responsibilities will include:

- raising public awareness of the effects of indoor air pollution and solutions to it
- reforming national technical and energy markets in order to expand availability of cleaner fuels
- developing locally acceptable ways of extracting smoke from the home
- social marketing of appropriate solutions introducing the necessary financial support for poor families such as microcredit and subsidies.

National government response

Specifically, national policies, and in particular the Poverty Reduction Strategy Papers (PRSPs), should include action on indoor air pollution. This would be in line with achieving MDG 4 on reducing infant mortality and MDG 7 on environmental sustainability. National environment strategy and national energy plans should then be amended in line with achieving this PRSP target.

Private sector response

The private sector is already becoming involved in some countries through the UNDP LPG Challenge. This programme aims to reduce the commercial risks for private sector involvement in developing countries, particularly in rural markets. It is also looking to develop best practice for providing a rural service. Private energy companies should support the UNDP in this effort, and contribute resources towards its goals.

Co-ordinating at a local level

Non-governmental organizations are ideally placed to bridge the gap between multilateral action and community action. It will be essential to bring together local stakeholders – community-based organizations, local government, health service, finance and the private sector – to develop strategies for scaling up the impact of local interventions.

Importantly, the impact of the interventions at a household level must be monitored for exposure, health and socio-economic impact. The Shell Foundation, USEPA, WHO, ITDG, ESMAP and others are all supporting work to this end – but it will need much greater effort to benefit millions of households.

Communities at the heart of development

The communities should be fully integrated into the development process. Poverty itself is the heart of the problem, and poverty eradication must be the main goal.

Appendix 1: Lessons to be learnt from improved stoves programmes

Many lessons have been learnt from the dissemination of stoves. While these programmes were not focused on reducing indoor air pollution, knowledge was gained about how to introduce technologies within poor communities.

In 1994 the World Bank recognized the value of improving stoves: 'the best stove programs yield economic as well as environmental and social benefits. For example, in urban areas, where most people purchase wood fuels, the payback time of an improved stove in fuel savings for consumers is sometimes only a few months; because the stoves last considerably longer, cash flow is improved for people even if they cannot yet make the transition to modern fuels. Likewise, in rural areas, more efficient stoves can reduce the time spent collecting fuel for cooking, freeing time for child care and income-producing activities.'[42]

But the World Bank was not naive to the reality. 'No matter how efficient or cheap the stove, individual households have proved reluctant to adopt it if it is difficult to install and maintain or less convenient and less adaptable to local preferences than its traditional counterpart. On the other hand, households have been most receptive when the dissemination process takes full account of the capacities and needs of local stove producers and consumers … technical improvements in efficiency must be complemented by appropriate project design and implementation, perceptibly superior services, and proper institutional support, if they are truly to take root.'[42]

For an intervention to be considered successful, it also needs to be sustainable – economically as well as environmentally. For example, work in Sri Lanka resulted in more than just a reduction of fuel wood consumption.[54] The project managed to:

- provide employment opportunities for stove producers and builders
- generate income for stove producers, builders, distributors and sellers
- enhance the technology development capacity of local artisans/research organizations/agencies

If interventions can work on this economic level, then they can become sustainable, running without the further interventions of external agencies.

Other results to emerge from Sri Lanka are that a successful programme can:

- raise awareness about environmental, ecological and energy concerns
- educate at national and household levels about health, safety and hygiene
- act as a springboard to other community and gender development initiatives.[54]

In his 1994 review on the uptake of improved stoves for the World Bank, Douglas Barnes assessed the key reasons for success and failure (see table 5).

It is interesting to compare the improved stove programme in China, which has had a high level of success, with that in India, which has produced mixed results (see table 6). The Chinese scheme was a national programme with effective and targeted local implementation. The Indian scheme attempted national implementation of a centrally controlled programme.

