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Addressing the Links between Indoor Air Pollution, Household Energy and Human Health

Based on the WHO-USAID
Global Consultation
on the Health Impact of Indoor Air Pollution
and Household Energy in Developing Countries
(Meeting report)

Washington, DC
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Preface

Household energy and indoor air pollution pose a substantial threat to the health of the world's poor. Although there are gaps in our knowledge of the health risks and the most effective interventions and appropriate policies at international, national and local levels, there is enough evidence to justify action now. This report is based on a WHO/USAID Global Consultation on the Health Impact of Indoor Air Pollution and Household Energy in Developing Countries (Washington DC, 3-4 May 2000). It is aimed at a general audience interested in household energy, indoor air and health issues. A companian technical report based in part on the meeting's deliberations was prepared for the Comission on Macroeconomics and Health, and can be consulted for further information and reference material [1]. The report sets out the rationale for action, and the priority research and policy interventions that can help achieve this goal are discussed. The context in which household energy is used is highlighted, as well as the impact on everyday life and prospects for development. Attention is then given to the evidence we now have on the risks to health arising from exposure of women and young children to smoke in the home, and the overall significance of this for the health of populations in poor countries. Potential economic benefits, options for interventions, together with approaches to assessing effectiveness and suitability, are subsequently considered. Finally, recommendations are made for concerted action to help bring about substantial improvements in the situation for poor communities.

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(1) WHO. *Addressing the Impact of Household Energy and Indoor Air Pollution on the Health of the Poor: Implications for Policy Action and Intervention Measures*. Geneva, World Health Organization, 2002 (WHO/HDE/HID/02.9).

Introduction

Poverty remains the greatest barrier to reducing the enormous global inequalities in health that still exist, and which in some countries are worsening. A hitherto neglected factor, which is both a cause and a result of poverty, is the continuing dependence of almost half of the world's population on polluting and inefficient household fuels and appliances. Household energy impacts on the health of the poor through a variety of physical, social and economic routes, but the most important direct health impact results from indoor air pollution (IAP) produced by burning biomass fuels (wood, dung, crop wastes) and coal in simple stoves with inadequate ventilation.

Until quite recently, there has been inadequate official recognition of the size and extent of the problem and little effective action. This is despite a number of key publications, meetings and other activities over the past 15 years (see box below).

Tackling indoor air pollution: examples of key activities to date

- 'Biofuels, Air Pollution and Health: a Global Review', presented the first comprehensive account of biomass use, pollution levels, health effects and interventions. [1]
- WHO Consultation (1991) held in Geneva, and associated Report, reviewed the current situation and action needed. [2]
- The 1992 World Development Report identified indoor air pollution as 'one of the four most critical global environmental problems'. The 1993 Report, 'Investing in Health' noted that 'rural people in developing countries may receive as much as two-thirds of the global exposure to particulates', and listed the main diseases associated with this exposure. [3]
- The 1997 UNDP report, 'Energy after Rio' provided a broad ranging review that recognised the links between energy, health and sustainable development. Biomass use, health effects and strategies for change were examined. [4]
- The 2000 WHO/USAID Global Consultation on the Health Impact of Indoor Air Pollution and Household Energy in Developing Countries, held in Washington DC.
- The 2000 UNDP/UNDESA/WEC World Energy Assessment report: "Energy and the Challenge of Sustainability" which highlighted the problem of household energy and human health. [5]

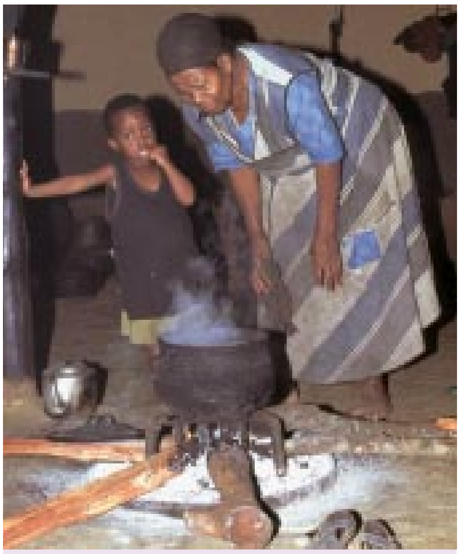
(1) Smith KR. *Biofuels, air pollution, and health. A global review.* New York, Plenum Press, 1987.

(2) WHO. *Indoor air pollution from biomass fuel.* Working papers from a WHO consultation, June 1991. Geneva, World Health Organization, 1992.

(3) World Bank. *Investing in health.* World Development Report. New York, Oxford University Press, 1993.

(4) Reddy A, Williams R, Johansson T. *Energy after Rio: prospects and challenges.* New York, United Nations Development Programme, 1997.

(5) UNDP/UNDESA/WEC. *World Energy Assessment: Energy and the challenge of sustainability.* New York, United Nations Development Programme, 2000.



Around three billion people are still primarily dependent on biomass fuels and coal for their everyday household energy needs.

Over the last 30 years or so, work has been carried out in the field of household energy by a wide range of research groups, NGOs, and some international agencies. Much of this activity however was project based, often donor-led, and mainly focused on reducing fuel use, cutting costs to households and protecting the environment from deforestation and erosion. There has been awareness of the connections with health, but in practice this has not been prominent. In addition, very little of this work was co-ordinated, and as a result did not bring about substantial change in policy, donor commitment or - most important - action in those countries and poor communities worst affected.

Where We Are Today

Recent estimates indicate that around three billion people are still primarily dependent on biomass fuels and coal for their everyday household energy needs, including up to 80-90% in some countries of sub-Saharan Africa. The overall use of biomass fuel is not falling, and indeed continues to increase among the poorest people who also are turning to cruder forms of biomass, and other waste, to use as fuel.

Evidence on the health effects of indoor air pollution has grown in the last 10 years, and there is now fairly good evidence that exposure increases the risk of acute lower respiratory infections (ALRI) in children, chronic obstructive lung disease (COPD) in adults, and lung cancer where coal is used extensively. In addition, evidence is now emerging of links with a number of other conditions, including tuberculosis, perinatal mortality (stillbirths and deaths in the first week of life), low birth weight, asthma, otitis media, cancer of the upper airway, and cataracts. Although there is now more evidence, it is still deficient in a number of important respects, including imprecise measurement of levels of exposure to pollution, inconsistent definitions of health outcomes, and inadequate attention paid to the influence of other 'confounding' factors(6). The implication of these limitations is that, although we can be fairly confident that IAP does increase the risk of a number of conditions such as ALRI, we cannot be yet sure by how much.

It is estimated that IAP is responsible for nearly two million deaths annually in developing countries and around 4% of the burden of disease (expressed as DALYs – disability adjusted life years). In addition to these direct effects of IAP on health, are other consequences arising from the use of household energy in conditions of poverty. These include burns to children falling onto open fires, ingestion of kerosene stored in soft drinks containers, restrictions on income generating activity, the opportunity costs for women of spending many hours collecting wood fuel as this becomes increasingly scarce, as well as injuries arising from carrying heavy loads and collecting fuel in areas where there is a risk of violence.

(6) A confounding factor is one that might also account for the poor health outcomes that are being attributed to IAP, such as malnutrition.

A wide range of interventions are capable of contributing to a reduction in indoor air pollution. These include interventions at the source of pollution (improved stoves with cleaner fuels), to the living environment (better ventilation); and to user behaviour (use of pot lids, keeping children away from smoke). For any intervention to be successfully implemented, it should be locally appropriate, and sustainable in the market. Full participation of local people (especially women), appropriate financial support (e.g. micro-credit, avoidance of subsidies), inter-sectoral collaboration at local and national levels, and energy policies that support rather than hinder access by the poor to cleaner fuels, are also important. There is an urgent need to consolidate experience of interventions to date, encourage the evaluation of future interventions in a systematic and comparable way, build capacity in countries, and promote the dissemination of experience in ways that are accessible locally and internationally.

Initial work on assessing the economic costs and benefits of interventions in household energy are encouraging. For example, the cost per DALY saved of an improved stove may be in the range US$ 50-100, comparing favourably with other important health interventions. However, more research is needed to quantify the relationship between exposure and risk of disease, and the health gains resulting from measured reductions in exposure.

There is now greater awareness of the inter-relationships between household energy, health and poverty. Poverty is a barrier in the transition to modern fuels, while reliance on such fuels holds back development due to the health burden, and the loss of time and opportunities for economic development.

1 Household Energy and Development – an Overview of the Issues

What Household Fuels Are Being Used Today?

Estimates suggest that wood provides around 15% of energy needs in developing countries, rising to 75% in tropical Africa. In more than 30 countries, wood still provides more than 70% of energy, and in 13 countries it is over 90%. Moreover, as the prices of alternatives such as kerosene and bottled gas have increased, the use of biomass fuels has increased.

With development there is generally a transition up the so-called 'energy-ladder' (Figure 1.1), towards fuels which are progressively more efficient, cleaner, convenient and expensive. Households typically use a combination of fuels, for example wood for cooking and heating, and kerosene or electricity for lighting, so it is not a simple linear progression. However, households do tend to carry out more tasks with more modern fuels as their socio-economic circumstances improve. The problem is that almost half of the world's population relies predominantly on fuels towards the lower end of this energy ladder, and for many the prospects of moving up it in the short term appear limited.

Biomass will remain the principal household fuel for the poor for many years to come.

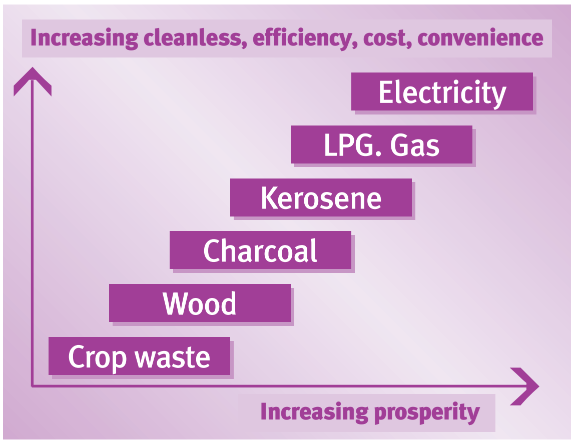


Figure 1.1. *The energy ladder: in practice, most households use a combination of fuels, and this mix shifts as prosperity increases.*

Why Indoor Air Pollution is Bad for Health

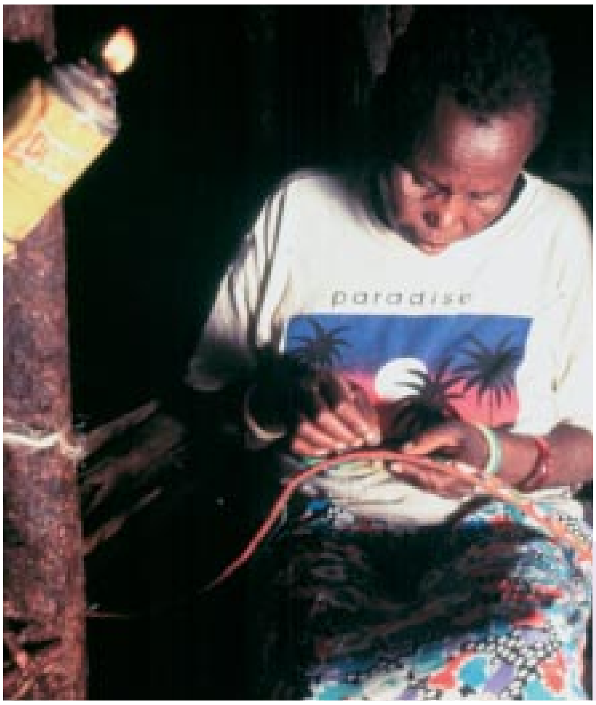
Households reliant on biomass and coal generally use the fuel indoors, in open fires or poorly functioning stoves, and usually with inadequate venting of smoke. The smoke from biomass fuel and coal contains a large number of pollutants that are dangerous to health, including small particles, carbon monoxide, nitrogen dioxide, sulphur dioxide (this mainly from coal), formaldehyde, and carcinogens such as benzo[a]pyrene and benzene. Studies from Asia, Africa and the Americas have shown that indoor air pollution levels in these homes are extremely high, many times the limits set by the U.S. Environmental Protection Agency (EPA) and WHO. The most important impacts appear to be on acute respiratory infections in children, and chronic lung disease in adults, and in developing countries the overall public health impact of IAP is substantial.

Quality of Life in the Home

For the majority of poor people, the fire, or hearth, is at the centre of home life. It provides the energy required for cooking, warmth and light, and is very often the focal point of the home with important cultural and spiritual significance. Although smoke is recognised as a nuisance, causing sore, running eyes, coughs and headaches, it can also have utilitarian value. Smoke may be used for curing food, protecting roof timbers from boring insects, waterproofing thatch, and helping to keep biting insects away.

Nevertheless, lack of access to more modern fuels and appliances does limit quality of life in a variety of ways:

- Lighting may be restricted and provided only by the fire, candles, or simple kerosene wick lamps which can be a significant source of pollution .
- The lack of light restricts activities in the home, including children's homework, reading and opportunities for income generating activities.
- Lack of access to electricity restricts the use of a wide range of appliances that can contribute to food safety (refrigerators), communication/ education, leisure (radio, TV), and economic activity.



A Maasai woman sewing beadwork by the weak light of a single kerosene wick lamp, rural Kenya. The poor lighting available makes this work, which is a valuable source of income, difficult indoors and outside of daylight hours.

Household Fuel as a Key Issue for Women

In almost all developing countries it is women who provide fuel for the home and carry out most tasks that require energy use in the home. Studies show that fuel collection takes on average between one half and two hours per day. The time spent collecting wood and other fuels has an 'opportunity cost' for women especially during busy agricultural periods. Carrying large loads of wood exposes women to injury from falls and weight carrying, including fractures and miscarriages, while in areas of war and civil unrest they may also be exposed to violence, and injury from land mines. Their work in the kitchen, often close to the fire, means that of all family members they have the greatest exposure, estimated – for example - at between four and seven hours per day in rural Guatemala.

In general, women also have less control than men over how more modern fuels are used and what appliances are obtained. In South Africa for example, it has been found that once grid electricity is available, men have greater influence in decisions about how the electricity is used in the home and cooking needs may be given lower priority than women would wish.

The Wider Environmental Impact

Deforestation and fuel supply. The use of wood fuel is often thought to be the major cause of deforestation and environmental damage. However, in rural areas wood fuel is usually gathered rather than cut from the trees; and it is agricultural practices, the need for building materials, and population pressure, that are the most important factors in deforestation.

Nevertheless, pressure on forests from the use of wood fuel is a problem. Taking South Africa as an example, it is estimated that the three million rural households currently use 10 million tonnes of wood annually, whereas six million tonnes is considered to be sustainably available.

A tree nursery in the village of Khiba, S. Africa. This highland community near the Lesotho border has suffered extensive deforestation and soil erosion. This nursery is contributing new trees for planting, some of which will be used as fuel, and also income for the women involved in the project.

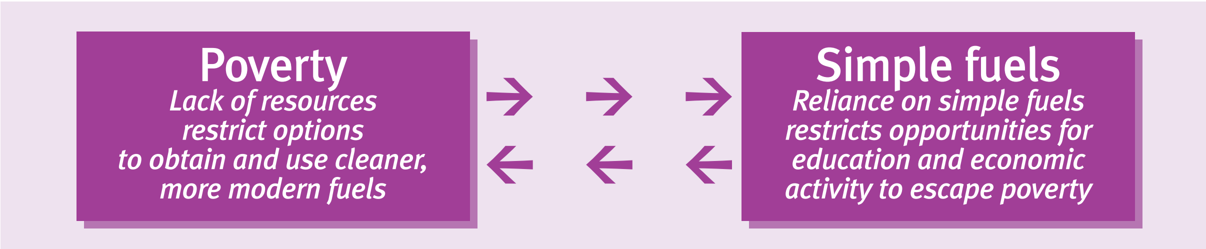
In urban areas, the use of wood requires transport over longer distances, which increases the demand for charcoal. Unfortunately, producing and using charcoal is less efficient than direct use of wood fuel, which leads to forest depletion in rural areas providing fuel to cities. An active approach to forest management can play a part in protecting the supply of fuel and the environment, and help place biomass on a firmer footing as a sustainable, renewable energy source. The use of biomass as a fuel should not necessarily be seen as a negative environmental pressure: what is important is how it is managed.

Contribution to greenhouse gases. The low energy use of homes in developing countries means that their contribution to the global output of greenhouse gases is relatively small. In 1995, per capita carbon dioxide (CO_2) production was estimated at less than two tonnes for developing countries, compared to 12 tonnes for developed countries and 20 tonnes for the USA. While it is possible to argue that since biomass is renewable, replacement of wood burned should result in a fairly neutral carbon balance (the CO_2 released from burning being taken up as new trees grow), the problem is that as stoves used in developing country homes have a low efficiency (around 15%), with (for example) nearly 10% of the energy of wood being lost as products of incomplete combustion (PICs). These PICs include methane, which has a greenhouse effect many times greater than CO_2. Modern fuels such as liquefied petroleum gas (LPG) burn with a far higher efficiency, and consequently produce considerably less greenhouse gas emissions. This lower impact of LPG on the global environment, in addition to the greater cleanliness and convenience, should be taken into account in considering the overall balance sheet for various energy options.

LPG distribution in rural Anatolia, Turkey. In addition to being clean and convenient, LPG has more efficient combustion which leads to a lower GHG yield per unit of energy used.

Poverty Makes it Worse

Recent years have seen growing recognition of the close inter-relationship between energy and poverty (see box below).



There is also evidence that, over time, the cost of using cleaner fuels is not necessarily higher, but that poverty prevents people from taking advantage of this fact as they generally find it difficult to invest money 'up-front' to obtain the appliances needed for using kerosene (particularly for pressurised stoves), gas or electricity, or to buy the fuel in sufficient quantity to benefit from lower unit prices. As a result, poor people may spend a higher proportion of income on fuel for cooking and heating, than those who are better off.