Reasons for success	Reasons for failure
Programme targets regions where traditional fuel and stoves are purchased or fuel is hard to collect	Programme targets regions where fuel or stoves are not purchased or fuel is easy to collect
People cook in environments where smoke causes health problems and is annoying	People cook in the open and smoke is not really a problem
Markets surveys are undertaken to assess potential market for improved stoves	Outside 'experts' determine that improved stoves are required
Stoves are designed according to consumer preferences including testing under actual use	Stoves are designed as a technical package in the laboratory ignoring customers' preferences
Stoves are designed with assistance from local artisans	Local artisans are told or even contracted to build stoves according to specifications
Local or scrap materials are used in production of the stove, making it relatively inexpensive	Imported materials are used in the production of the stove, making it expensive
The production of the stove by artisans or manufacturers is not subsidized	The production of the stove by artisans or manufacturers is subsidized
Stoves or critical component are mass produced	Critical stove components are custom built
Similar to traditional stove	Dissimilar to traditional stove
The stove is easy to light and accepts different sized wood	The stove is difficult to light and requires the use of small pieces of wood
Power output of stove can be adjusted	Power output cannot be easily controlled
The government assists only in dissemination, technical advice and quality control	The government is involved in production
The stove saves fuel, time and effort	The stove does not live up to promised economy or convenience under real cooking conditions
Donor or government support extended over at least five years and designed to build local institutions and develop local expertise	Major achievements expected in less that three years; all analysis, planning and management done by outsiders
Monitoring and evaluation criteria and responsibilities chosen during planning stages according to specific goals of project	Monitoring and evaluation needs are not planned and budgeted, or criteria are taken uncritically from other projects or not explicitly addressed
Consumer payback of one to three months	Consumer payback of more than one year

Table 5: Possible reasons for success or failure of stove programmes.[42]

China	India
The programme focused on areas with the greatest need and selected pilot counties with biomass fuel deficits	The programme was implemented countrywide, resulting in dispersion of effort and dilution of financial resources
Direct contracts between the central government and the county bypassed much bureaucracy. This arrangement generated self-sustaining rural energy companies that manufacture, install and service stoves and other energy technologies.	The programme administration was cumbersome, moving from the centre to the state level, then to the district, and finally to the *taluka,* where the stove programme is just one of many national efforts being implemented locally by the same people
Local rural energy offices run by provincial governments are in charge of technical training, service, implementation and monitoring for the programmes. These efforts are separately funded and relatively independent	Lack of a strong monitoring plan was a severe weakness in early programmes. Some improvement has occurred through assignment of the task to university-based technical backup units. Coverage is still incomplete, however
Stoves are not only suitable for fuel savings and reduction of household smoke, but also are designed for convenience and attractiveness, highlighting the lessons learned from problems in early programmes that stressed only fuel savings	India has made a wide variety of attempts to integrate efficiency and convenience, which have suffered from the top-down structure of the programme
Stove adopters pay the full cost of materials and labour. The government helps producers through stove construction training, administration and promotion support	Stove adopters pay about half the cost of stoves; the government pays the rest. As a result the producer's incentive to construct stoves is oriented towards the government
Emphasis has been on long-lived stoves made of ceramic or metal and otherwise designed to be a significant household asset for a number of years	Many of the stoves have been made from local materials and by villagers without artisanal skills, resulting in short lifetimes in day-to-day household use

Table 6: Comparison of stoves programmes in India and China.[21]

Appendix 2: Getting the market right for wide-scale dissemination

ITDG are using the following strategy for scaling-up dissemination of interventions to reducing indoor air pollution. This strategy is based on many years of experience of implementing technology transfer.

- Market surveys are used to identify women's and men's opinions on how they prioritize smoke alleviation and their preferences for smoke removal products, before and after a smoke/health campaign. Considering consumer willingness and ability to pay, as well as identifying appropriate technologies, will be key factors in this survey.
- Intermediaries, such as non-government organizations, community groups, local government and the private sector play a key role in maintaining the sustainability of the market through support and encouragement of women to promote improved cooking technologies.
- Public awareness raising for both women and men on the risks caused by smoke, and the greater comfort levels experienced with its removal, is required to increase the demand for smoke alleviation and make it a priority.
- Effective marketing and promotion strategies should be tested to see what is effective and appropriate to get the public awareness message across to the target audience. Working with target communities and other stakeholders, successful promotion methods (e.g. radio, video, street plays) can be identified.
- Microcredit schemes and revolving funds for both suppliers and consumers, which will allow men and women to access credit, can encourage take-up by ensuring that there is enough 'up-front' capital to provide and pay for products. It is important to create links with credit institutions, with the aim of establishing microfinance facilities to encourage households to purchase smoke alleviating products.
- To ensure a supply of good-quality products, entrepreneurs should be trained in both technical and business skills.
- Providing a sustainable and affordable product supply to the consumer is paramount in determining which business models should be adopted. Factors include: quality and affordability; expected product life; locally produced versus locally assembled or distributed products; added value within the community; cost and reliability of supply – if manufactured outside the community; supply chains for products requiring consumables; maintenance and after-sales service.
- An analysis of how appropriate credit facilities should be structured to stimulate demand and facilitate manufacture and distribution of quality products will complement the business plans.