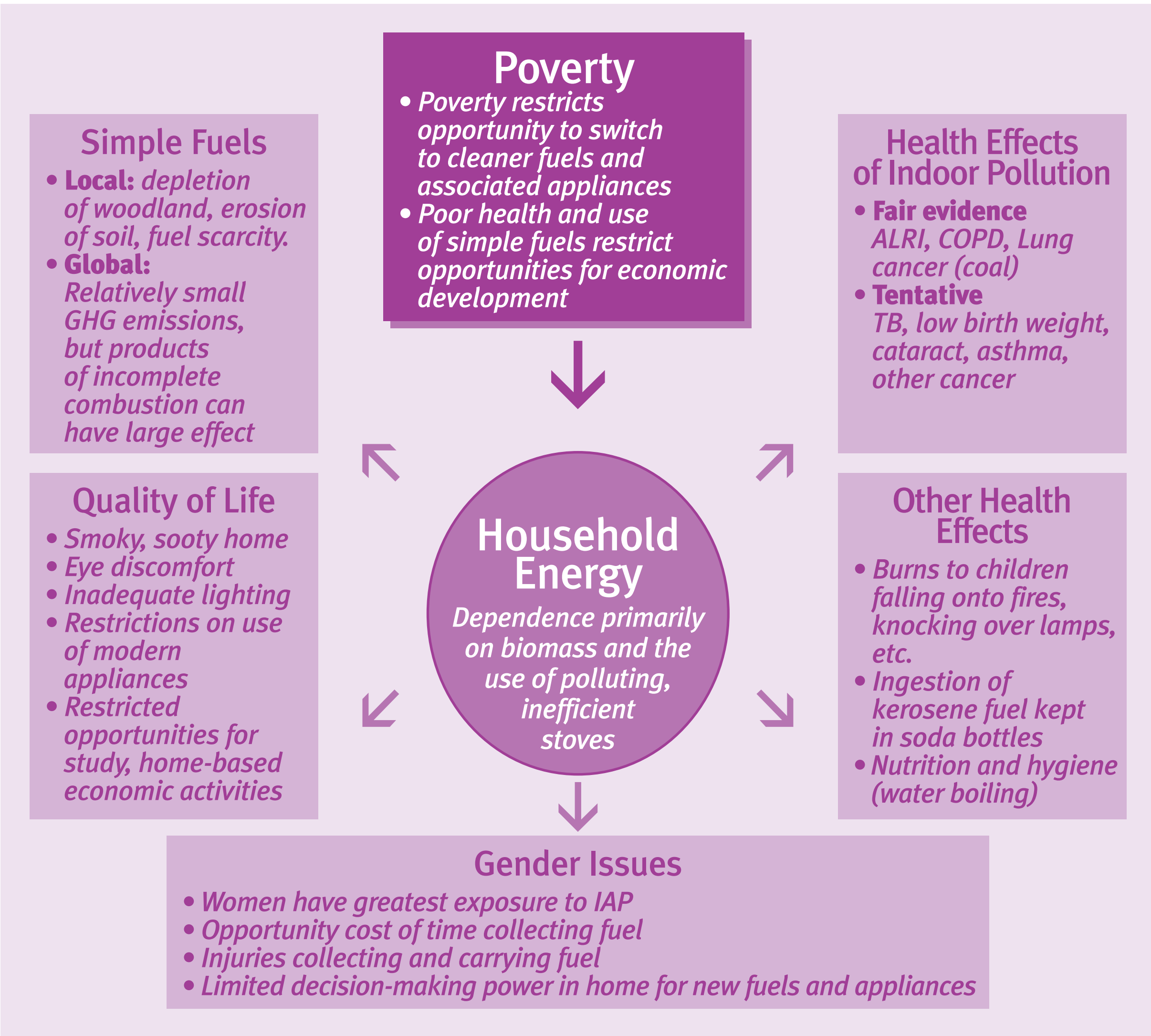


Figure 1.2. *Summary of health and development issues associated with the use of household energy in developing countries.*

Case Study 1 Electrification in South Africa

An ongoing, community-based electrification programme in South Africa has found that about 50% of households continue to use wood for cooking and heating after electrification. There are several factors that account for why so many households continue to use wood:

- **Economics.** 25% of households remain below the poverty line; they switch back to other fuels for economic reasons. The very poorest cannot afford electric appliances.
- **Political.** The electricity utility company was associated with the apartheid system, which in some areas, has led to unwillingness to become involved in the electrification programme.
- **Lack of information.** For example, confusion about what various appliances use in terms of electrical current and about ways to conserve energy. Unexpected costs then discourage further use.
- **Gender.** Men appear to have greater influence over how electricity is used in the home, and kitchen uses may be given lower priority.
- **Age and culture of users.** Older people tend to prefer to stay with traditional cooking methods. In addition, people claim that certain foods taste better when cooked with wood, and they like to gather around the fire, etc.

To increase the success of the electrification programme, an integrated approach must be taken, based on a full understanding of the socio-economic and cultural features of the community. Information, education, and communication programmes are essential, not just for beneficiaries, but also for service providers.

Based on a paper by Angela Mathee, Medical Research Council, South Africa

2 The Health Burden of Indoor Air Pollution Exposure

Levels of Smoke Pollution

Studies from countries in Asia, Africa and the Americas have measured levels of indoor air pollution associated with cooking with biomass fuels. Most have measured particles – complex mixtures of chemicals in solid form and droplets. These particles are thought to be the most health-damaging component of smoke pollution (especially the smaller ones which are able to penetrate deep into the lungs). Particles are therefore usually described by size – their effective (or aerodynamic) diameter –which is measured in millionths of a metre (microns).

Smoke pollution levels in the kitchens of developing country homes are very high.

Particles of up to 10 microns in diameter (PM10) have been most commonly measured, although some have looked at all (total) suspended particles (TSP). Recent evidence suggests that the very smallest particles are the most dangerous, therefore some studies have measured particles up to 2.5 microns in diameter (PM2.5). Concentrations of particles are expressed as the weight of particles (in micrograms, mg) per cubic metre (m^3) of air, thus mg/m^3. Only results for PM10 will be discussed here.

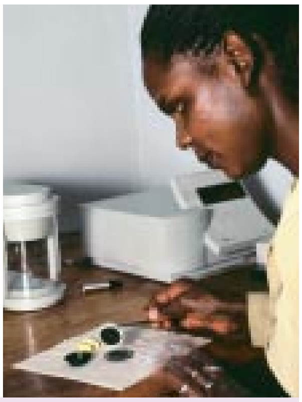
Typical 24-hour mean levels of PM10 in homes using biofuels range from 300 to 3,000+mg/m^3. While using an open fire the PM10 level can reach 20,000 mg/m^3 or more. Yet the EPA standard for average daily (24-hour) PM10 is 150 mg/m^3 (which should be exceeded only once per 100 days). The annual average should not exceed 50 mg/m^3. Most 'western' cities rarely exceed these standards.

What Should We Be Measuring?

In assessing the health implications of indoor air pollution, two measures should be considered:

- The level of ***ambient pollution*** in the home, which shows how polluted the domestic environment is.
- The level of ***exposure*** that different members of the family receive, which is a reflection of the time each person spends in polluted environments. A study in rural Kenya, for example found that exposure during brief high-intensity emission 'episodes' (when the fire is stirred or blown upon) accounted for 30 to 60% of the total exposure of household members who took part in cooking and 0 to 11% for those who did not. Simple models that neglect the spatial distribution of pollution within the home, intense emission episodes, and activity patterns may seriously underestimate exposure.

Unfortunately, the measurement of smoke particles in the home is technically quite demanding, involving moderately expensive equipment, careful procedures and quality control and well-trained staff. The measurement of personal exposures adds additional complexity. These methodological complexities are one reason why direct measurement of pollution exposure has rarely been carried out, and why the development of methods for exposure assessment is an important priority for further work in this field.



Measurement of particles requires great care at all stages. Shown here are pump calibration prior to testing in a rural Kenyan home, and removal of an exposed filter from a desiccator prior to weighing on a microbalance.

Young child with CO diffusion tube attached near breathing area.

Case Study 2 | Indoor air pollution from biofuels in rural Tamil Nadu, India

In rural Tamil Nadu, where more than 90% of households use biofuels and there is minimal use of improved stoves, personal exposure of women to respirable particles ranges from 500 to 2,000 mg/m^3 during cooking with biofuels, but decreases to 70 mg/m^3 while cooking with cleaner fuel, and to 50 mg/m^3 when cooking exclusively with cleaner fuels. The 24 hour average respirable particulate exposure exceeded 100 mg/m^3 for all those cooking, and for about a third of other people in the home. Results for the gaseous pollutants showed that these were highest close to the stove *during cooking* with biofuels, with values of 30 ppm recorded for carbon monoxide (CO), 1.5 ppm for sulphur dioxide (SO2) and 1ppm for nitrogen dioxide (NO2).

The research team now plan to monitor pollutants and children's ALRI in approximately 100 of these home over two years, with half using clean fuels and the other half continuing with traditional biofuel stoves.

Based on paper and presentation by Kalpana Balakrishnan, Sri Ramachandra Medical College Chennai, India

Health Effects of Exposure to Indoor Air Pollution

A few key references are provided for the most important health outcomes, but readers are referred to review papers for more comprehensive discussion and listing of available studies.

Conditions for which Evidence is Quite Strong

Acute lower respiratory infections (ALRI) are one of the most important causes of death globally in children under five years.

A number of studies from developing countries have reported on the association between indoor air pollution exposure and ALRI, and two further studies among Navajo Indians in the US. Overall, these studies strongly suggest that exposure to indoor air pollution increases the risk of ALRI; although the actual level of increased risk may be poorly estimated due to the lack of measurement of exposure levels, and the inconsistent way in which confounding factors have been allowed for.


Acute respiratory infections are still the single most important cause of death for children under 5 years.

There are also a number of community and hospital-based studies of biomass fuel use and *chronic lung disease* in adults in developing countries. These cover a range of disease outcomes, including chronic bronchitis, chronic obstructive lung disease (COPD) and progressive obstructive lung disease. Some people with these conditions also go on to develop emphysema or cor pulmonale. The majority of studies report that biomass smoke exposure is associated with an increased risk of chronic bronchitis and/or COPD. Around 15% of those exposed long-term to wood smoke appear to suffer from COPD, although the prevalence of chronic bronchitis appears to be considerably higher.

Smoke from both coal and biomass contains substantial amounts of carcinogens (chemical substances known to increase the risk of cancer). A consistent body of evidence has shown that women exposed to smoke from coal fires in the home have an elevated risk of *lung cancer*. This effect has not been demonstrated among populations using biomass, but the presence of carcinogens in the smoke implies that the risk may be present.

Conditions for which Evidence is Tentative

Several studies have reported an association between biofuel smoke exposure and *general acute respiratory illness in children,* mostly *acute upper respiratory illness (AURI)* such as otitis media (middle ear infection). Evidence from developing countries is very limited, but there is reason to expect an association. There is also now strong evidence that environmental tobacco smoke (ETS) exposure causes middle ear disease, and extrapolating from these studies it is reasonable to expect that children in developing countries exposed to biomass smoke would have also an increased risk of middle ear infection.

The evidence for an association between biomass fuel smoke and ***asthma*** (mainly in children) is inconsistent in both developed and developing countries. However, taken together with studies of ETS and outdoor urban pollution, it does suggest that wood smoke pollution probably exacerbates and/or triggers asthma in people who are sensitised (their immune system is likely to react to certain stimuli and lead to asthma attacks).

Several studies have found an increased risk of ***nasopharyngeal cancer*** (lining of nose, mouth and throat) and ***laryngeal cancer***, although this is not a consistent finding. The most recent study estimates that exposure to wood smoke accounts for around one third of such cancers in South America.

There are three studies that examine the association with ***tuberculosis***. One of the studies found that those living in households burning biomass, self-reported tuberculosis more frequently than those using cleaner fuels - although relying on self-reported tuberculosis may make the study unreliable. The other studies, using clinically defined tuberculosis, had similar results, however more research is needed to fully understand this relationship.

Only one study of the effect of biomass exposure on ***perinatal mortality*** (stillbirths and deaths in the first week of life) has been reported from a developing country. This found an association between perinatal mortality and exposure to indoor air pollution, which is supported by evidence from outdoor urban air pollution studies in developed countries.

Babies with ***low birth weight*** (less than 2,500 grams) are at increased risk of ALRI, and death from a range of other causes. Currently only one study of the effects of biomass smoke on birth weight in a developing country (Guatemala) has been published. It found that birth weight was 63 grams lower for babies born in households using wood than those using cleaner fuels. This result is, however, consistent with a meta-analysis of the effects of environmental tobacco smoke, and with several outdoor urban air pollution studies.

Sore, red eyes and tears are widely reported by women who cook with biomass fuels, but there is some evidence that smoke exposure may also impair vision and contribute to blindness from cataract. A hospital-based case-control study in Delhi, comparing liquid petroleum gas (LPG) with biomass fuels use, found that those using LPG had lower risk. Animal studies that report that biomass smoke damages the lens and evidence from ETS supports this finding.

Shortcomings of Studies

While the overall body of research on the effects of air pollution on human and animal health provides important evidence of associations with a range of serious and common health problems, most of the studies suffer from a number of methodological limitations:

- The lack of detailed and systematic pollution and/or exposure measurement.
- Variations between studies in the ways that disease outcomes are defined and cases found.
- The fact that all studies to date have been observational rather than intervention studies which may ultimately result in more robust evidence on the nature of the relationship between indoor air pollution and health.
- Some studies have dealt inadequately with confounding factors.

What Does the Evidence Tell us?

The evidence on ALRI and chronic bronchitis (for biomass) and lung cancer (for coal) is moderately strong and consistent, particularly when viewed in conjunction with what is known about the effects of environmental tobacco smoke and urban outdoor air pollution, and the evidence from animal studies.

Indoor Air Pollution and the Global Burden of Disease

Taken together, estimates of health risk, levels of personal exposure, numbers of people exposed and disease rates, can provide an idea of the overall global burden of disease (GBD) resulting from IAP. This approach is encapsulated in the global burden of disease (GBD) project.

The aim of the GBD project is to help prioritisation in research, policy and resource allocation. Originally the method was applied to disease outcomes, but more recently it has included the disease burden attributable to various risk factors including malnutrition, water and sanitation, tobacco, unsafe sex (risk of HIV/AIDS) and air pollution. For risk factors, the method combines information on level of exposure, level of risk of disease for conditions known to be associated with the risk factor, incidence of disease and the number of people at risk.

The GBD project uses the concept of 'disability adjusted life years' (DALYs) lost. This measure combines deaths and illness, allowing for the level of disability (impaired health) resulting from the illness and the number of years of life affected by this disability (if the person survives) or lost completely (if the person dies). A condition such as ALRI which has a high mortality in very young children would contribute significantly to the DALYs measure, since many years of potentially healthy life are lost if a young child dies.

There are currently four methods for estimating the burden of disease from the use of solid fuels in developing countries: the pollutant based method, child survival curves, cross-national (ecological) comparisons and the exposure-based method. The results from each method are fairly similar, which provides some credibility for the approaches taken and confirms the extent of the public health problem of IAP in developing countries.

The table below present results derived from the exposure-based method, as this would appear to be the most valid and generally applicable for developing country populations.

Table 2.1.
Burden of disease from solid fuel use in the early 1990s using the exposure based method

Region	Deaths	Illness Incidence	DALYs
India	496,059	448,351,369	15,954,430
China	516,475	209,727,474	9,335,387
Other Asia & Pacific Islands	210,721	306,356,582	6,599,471
Sub-Saharan Africa	429,027	350,703,204	14,323,188
Latin America	29,020	58,246,497	,918,236
Middle East and North Africa	165,761	64,150,732	5,633,022
LDC Total	**1,800,000**	**1,400,000,000**	**53,000,000**

Excess significant figures retained to reduce rounding errors.

Table 2.2. Percentage of total LDC burden attributable to solid fuel use

Region	Deaths	Percent ARI	DALYs	Percent ARI
India	5.3%	81	5.5%	87
China	5.8%	25	4.5%	50
Other Asia & Pacific Islands	3.8%	75	3.7%	85
Sub-Saharan Africa	5.2%	85	4.9%	90
Latin America	1.0%	71	0.9%	82
Middle East and North Africa	3.6%	89	3.7%	93
LDC Total	**4.7%**	**67**	**4.3%**	**81**

The GBD approach offers clear evidence that the public health problem of IAP in developing countries is severe, accounting for nearly two million deaths and 53 million DALYS lost; which represents around 4.3% of the global total of DALYs lost in developing countries.

What Further Health Research is Needed?

There is a strong case for acknowledging the large public health risk arising from indoor air pollution exposure in developing countries. However, more research is needed, in regard to the following:

- Develop a more systematic population-based approach to assessing and monitoring over time patterns of fuel use, air pollution and exposure in a wide range of countries and communities where the problems are most severe.
- Employ more direct exposure assessment in future studies, for which better methods need to be developed.
- Utilise intervention trials to obtain evidence on the effects on key health outcomes (e.g., ALRI in children) of actually reducing exposure, and to describe the exposure-response relationship.
- Conduct further observational studies (using case-control and longitudinal designs) for conditions where there are only very few studies and/or intervention studies are not practical, or the evidence is conflicting, paying careful attention to confounding factors.
- Strengthen the evidence on other direct effects of use of household energy, including burns, kerosene ingestion, etc., initially though population rather than hospital based studies.
- Review and strengthen evidence on less direct effects of household energy supply and use, including women's time, injuries from collecting fuel, economic and educational activities in the home, etc.

What Can We Now Conclude?

The health consequences of IAP exposure from biomass and other solid fuels in developing countries are substantial, and biomass and coal will continue to be used by a large number of households for many decades. If economic growth continues, use of kerosene and liquid petroleum gas (LPG) will continue to increase slowly, but well over a billion people will still be using simple solid fuels for the foreseeable future.

The information we do have – on exposure levels, number of people involved, trends in use of household fuels and the close association with poverty - is more than enough evidence to require concerted global action to improve this situation.

3 Economic Evaluation of Household Energy Interventions

For any intervention to be successful, those for whom it is intended need to believe it is worth making a change. Households can be expected to adopt a new technology if the perceived benefits of adoption are greater than the costs. While the physical impacts of adopting an improved stove, such as reduced emissions or improved fuel efficiency, can be observed directly, the value in monetary terms to the household is less evident. Estimating monetary value is useful if we are to understand the household benefits of potential interventions and, therefore, household incentives for adoption. A clear understanding of such incentives helps identify supporting policies that increase—and conflicting policies that reduce—household benefits of implementing the interventions; and provides important evidence for decision-makers weighing up the 'value for money' offered by various interventions for health improvement.

Research indicates that interventions in household energy are potentially attractive from an economic standpoint. We know, for example, that:

- Cost-benefits studies suggest a favourable cost to benefit ratio for existing interventions.
- Cost-effectiveness estimates carried out to date estimate a cost of $50-100 per DALY saved, based on data from India. This compares well with a range of other preventive and curative health interventions.

Households make production, consumption, and time-allocation decisions to maximize their welfare, which depends on (amongst other factors) child and adult health. Their decision-making is affected by:

- Constraints that are external to the household, such as market prices.
- Household technological constraints on crop production, fuel production, the production of health, etc.
- The household budget constraint, because cash expenditures must equal cash income.
- Constraints imposed by household endowments, including land, labour time, and so on. The household's time constraint 'allows' available female labour time to be allocated to fuel collection, crop production, cooking, and other household-related activities.
- Constraints imposed by information the household possesses about technologies, health impacts, etc.