It will be important to monitor the impact of the dissemination of the technologies on the target area. This will not just be in terms of how many hoods or stoves have been disseminated, but will involve monitoring smoke levels and some quantitative measure of the expected health improvements in selected homes, and socio-economic assessment of the impact of the interventions on the household. It is also important to maintain quality control of the products, to ensure they are reliable, and therefore maintain a good reputation.

Appendix 3: Action by key stakeholders on indoor air pollution

A number of groups – intergovernmental and non-governmental organization – are active in research and development on indoor air pollution.

World Health Organization

WHO is building a programme to reduce the burden of disease attributable to indoor air pollution. Ths programme includes:

- encouraging research into health effects of indoor air pollution
- developing a harmonized methodology to facilitate comparative evaluation of intervention studies
- supporting on-going research on interventions
- building capacity at a regional and national level to assess health impacts
- providing evidence to policy makers on the need to reduce indoor air pollution.

At the World Summit for Sustainable Development (WSSD) in Johannesburg, WHO launched the Healthy Environments for Children Alliance (HECA), which aims to create:

> 'A world-wide alliance to intensify global action on environmental risks to children's health that arise from the settings where they live, learn, play and earn, by providing knowledge, increasing political will, mobilizing resources, and catalysing action.'[10]

HECA was launched by WHO as an important follow-up contribution to WSSD and realization of the health and environment components of the Millennium Development Goals. One of its main targets is to reduce indoor air pollution in homes. This alliance is in its early stages, but it aims to bring together a large range of stakeholders to work towards healthier environments for children, with interventions to reduce indoor air pollution high on their agenda.

Energy Sector Management Assistance Programme

In recent years, the joint World Bank/UNDP Energy Sector Management Programme (ESMAP) has been sponsoring a group of studies and programmes on indoor air pollution.[66] Projects are being implemented in India, China, Guatemala, Mongolia and Nicaragua, and include awareness raising on indoor air pollution, studies of health impacts, development and dissemination of interventions to reduce indoor air pollution, and assessment of policy for reducing indoor air pollution in homes. In addition, ESMAP is undertaking work on capacity building and policy assessment in indoor air pollution. This study aims to increase the capabilities and knowledge needed to reduce the human health and associated social, economic and environmental impacts of household solid fuel use in the poorest households in key developing countries.

The ESMAP-sponsored study of indoor air pollution in India is being carried out by the World Bank South Asia and Environment Unit.[67] This study entitled *Household Energy Air Pollution and Health*, aims to:

- facilitate political commitment to mitigating health impacts from household energy use
- assist in formulating and implementing action programmes in India at local, state and national level
- enhance knowledge and create greater awareness amongst stakeholders in India
- contribute to developing practical tools for measuring and predicting levels of indoor air pollution and health impacts.

The WHO Director-General, Gro Harlem Brundtland, highlighted the urgency of this issue on World Health Day 2003. She stated: "The biggest threats to children's health lurk in the very places that should be safest – home, school and community.' The main dangers were from air pollution caused by dirty household fuel, lack of safe drinking water and poor sanitation.[65]

Partnership for Clean Indoor Air

A new positive initiative has come from the United States Environmental Protection Agency (USEPA) in developing the Partnership for Clean Indoor Air. The aim is to halve mortality related to indoor air pollution in targeted areas. This partnership is in its early stages, but its aims are for the partners to contribute their resources and expertise to implement the goals of the initiative and work together to:

- obtain formal commitments from, and develop action plans with, key sectors (e.g., health, environmental, energy) in partnering countries before beginning efforts in a given country
- develop culturally appropriate training and other public outreach materials, educational programmes, and awareness campaigns, and adapt economic and planning tools to local settings
- identify in-country industry – including local entrepreneurs – and other non-governmental partners to participate in planning and implementation activities
- identify lessons learned from past efforts and develop performance measures to evaluate past and current activities, and identify successful locally based implementation strategies.

In the longer term, the Partnership for Clean Indoor Air will focus on broad expansion of efforts throughout partnering countries.[68]

United Nations Development Programme

The United Nations Development Programme (UNDP) is championing one solution to indoor air pollution through its LPG Challenge. The aim of this initiative is to reduce the risks for private sector companies to supply rural markets in developing countries. The LPG Challenge plans to bring liquefied petroleum gas (LPG) to the rural population by linking UNDP's knowledge and experience of development and community consultation with industrial suppliers of LPG and their gas appliances. The key issue is to address market and technical barriers to expand the use of LPG in rural areas.[69] The first stage of action will be pilot schemes in selected countries.