The costs of adopting an intervention are usually clear, but the benefits are not. How then can benefits be identified and measured?

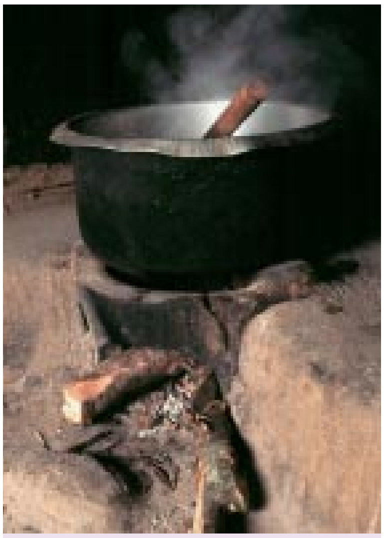
Benefits are all changes in household welfare due to the outcome of the intervention and costs are the value of the inputs required to adopt and use the intervention. Benefits of interventions to control indoor air pollution are here assumed to include direct improvements in adult and child health and indirect improvement in child health generated by better adult health.

Working Out the Costs and Benefits

The costs and benefits have been estimated for mortality and morbidity (ALRI) using examples of interventions from Guatemala and a ceramic chimney-less stove from Kenya. Briefly, a three-step method has been used to compute the cost-benefits of interventions to control indoor air pollution:

1. Estimate the three types of health impacts (direct child and adult and indirect child).
2. Estimate the monetary value to the household of these health impacts.
3. Compare the monetary value to the costs of the intervention.

These examples indicate that for mortality (all cause) the benefits exceed the stove costs by a factor of at least five. For morbidity (ALRI incidence) the findings indicate that if there are several children in a household (which is typically the case) the direct household benefits of reduced ALRI in children alone could justify an investment in an improved stove.


Ceramic wood stove, typical of that used extensively in Kenya.

Why, then, have so few households adopted the interventions? Explanations include:

- ***Practical problems*** with the improved stoves.
- ***Additional costs.*** For example, loss of the social benefits of a traditional stove.
- ***Lack of information.*** Households may not know or may not understand the relationship between fuel use, cooking technology, and household health.
- ***Poverty.*** Household valuation of risk reduction in developing countries is constrained by income levels that are substantially lower than those found in developing countries.

Is Intervening Cost-Effective?

There are a few studies that attempt to assess the effectiveness of selected interventions outside the purview of the health sector in terms of the costs per DALY saved. A review by the World Bank has yielded the following estimates:

Comparative costs per DALY gained

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

Source - World Bank, 1993.

These data suggest that the cost-effectiveness of measures to improve health covers a very wide range, particularly evident in the area of ambient air pollution control, where a larger number of studies and measures are available.

What Else Do We Need to Know?

The work so far re-enforces the need:

- For better information on the relationship between levels of (or changes in) exposure for key health outcomes such as ALRI.
- To further develop the methods used.
- To carry out cost-effectiveness analyses for a wider range of interventions and settings.
- For better information on key parameters used in the analyses and on the full range of household adjustments to interventions.

4 Towards Effective and Sustainable Interventions

Lessons from Past Experience

There has been little systematic evaluation of the direct impacts (e.g. reduction of IAP exposure, safety) and indirect impacts (e.g. opportunity costs of women's time, environmental impacts, etc.) of these potential interventions on health. Available information relates mainly to the impact on fuel consumption, emission levels, and in fewer cases on the resultant pollution and exposure levels. Therefore current knowledge is almost entirely restricted to source interventions, and mainly for various types of improved stove. Experience regarding the acceptance and sustainability of household energy programmes has increased, although these aspects have rarely been the subject of systematic research.

The emphasis in the 1970s was on fuel efficiency, which brought with it a somewhat narrow focus on technological solutions such as improved biomass stoves. These stoves included enclosed mud devices, often with chimneys, which were largely unsuccessful because of their low efficiency and rapid deterioration. A large-scale stove programme in India appears to be suffering from these problems, although a thorough evaluation is not available. Furthermore, work on the benefits of improved stoves was often marked by a lack of data on stove performance in everyday use. Efficiencies and emissions, for example, were commonly measured in controlled environments by technical experts under conditions very dissimilar to those in the field. More recently there have been evaluations of efficiency and pollution levels in more typical everyday circumstances in the home environment.

Recent surveys have identified several hundred improved stoves programmes in over 50 nations. They range from entirely local, non-governmental advocacy to national initiatives reaching millions of households. The quality and efficiency of individual stove designs has also varied greatly, as has the success of the programmes. This lack of success has shifted the focus to identifying factors that can result in successful technical design, and dissemination of improved stoves. For example, a more successful approach has been with ceramic chimney-less stoves which are cheap, relatively durable, and more fuel-efficient. Such stoves have been quite popular, especially where sustainable markets have developed. They can reduce indoor air pollution because of better combustion, with lower emissions and potentially also shorter cooking time, although the reduction in IAP is generally no more than 50% at best.

Levels of indoor air pollution, exposure, the subsequent health impact and potential solutions are all highly dependent on the local context and the specific needs of a particular household. If interventions are to be successful they must be sensitive to local conditions and build on the particular ways in which the people exposed to high levels of pollution in the home respond to the problems they face, and the opportunities they have for change. The key to success is to broaden the range of secure and sustainable choices available to the local actors in devising solutions. The characteristics of successful implementation are outlined in the box below:

Intervening successfully

For household energy projects to be successfully implemented they should be:

- Needs-oriented: solutions developed should meet the wishes and needs of consumers.
- Participatory: the users and producers should be involved in the planning and implementation of activities.
- Holistic in design: they should be treated as a complex system which addresses issues such as energy saving measures, resource conservation measures, lighter workloads, improved health and higher incomes.
- Tailored to the situation at hand: they should be carefully designed to ensure they are appropriate to the respective local socio-cultural and economic circumstances.
- Sustainable: local production should be reinforced to secure a sustainable supply of stoves, ovens and accessories by local stove fitters, potters or smithies (promotion of local artisans, self –help measures).
- Promoting demand: this can be achieved through awareness-raising, sensitization, advertising and education .

Adapted from GTZ 1997, in von Schirnding 2000

Selecting the Right Intervention

Tools are needed to ensure the characteristics of successful interventions outlined above are taken into account in local planning, and in the way that interventions and policies are evaluated. As a basis for such a tool, nine criteria (Table 4.2) have been proposed to reflect the broad range of health, environmental and development issues identified as being relevant to household energy use in poor countries and the over-riding goal of improving health.

Table 4.1. Criteria proposed for assessment of household energy options

Criterion	Issues in definition and measurement
Exposure level	Exposure level achieved for key members of the household, in particular women and young children. Assessment of time-activity, and reasons for these patterns, should also be encouraged.
Cost	Comparison should be made on the basis of both capital (initial purchase) and operating expenses.
Local environment	Supply of fuel, deforestation, loss of soil, and other issues such as lead contamination through the disposal of batteries, should be assessed through surveys of land use patterns and trends, forest management, disposal of batteries, etc.
Regional and global environment	For example greenhouse gas emissions, acidification or “acid rain”. This requires testing of emissions.
Risk of injury	Injury from carrying heavy loads of wood, burns and scalds, electrocution, fire hazard, and poisoning. Assessment requires input from users, in particular women, as well as community and health service studies.
Local employment	Opportunities for wood fuel trade, cottage industries and small to medium enterprises such as pottery, metal work, masons, etc. Surveys and other studies of the experience and views of community members and artisans required.

Criteria proposed for assessment of household energy options

Criterion	Issues in definition and measurement
Acceptance and suitability	The household energy system must meet a variety of needs including cooking, warmth, lighting, mechanical power, etc. Features of concern include durability, appearance, cleanliness, ease of maintenance, convenience, and flexibility. Assessment requires input from users, in particular women.
Gender impact	Household energy has a major impact on women's lives and well-being. Assessment would rely principally on reports from women.
Market readiness	Some interventions promise to deliver exposure reductions at a low cost and with minimal environmental damage, but do not yet offer a sufficiently attractive product to potential purchasers. These issues can only be assessed through surveys, and observation of availability in markets.

Fuel efficiency *per se* is not included, as it is thought to be more usefully considered through its contribution to operating costs, exposure and environment.

These criteria can be applied in a similar way to a health impact assessment, although in this situation the focus is primarily on household energy. The criteria are intended to be relevant both to ***rapid local option appraisal***, as well as more ***systematic evaluation at national and international levels***. At a local level, criteria may be used to help inform choices through a broad-based assessment of likely impacts on health. The criteria should not be applied too rigidly, as priorities will vary and information will often be unavailable. However, discussion of the criteria should ensure that all key issues, including those impacting directly on health, are at least considered by all concerned. At an international level, the criteria would be useful for formal comparative evaluation, as part of national and international efforts to compile experience with interventions using relatively well-standardised criteria and methods. Information from existing studies is quite limited, but this would be built up as further evaluation is carried out using agreed criteria and methods and would provide the basis for a reference resource. Findings from comparative evaluations so far undertaken have shown both the potential local usefulness of the method, as well as the need for integration of local assessment with international collaborative assessment of health impacts.

When the criteria are applied to the interventions, certain conclusions can be drawn:

Interventions on the source of pollution. The maximum benefits in terms of exposure levels (and probably also the overall protection of the environment) can be achieved through the use of alternative fuels, including kerosene, LPG, biogas, producer gas or electricity. Solar cookers, however, are still not accepted socially in many areas. Improved biomass stoves may be a better option in poor, rural communities where cleaner fuel use is very limited due to problems of supply and affordability, and biomass remains the most practical fuel.

Despite environmental concerns, charcoal is a popular fuel in a number of African cities.

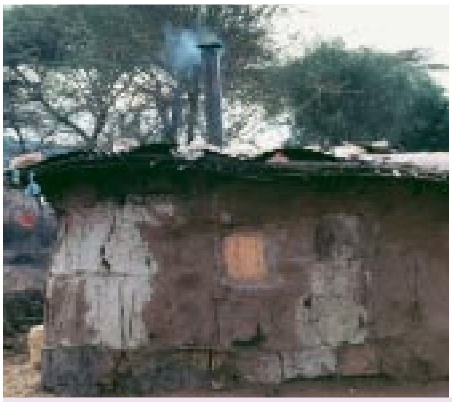
Charcoal gives a reasonable reduction in exposure levels, but is unacceptable from a cost, local environment and global environment perspective. However, its popularity especially in urban areas of African cities, means attention should be given to confirming the validity of this conclusion in local contexts.

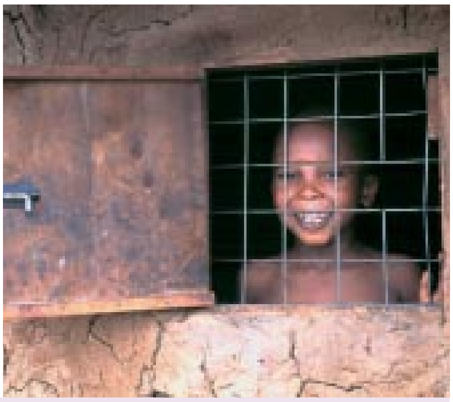
Biogas is very beneficial from an exposure level, cost, and environmental point of view, but is limited to a specific set of circumstances – namely where cattle are kept, dung is easy to collect, and water is available. Alternative fuels, such as ethanol and biodiesel, may be produced from energy crops such as sugar cane and rape seed and are thus non-fossil fuels, but as liquids benefit from easier combustion conditions for complete combustion. Ethanol may be socially unacceptable in some areas because of alcohol taboos, but this may be overcome by the production of *gel fuels*, which are currently being developed and evaluated.

Interventions to the living environment. From data that is available, the benefit of a cooking window (a type of enclosed 'fume cupboard') as based on findings of Nyström was notable. Work in rural Kenya is assessing the usefulness of hoods (with flues), enlarging and repositioning windows, and enlarging eaves spaces. Developed with full participation of local women, these interventions are acceptable and quite robust. They are also quite effective at reducing pollution and personal exposures of women, especially the use of hoods that are able to vent smoke to the exterior of the house. Further work to develop and assess the market readiness of these interventions among the poor rural communities concerned is currently underway.

Interventions to user behaviours. Objective information about user-based interventions such as drying wood, or protecting the child from smoke, is scarce, although proposals for further research are being developed.

However, reductions through changes in the behaviour are unlikely to bring about exposure reductions as large as can be expected from a fuel switch or installation of a hood, chimney or cooking window. So user-based interventions should perhaps be seen as important supporting measures for interventions in other subsystems, but further work is needed.





Interventions to the living environment being developed in rural Kenya:
(Left): enlargement of windows in traditional Maasai home.
(Middle): hood with flue, enlarged eaves spaces and enlarged and better positioned windows.
(Right): smoke vented from the home through a hood with flue.
See Case Study 3 (next page) for further explanation.

Case Study 3 Reducing smoke in rural Kenyan homes

This project had the following aims:

- Assess household energy use, pollution levels and socio-economic conditions.
- Work with households and local artisans to develop and implement appropriate interventions.
- Determine the extent of change in pollution levels.

In West Kenya, improved stoves (the Upesi ceramic chimney-less stove was available in west Kenya and already used by some study homes), larger and better-sited windows, larger eaves spaces were popular options. A few houses also expressed interest in hoods with chimneys. In Kajiado, there was no suitable, locally available improved stove. Windows were very small, for reasons of privacy and protection from animals, and eaves paces were not practical. Households were interested in having larger windows with wooden shutters, and many were keen to try a hood with chimney.

Repeat assessment of energy use and pollution and exposure was carried out during 2001, and attention given to reporting the experience in ways that can promote local, national and wider dissemination of the lessons learned. Initial analysis shows that the interventions, in particular the hoods, have been very effective in reducing ambient pollution levels and personal exposure of women, although residual levels are still of concern. Work is now underway to explore the most effective means of achieving sustainable financing and marketing of those interventions desired by local people and shown to be effective at reducing pollution in the home.

Based on a paper presented by Stephen Gitonga, ITDG Kenya

Drying fuel wood improves combustion and reduces pollution.

Getting Results: the Importance of Supportive Policies

If interventions are to succeed, there needs to be supportive policy at international, national and local levels. The experience of the Indian national improved stove programme (see box next page) illustrates the importance of this.

Experience from Indian national improved stove programme

All too often, well-intended interventions in household energy have been primarily supply orientated, with little or no integration with development processes being sought. The National Programme for Improved Stoves in India is illustrative of this approach. The programme was launched in 1983 and was oriented around targets and driven by subsidy. It was assumed that the stoves would save 30-50% of woodfuel equivalent. By March 1999, a total of 23 million stoves had been installed. However, impact studies show that the maximum lifetime of the stoves is two to three years, and most users do not replace their stoves after this period. This implies that by now less than six million stoves may be functional. This number amounts to only 4% of the rural households and hence, the national impact can only be small. Indeed the annual fuelwood saving for the country is estimated at 1.44-2.4 million tonnes, which is 0.6-1% of the total fuelwood actually being used.

Venkata Ramana P. 1999

The key to success is to adopt approaches that broaden the range of secure and sustainable choices available, and thus to enable people to devise their own solutions.

Making it work on the ground

Developing appropriate local policy for a particular setting should start with a careful analysis, involving the local community. This should include:

- Activities of the household.
- Impact on the physical environment.
- The social and cultural context.
- The factors contributing to people choosing one option over another.

The next step should be to work with the local community to establish the potential options. It should then be possible to identify the additional resources required such as finance, information, appropriate technologies and so on, as well as any barriers such as cultural issues, that stand in the way of these potential changes being realised.

The role of the international and expert community should be to increase the available options through the provision of missing resources, and supporting the development of local institutions that could then provide these resources in the future.

Why international and national policies are vital

Few developing countries have invested in a level of national policy effort that reflects the importance of household energy to health, environment and development. Strategic planning is limited and uncoordinated, there is little in the way of human capacity or financial resources available, and there has been a tendency for macro-economic policy to be counter-productive.

Among the factors that have led to distortions in the supply and demand of petroleum-derived cooking fuels (Kerosene, LPG) at national levels, have been government price controls (particularly subsidies on domestic kerosene and LPG), and protection of state oil monopolies (for example, through import restrictions and discrimination against the private sector). Although these measures may have been introduced to make cleaner fuels more accessible to the poor, universal fuel subsidies have tended to be counter-productive, with wealthier people - who have better access to these fuels - gaining most advantage. To reduce the adverse fiscal impact of such policies, some governments have supplemented a heavy kerosene subsidy with a ration system that made subsidised kerosene available in small amounts, not sufficient for cooking. In addition, a price differential between domestic kerosene and LPG on one hand and other petroleum products that are close substitutes (e.g. commercial kerosene and LPG, and diesel) has led to illegal diversion of domestic fuels to the commercial and transport sector; thus further reducing their availability for the poor.

Lack of incentives and enabling environments for the private sector slows growth in supply, removal of infrastructure bottlenecks and development of effective marketing strategies. Although in some countries the recent removal of subsidies on kerosene is believed to have pushed poor families back to reliance on biofuels, 'across-the board' subsidies are neither sustainable nor efficient. If necessary, alternative subsidy schemes could be carefully assessed and designed to target households in the greatest need, while creating an open and competitive market for products which can benefit all consumers.

Money matters

Although it appears that subsidies on fuels are not helpful, and frequently benefit higher-income households more than those for whom they are intended, carefully targeted financial support for technical development and production of appliances may be justified. In a biogas project in Nepal, for example, quality standards were met through government provision of a bonus. Another mechanism that is receiving growing attention is the provision of affordable micro-credit to households. If used to support the purchase of efficient appliances that reduce fuel (and health) costs in the long term, this could be a powerful instrument for change.

Thus, well-targeted and locally relevant interventions that include finance initiatives (through income generation and/or micro-credit) where appropriate, can be expected to facilitate some change in access to cleaner household energy despite continuing high levels of poverty. However, in rural areas where wood and other biomass are cash free, cleaner fuels such as LPG are seen as expensive. Moreover, in some areas, cleaner fuels may simply not be available because of poor distribution networks and markets. So even if fuel is made cheaper, and people want to buy it, barriers to accessing cleaner fuels remain.