National governments

The macro-energy policies of most developing countries frequently include no mention of their most important fuel source – biomass. The three notable exceptions are India, South Africa and China. These countries have carried out significant improved stove programmes to reduce fuel consumption in the past decade, with varied degree of success.

The World Bank, IMF and donor governments provide assistance to national governments and citizens through their Poverty Reduction Strategy Papers (PRSPs), which have become the main route for overseas development funding. The PRSPs are action plans for the implementation of the MDGs on a national level, and funded through Medium Term Expenditure Frameworks. Very few PRSPs currently include energy planning in any form, and those that do focus on electricity supply. While acute lower respiratory infections may be included in public health plans, there is no focus on indoor air pollution. The percentage of the population using solid fuel is being monitored under MDG 7 as an indicator of sustainable development, so should be introduced to the PRSPs.

Global Village Energy Partnership

Global Village Energy Partnership was launched at WSSD in Johannesburg in 2002 by ESMAP. The partnership aims to connect 400 million people to electricity and cleaner fuels over the next decade – virtually doubling the number of poor villagers who each year gain access to lighting, heating, and power – and providing 50 000 communities with energy services for schools, hospitals, and clinics.[70] With very strong partners from the energy sector across the developing world, GVEP could be a strong agent for

introducing clean cooking practices and policies at a national level, and for implementation of projects on the ground.

Shell Foundation

The Shell Foundation, through its Sustainable Energy Programme, is funding a substantial body of work on household energy and health, contributing US$10 million over five years.[71] The programme is supporting a number of pilot projects in India, Africa and Latin America. These pilot projects focus on developing appropriate technologies, which will then be disseminated widely through local commercial markets. Shell Foundation has sponsored studies on the lessons learned from previous stoves programmes, including the huge dissemination scheme in China. In addition it has commissioned a substantial programme entitled Standard Monitoring Packages for Household Energy and Health Field Projects, which aims to develop a standardized and manageable package of monitoring tools for this purpose.

Research community

There are a limited number of research centres that have been leading the way in assessing the health impact of indoor air pollution, and working in the field to establish the health benefits of interventions to reduce exposure to indoor air pollution. Leading research centres include:

- School of Public Health, Environmental Health Sciences Division, University of California Berkeley, research headed by Professor Kirk Smith
- Department of Public Health, University of Liverpool, research headed by Dr Nigel Bruce
- Renewable and Appropriate Energy Laboratory (RAEL), research headed by Professor Dan Kammen
- Indira Gandhi Institute of Development Research, research headed by Professor Jyoti Parikh.

Though there is little doubt that exposure to indoor air pollution in developing countries presents a major threat to health, there is still a need for more research investigating the specific links between disease and exposure. And while there is a great deal of observational evidence, the case will be strengthened by more rigorous studies, quantifying exposure and ensuring that confounding factors, such as socio-economic status, are adequately addressed. However, the need for further research should not hinder the development and implementation of interventions to reduce exposure.

Development community

ITDG has on-going projects in Kenya, Nepal and Sudan, working with communities, local businesses and policy makers to develop and scale-up locally appropriate interventions to reduce indoor air pollution in homes. A handful of other NGOs are carrying out similar projects at a country level, for example Aprovechio and HELPS International in Guatemala, the Appropriate Rural Technology Institute in India, Winrock International in Kenya, and the Child Welfare Scheme in Nepal. These projects are being sponsored mainly by the UK Department for International Development, the World Bank Energy Sector Management Assistance Programme and the Shell Foundation.

Notes and references

1 High mortality developing countries: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe, Bolivia, Ecuador, Guatemala, Haiti, Nicaragua, Peru, Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen, Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal

2 'UNDP pushes for expanded energy services to meet the poor's basic needs', press release (8 April 2002) www.undp.org/dpa/pressrelease/releases/2002/april/08apr02.html

3 *The World Energy Outlook 2002,* International Energy Agency, www.iea.org

4 'Initiating an alliance for action: healthy environments for children', WHO (2002) www.cgil.it/org.politicasalute/adessostomeglio/200250/OMS.pdf

5 *Addressing the Impact of Household Energy and Indoor Air Pollution on the Health of the Poor: Implications for policy action and intervention measures*, paper prepared for the Commission on Macroeconomics and Health, WHO (2002)

6 Bruce, N. et al. 'Indoor air pollution in developing countries: a major environmental and public health challenge', *Bulletin of the World Health Organization* (2000) 78 (9)

7 *The World Health Report: 2002: Reducing risks, promoting healthy life*, WHO (2002)

8 'Roll Back Malaria', WHO (2001 to 2010), www.rbm.who.int

9 www.developmentgoals.org

10 'Healthy environments for children: an alliance to shape the future of life', WHO (2002) www.who.int

11 *Energy for the Poor: Underpinning the Millennium Development Goals,* DFID (August 2002)

12 http://ecoharmony.com/hedon/ quote from Dr E. Bates

13 *Addressing the Links between Indoor Air Pollution, Household Energy and Human Health*, WHO (2002)

14 Budds, J. et al. *What's Cooking: A review of the health impacts of indoor air pollution and technical interventions for its reduction*, WELL (2001) www.lboro.ac.uk/WELL

15 Bruce, N. et al. *The Health Effects of Indoor Air Pollution Exposure in Developing Countries*, WHO (2002) www.who.int/peh/air/Indoor/OEH02.5.pdf

16 Clancy, J. 'Blowing the smoke out of the kitchen: core issues in household energy and gender', www.sparknet.info/goto.php/view/2/theme.htm

17 Clancy J. et al. 'The gender – energy – poverty nexus: finding the energy to address gender concerns in development', DFID Project No. CNTR998521

18 Cecelski, E. *The Role of Women in Sustainable Energy Development*, report to the National Renewable Energy Laboratory, Boulder Colorado, USA (1999). Referred to in 15

19 Branco, A. et al. 'The WSSD and its results regarding gender and energy', *ENERGIA News* Vol.5 (4 December 2002)

20 'Scaling-up of sustainable biomass energy management systems in sub-Saharan Africa', proposal by ITDG and GTZ-ProBEC in response to WSSD (2002) www.earthsummit2002.org/ic/energy/biomass.pdf

21 'Rural energy in developing countries', *World Energy Assessment: Energy and the challenge of sustainability*, UNDP (2000) chapter 10, www.undp.org/seed/eap/activities/wea/

22 United Nations Millennium Declaration (September 2000) www.un.org/millennium

23 Litvak, V. 'Household energy and health: summaries of on-line forum', weeks 1–5, Shell Foundation Sustainable Energy Dialogue (20 July 2001)

24 *Tapping the Potential: Improving water management in Tajikistan,* National Human Development Report (2003)

25 *Progress since the World Summit for Children:A statistical review* (2003), www.childinfo.org

26 'Energy, the environment, and health', *World Energy Assessment: Energy and the challenge of sustainability* (2000) Chapter 3, www.undp.org/seed/eap/activities/wea/

27 Ezzati, M. et al. 'The health impacts of exposure to indoor air pollution from solid fuels in developing countries: knowledge, gaps, and data needs', *Environmental Health Perspectives,* Vol.110, No.11, (November 2002)

28 www.met-office.gov.uk/health/features/200302/pea_soup.html

29 Smith, K. et al. 'Indoor air pollution in developing countries and acute lower respiratory infections in children', *Thorax* (2000), Vol.55, pp.518–532

30 *APHEIS Health Impact Assessment of Air Pollution in 26 European Cities*, second-year report (2000–2001), Institut de Veille Sanitaire, Saint-Maurice

31 Smith, K. and Jantunen, M. 'Why Particles?' *Chemosphere,* 49 (2002) pp.867–871

32 Ezzati, M. et al. 'Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: an exposure-response study', *The Lancet,* 358 (25 August 2001)