Case Study 4 Modernising the fuelwood sector in Nicaragua

Nicaragua still relies on wood for its energy needs, yet its fuel wood sector is very under-developed. The NGO PROLENA has been working to modernise this situation with a strategic approach for developing the fuelwood sector, and for promoting alternative fuels by 2010. The aim is to adopt policies to regulate and create incentives, and includes the following elements:

- Create incentives to establish fuel wood plantations close to the markets to improve sustainability of supply.
- Develop a good quality woodstove that can be mass-produced and widely distributed and that will meet consumers' expectations (smoke free, does not leave soot on pots, economical, practical, and good-looking).
- Ease taxes and regulations on LPG and kerosene.
- Improve LPG distribution and safety concerns.
- Conduct an aggressive consumer-awareness campaign.
- Create a micro-credit fund for stove purchase.

An important aspect of this strategy is the recognition of the continuing importance of fuel wood in Nicaragua, while at the same time promoting transition to cleaner fuels.

Based on a paper by Rogerio de Miranda, PROLENA, Nicaragua

Is Sustainable Intervention Possible?

Changing to cleaner fuels appears to offer the greatest overall benefits as far as reducing IAP is concerned, although a number of other interventions (including improved stoves and changes to the home to vent smoke more effectively) also have potential.

Policy needs to support the process of implementing specific interventions. At local level this should be needs driven and participatory. At national and international level, policy should recognise the importance of household energy to the country with an appropriate strategic response that includes capacity and resources. Macro economic policy should support increased access of the poor to more efficient and cleaner household energy systems, rather than stand in the way of that access.

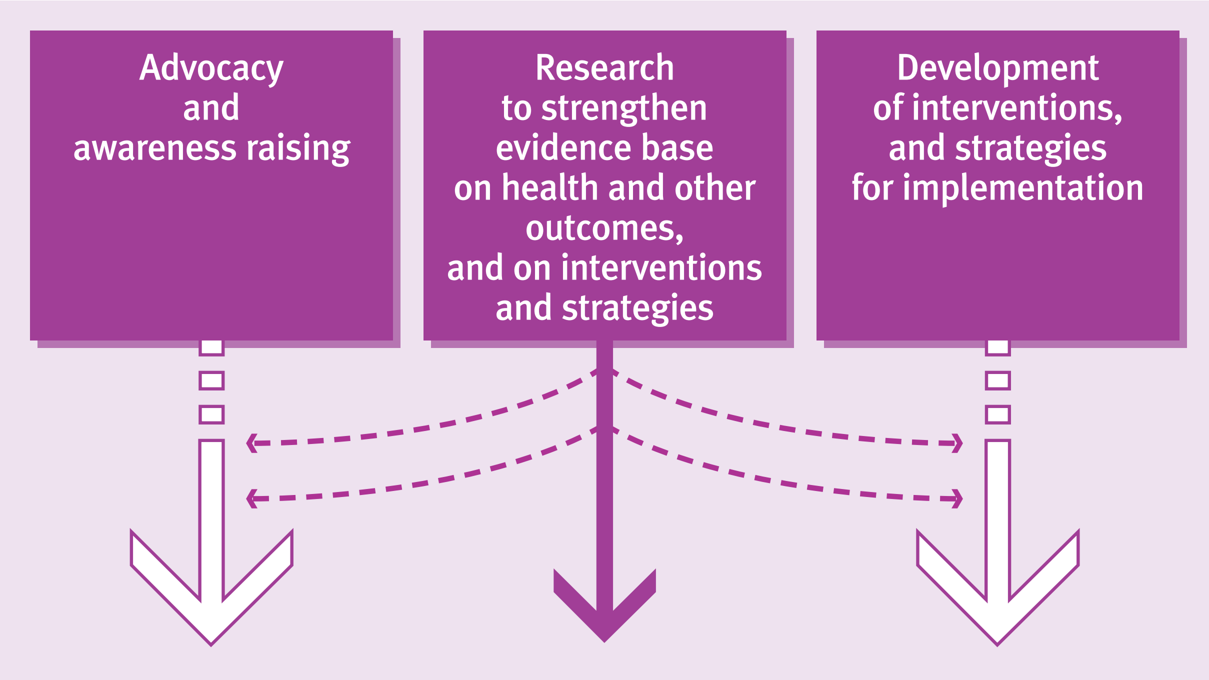
5 The Way Forward

Why Global Action is Worth It

Although there are a number of important gaps in our knowledge, there is clearly enough evidence that current household energy use in poor countries presents a substantial pubic health risk that demands concerted global action. This action requires a combination of advocacy, policy, development of interventions and a range of basic and applied research.

The focus should be on actions that can really make a difference in bringing about change in the communities where this is most needed. A key priority must be encouraging better co-ordination, recognising the complex and multi-sectoral nature of the problem and solutions required.

There are also opportunities for integrating research and policy goals, and moving away from seeing these as entirely separate activities, competing for time and resources. Integration can help to ensure that the research carried out is relevant to the pressing issues for implementation, and that those involved in decision-making and implementation are more aware of the evidence base for their work. As new information and experience becomes available, this can be used to refine the range of action being taken. This parallel, integrated action and research approach is illustrated schematically below.



Getting More Countries Involved

For many of the poorest countries and communities, where there may have been little in the way of effective programmes for reducing the impact of indoor air pollution from household energy, well-targeted demonstration projects working with and developing existing local capacity (political, technical, community, etc.) are likely to be most appropriate approaches in the first instance. Such activities can provide a basis from which to build broader-based strategic action (see box next page).

Key components of strategies for wider implementation of household energy interventions

- Strengthening government, multi/bilateral and international agency awareness of the links between household energy, health and development, and their commitment to action in poor communities.
- Facilitating collaboration between relevant sectors (government: health, environment, housing, energy, etc; as well as NGOs and businesses) at national and local levels.
- Involvement of communities, particularly women.
- Support for technical development and evaluation of interventions; micro-credit for households; policies promoting more equitable access to cleaner fuels; support for favourable institutional and market structures, small business development, capacity building, information and dissemination.

Working Together: the Need for Collaborative Action

There is a clear need for collaborative action from a wide range of 'sectors', yet multi-sectoral collaboration is not usually straightforward, and often requires active development and support. This raises a number of issues:

- The role of each sector needs to be more clearly defined in order to avoid duplication and confusion about responsibilities.
- Multi-sectoral action requires good co-ordination, a function that will need to be put in place.
- Collaborative action is often difficult for partners in practice: typically this requires an institutional or programme focus, leadership and adequate time for partners to learn how best to work together.

Table 5.1. Possible roles for various sectors involved in work on household energy, health and development

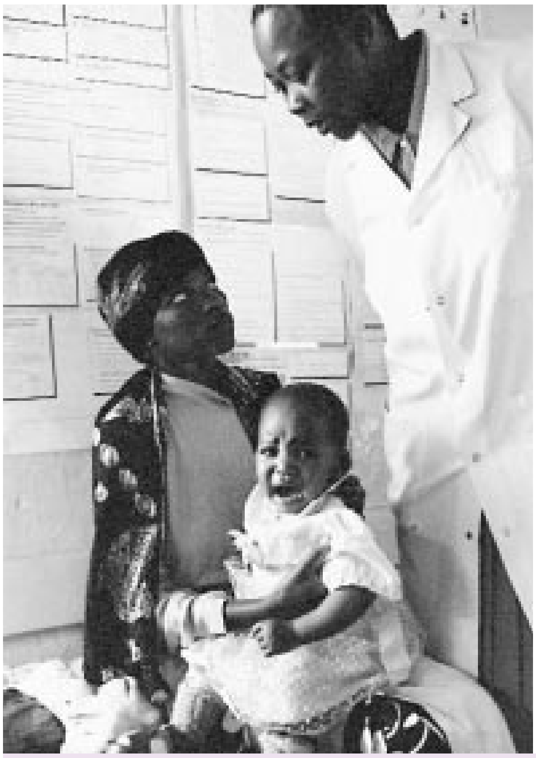
Sector	Possible role and issues to address
Health	• Assessing health impact, health promotion including awareness raising of importance of household energy to health, monitoring of situation and trends. Possible leadership role through public health function.
Environment	• Development of appropriate air quality standards and targets, and measurement of pollution. • Deforestation, forest management, emissions and climate.
Housing	• Housing construction and quality, materials and design, safety, ventilation and energy efficiency.
Energy	• Supply, including management of biomass and renewables.
Industry and commercial operators	• Supply and distribution of cleaner fuels (Kerosene, LPG, electricity) and appliances.
Women/gender	• Health, wellbeing, education for women.
Development, finance	• Awareness raising of importance of household energy to development, integration with poverty alleviation, credit and finance opportunities.
Education	• Awareness raising and skills through education at all levels.

What can be learnt from other development programmes?

Development of the roles outlined in Table 5.1 may take time, but much can be learned from other programmes. Healthy Cities and communities initiatives offer two sources of experience. Specific programmes, for example water and sanitation, provide an example of how these have evolved as health interventions, primarily for the prevention of child diarrhoeal disease.

Until recently, water and sanitation was not considered a suitable ***health*** intervention because the infrastructure was too expensive for the results achieved. It has become clear, however, that the health sector does have a role, but because there are benefits ***across sectors***, several sectors must work together to share costs.

As a result, the health sector now tends to focus on programmes to maximize the benefit of the inputs, e.g., behaviour change (making best use of water and sanitation when provided), while other sectors facilitate provision of infrastructure.



The health sector, and in particular health care services, are relatively clear about their role in respect of those who become ill. What is less evident is their role as part of 'multi'sectoral' efforts to address interventions capable of bringing about substantial improvements in health, but which are implemented primarily by other agencies. The reduction of indoor air pollution is a good example of this, as responsibility of the interventions fall mainly within sectors such as energy, housing, health and finance.