33 www.shellfoundation.org/breatheeasy

34 'Will less exposure to indoor air pollution

prevent childhood pneumonia?' *Bridges*, COEH newsletter (September 2001)
35 Smith, K. 'The Guatemala stove intervention trial' (January 2003) http://ehs.sph.berkeley.edu/guat/
36 Smith, K. 'Indoor air pollution in developing countries: recommendations for research', *Indoor Air* (2002) Vol.12, pp.198–207
37 von Schirnding, Y. et al. *Addressing the Impact of Household Energy and Indoor Air Pollution on the Health of the Poor: Implications for policy action and intervention measures*, Commission on Macroeconomics and Health, WHO (2002)
38 Smith, K. and Liu,Y. 'Indoor air pollution in developing countries', *Epidemiology of Lung Cancer,* Marcel Dekker, New York. Referred to in 13
39 Parikh, J. *Rural Energy and Health Impacts*, report for the Ministry for Environment and Forest, Indira Gandhi Institute of Development, Mumbai (2000) www.igidr.ac.in/~jp/rural.htm
40 Boy, E. et al. 'Birth weight and exposure to kitchen wood smoke during pregnancy in rural Guatemala', *Environmental Health Perspectives* (January 2002) 110 (1)
41 Beesley, J. *Making Bread Eritrea Style,* Oxfam Eritrea Emergency Response (August 2003)
42 Barnes, D.F. et al. *What Makes People Cook with Improved Biomass Stoves? A comparative international review of stove programs*, World Bank technical paper, No.242 Energy Series (1994)
43 *Fuel Substitution: Poverty impacts on biomass fuel suppliers* DFID, (February 2003)
44 Quaye-Foli, E.A. 'Liquefied Petroleum Gas (LPG) promotion: the Ghana experience', presentation from the UNDP/World Bank Energy and Poverty Workshop, Addis Ababa, Ethiopia (October 2002)
45 Smith, K. 'In Praise of Petroleum?' *Science,* Vol.298 (6 December 2002)
46 *Reducing Indoor Air Pollution in Rural Homes in Kenya: Working with communities to find solutions*, The ITDG Smoke and Health Project (1998–2001), ITDG (January 2002)
47 Budds, J. et al. 'What's cooking: a review of the health impacts of indoor air pollution and technical interventions for its reduction', *WELL* (2001) www.lboro.ac.uk/WELL
48 Stills, D. et al. 'Increasing efficiency and reducing harmful emissions in traditional cooking stoves', *Boiling Point* No.47, ITDG (Autumn 2001)
49 Miranda, R. 'The modernization of small business through the Ecostove in Nicaragua', *Boiling Point* No.47, ITDG (2001)
50 'Haybox Cookery', Centre for Alternative Technology, Tip Sheet 5, CAT Publications, Machynlleth (1997)
51 Gore, J., presentation at meeting of the Partnership for Indoor Air Pollution, New York (9 May 2003)
52 Bates, E., personal comment, ITDG (May 2003)
53 Ballard-Tremeer, G. et al. *Review of Interventions to Reduce the Exposure of Women and Young Children to Indoor Air Pollution in Developing Countries*, WHO/USAID Consultation on Indoor Air Pollution and Health (3/4 May 2000) www.ecoharmony.com
54 Crewe, E. et al. *Sri Lankan Stove Programmes: A sustainable success story,* ITDG (June 2002)
55 'Smoke, health and household energy', ITDG DFID project No.R802 (September 2002 to March 2003)
56 Bruce, N. 'Household energy, smoke and health: developing sustainable interventions', Global Health Council Conference, Washington DC (28 May 2003)
57 Lu, Y., *Fueling One Billion: An insider's story of Chinese energy policy development,* Washington Institute Press, Washington DC (1993)
58 Smith, K. 'One Hundred Million Improved Cookstoves in China: How Was It Done?' *World Development* (1993) Vol.21 No.6, pp.941–961.
59 Misra, et al. 'We can do something about deadly smoke', *International Herald Tribune* (14 February 2003)
60 'Hitting the targets', recommendations to the G8 for delivery of the Millennium Development Goals on water and sanitation, Action Aid (2003)
61 www.globalfundatm.org
62 Lvovski, K. *Environment and Health*, Environmental Strategy Paper No.1, World Bank (October 2001)
63 'World Bank. Investing in health', *World Development Report,* Oxford University Press, New York (1993), referred to in 36
64 Tata Energy and Research Institute, *Green India* 2047 (1997)
65 'WHO calls for urgent and concerted international action to prevent 5 million children's deaths annually from environmental hazards', WHO press release (7 April 2003) www.who.int/mediacentre/releases/2003/pr28/en/
66 http://wbln0018.worldbank.org/esmap/site.nsf
67 http://wbln1018.worldbank.org/sar/sa.nsf
68 Partnership for Clean Indoor Air, part of the US Government initiative Powering Sustainable Development, US Environmental Protection Agency (2002)
69 'The LPG Challenge', Partnership Initiative Information Sheet, WSSD, Johannesburg (2002)
70 Lallement, D. et al. 'International programmes: focus on global village energy partnership', *ENERGIA News* (2002) Vol.5 No.4
71 www.shellfoundation.org