6 Recommendations

Policy and Strategy Recommendations

Donor funding: Although solutions need to be based primarily around interventions that are sustainable in the market, donor funding can have a valuable and appropriate input, at least in the short to medium term. The recommendations in this report would provide a useful starting point for selecting priority actions and deciding how much, and where, funding can most usefully be made available.

Advocacy: Advocacy should be supported by a range of products, including:
- A state of the art document for a multi-sectoral audience, based on currently available evidence and experience.
- Concise summary publications setting out key information and actions for specific audiences and sectors, including clear messages on 'what works' and what experience has shown to be ineffective.
- Innovative use of the media, internationally and nationally, including documentary and educational use of television, maximising opportunities for creative use of this medium in community education.
- Ensure the evolution of products and tools as new evidence and experience becomes available.

Communication and marketing: This requires a systematic and effective approach. A range of communication and marketing activities should be developed, including:
- Assessment of what information decision-makers will respond to with respect to household energy, health, and development.
- Awareness raising at highest levels, using key conferences and forums, as well as one or more events designed specifically for this purpose.
- Translation of information on 'best practice' into other languages.
- Identification of a high profile 'champion'.

Identify entry points: Action could be adopted more quickly if entry points on the issue of health impacts of household energy in various sectors were identified and developed, including:
- Health: Integrated Management of Childhood Illnesses; focus for community action in context of Healthy Cities projects.
- Energy: policy for the oil and gas industry, etc.
- Environment: National and local environmental action planning mechanisms; including development of locally appropriate targets for air pollution and access to cleaner fuels.
- Housing: Clearer linkage of energy issues (efficiency, ventilation, sources) in housing standards.

Develop tools: A number of tools should be developed for application in household energy, including:
- Community needs assessment.
- Health impact assessment, and variations on this including option.
- Standardised indicators to monitor progress with implementation and outcomes.

Implementation strategies: Building on existing experience, strategies for implementation of interventions should be developed that:

- Clearly define national and local components, including respective roles and responsibilities of statutory, voluntary, NGO, community and business sectors.
- Are participatory and sensitive to local circumstances.
- Integrate the contributions of local 'actors'.
- Involve the private sector in production, supply and maintenance.
- Promote demand through information on potential benefits and availability of finance and credit arrangements.
- Ensure sustainability through appropriate market-based approaches and local capacity building.
- Incorporate new evidence and experience as this becomes available.

Research Recommendations

The following research priorities encompass a wide range of research from basic to operational, and are all judged to be important for the development and implementation of effective policy.

Distil and disseminate experience of interventions and policies: Review the experience from existing household energy implementation efforts to identify, compile and disseminate lessons learned from both the technology employed, and the implementation approaches taken (policies):

- Examples of interventions to include improved biomass stoves programmes; promotion of cleaner fuels (electricity, LPG, renewables); housing improvements (venting smoke, energy efficiency); behavioural changes (fuel drying, use of put lids, protecting children).
- Examples of approaches taken to implementation, to include national programmes (electrification, stove programmes, promotion of LPG, etc.); participatory community development which includes household energy initiatives; examples of use of micro-credit for household energy development, etc.

Evaluate new interventions and policy developments: Build on existing experience to develop and evaluate a range of interventions and policies for implementation in a variety of settings. Evaluation should include:

- Health benefit – recognising that exposure may need to serve as measure of expected health benefit from reduced indoor air pollution for outcomes such as ALRI, due to the complexity and cost of measuring incidence. As better exposure-response information becomes available, the translation of exposure reduction into health gain will become more precise.
- A range of other criteria reflecting the context and impacts of household energy, including sustainability.

Measures of exposure and outcomes: Develop and test instruments to provide practical and well-standardised measures of exposure, health and development-related outcomes.

Other indicators: Develop and test standard indicators for routine application in countries, and for use in policy-level documents such as the World Development Report, etc. Assess practicality of various vehicles, such as national censuses, for applying these in practice.

Review of broader health effects of household energy: Two main areas appear to need more systematic study:

- Direct effects arising from the use of household energy, not resulting from indoor air pollution, including burns, scalds, kerosene poisoning, house fires, etc. Particularly lacking are good population studies of incidence and factors determining risk.
- Less direct health consequences including opportunity costs of women's time; injuries from carrying large loads of wood; restrictions on opportunities for education (adult and child), leisure and economic activities in the home; other economic activity outside of the home; issues arising from gender power imbalance and decision-making about the use of energy and appliances; impact of inter-relationships between scarcity of fuel and stressed local environments; etc.

Systematic review of health risks of indoor air pollution (existing data): Carry out a meta-analysis (systematic review and estimate of pooled relative risk) of available evidence – if determined to be feasible - on the impact of indoor air pollution on:

- Acute lower respiratory infections in young children.
- Chronic obstructive pulmonary disease in adults.

Obtain new evidence on health risks of indoor air pollution (new data collection): Carry out new studies, including:

- At least one randomised controlled trial to demonstrate the effect of a measured reduction in exposure on incidence of ALRI in young children.
- A limited number of new observational studies (e.g. case-control, cohort) to strengthen the evidence on outcomes where very few studies currently exist, including for: tuberculosis; low birth weight and perinatal mortality; cataract; asthma (development and exacerbation).

Exposure-response relationship for indoor air pollution: Collate existing and new evidence to generate improved exposure-response relationship information for key outcomes, such as ALRI in young children.

Economic studies: Further develop methods required for economic studies, and carry out additional assessments, including:

- Research to help understand and estimate secondary impacts of interventions on cooking time, fuel gathering, crop production, etc. The complete set of direct impacts of the intervention must be clear for households to evaluate the desirability of the intervention.
- Research to understand household benefits of risk reduction using cost-of-illness and willingness-to-pay valuations. This should allow for differences in household values for adult and child risks.
- Further cost-benefit and cost-effectiveness analyses of specific interventions in various settings.
- Macro-economic (national) consequences of policy options relating to the supply and uptake of cleaner household energy for the poor.
- Develop and assess appropriate means for conveying information on health risks and interventions to households.

People interested in science can co-operate or compete. People learn to co-operate through action, not through talk. Groups should collaborate only on things they agree on. Collaboration is hard work; it is necessary to hammer through tough issues (ego, leadership, funding, etc). For collaboration to succeed, we need to accept that there will be areas of commonality and divergence and that various organizations may develop arrangements outside the collaborative mechanism.

Research discussion group, Washington Consultation May 2000

Final Conclusions

Outlined here is an agenda for both research and policy action to reduce the health impact of household energy and indoor air pollution, which represents a consensus of views drawn from a wide range of sectors, countries and areas of expertise and interest. Research and policy should be co-ordinated and integrated where this is useful and appropriate. Donors need to give household energy greater funding priority in the context of health and poverty reduction. A mechanism for co-ordination should be established to support efficient collaboration and the dissemination of new research knowledge and experience with interventions and policy.

List Of Acronyms Used

ALRI – Acute Lower Respiratory Infections
AURI – Acute Upper Respiratory Illness
COPD – Chronic Obstructive Lung Disease
CO – Carbon monoxide
CO2 – Carbon dioxide
DALY –Disability Adjusted Life Years
U.S. EPA – United States Environmental Protection Agency
ETS – Environmental Tobacco Smoke
GBD – Global Burden of Disease
HEDON – Household Energy Organization Development Network
IAP – Indoor Air Pollution
LDC – Least Developed Countries
LPG – Liquefied Petroleum Gas
NGO – Non-Governmental Organization
NO2 – Nitrogen dioxide
PICs – Products of Incomplete Combustion
TSP – Total Suspended Particles
UNDP – United Nations Development Programme
USAID – United States Agency for International Development
WEC – World Energy Council
WHO – World Health Organization

Annex 1: Background of the Meeting

Based on Consultation which was organised to (a) review the agenda for research and policy action required, and (b) crucially, to identify what was required to get that action implemented.

The Global Consultation on the Health Impact of Indoor Air Pollution and Household Energy in Developing Countries was held in Washington, D. C., May 3 and 4, 2000. The consultation was co-sponsored by the U.S. Agency for International Development (USAID) and the World Health Organization (WHO). A steering committee with representatives from WHO, USAID, and the World Bank set the goals and agenda.

The consultation had four objectives:

1. To promote a dialogue on :
   - the health impacts of indoor air pollution and household energy use;
   - interventions to reduce exposure and improve the health of the poor; and
   - policies and strategies that contribute to sustainable economic and social development.
2. To identify the priority research, development, and policy initiatives required to define such interventions.
3. To recommend an agenda for action that articulates the roles that donors, international organizations, non-governmental organizations, and research institutions could play in addressing these priority needs.
4. To identify next steps needed to introduce and co-ordinate the proposed action agenda.

Approximately 50 persons attended the consultation. They included people from developing countries with local experience of research and development work in environment, health and development, staff from USAID, WHO, USAID's Environmental Health Project (EHP), the Harvard Institute for International Development (HIID), the World Bank, UNICEF, and other international organizations, foundations, US government agencies, and representatives of university-based research groups in the US and UK.

Three consultation involved three types of sessions:

- *Technical panels* during which commissioned papers were presented and discussed. Two such panels were held: one on the health impacts of indoor air pollution in developing countries and the other on interventions to reduce indoor air pollution.
- *Case study presentations* on research and development work conducted in developing countries on the health impacts of indoor air pollution and household energy development.
- *Small group discussions* in which participants were asked to examine issues raised in the panels and case studies and those drawn from their own experience, and then to develop an agenda for action.

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