DISEASE CONTROL PRIORITIES PROJECT

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How to Reduce Indoor Air Pollution Through Cost-Effective Solutions

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More than half of the world's population still depends on fuel sources that are inefficient, highly polluting, and unhealthy. These solid fuels include biomass (wood, animal dung, crop wastes) and coal. People who use these fuel sources burn them in open fires or simple stoves that release most of the smoke into their home, resulting in indoor air pollution that threatens the health of household members, especially women and young children.

Burden of Indoor Air Pollution

Indoor air pollution from solid fuel is responsible for a large burden of disease among the world's poorest and most vulnerable populations. In sub-Saharan Africa and South Asia, more than 80 percent of the population use solid fuel. Although there is a trend toward cleaner and more efficient energy with increasing prosperity, use of biomass, while generally in decline worldwide, increased in sub-Saharan Africa during the 1990s as a percentage of total energy use. And reliance on biomass, generally the only fuel available in rural areas, is projected to increase until 2030.

Globally, solid fuels were estimated to account for 1.6 million deaths annually and 2.7 percent of disability-adjusted life years (DALYs)[1] lost, making them the second most important environmental cause of disease after contaminated water, poor sanitation, and hygiene. One-third of this burden (32 percent) is in sub-Saharan Africa, 37 percent in South Asia, and 18 percent in East Asia and the Pacific. In developing countries with high child and adult mortality, solid fuel use is the fourth most important risk factor for ill health, after malnutrition, unsafe sex, and lack of safe drinking water and adequate sanitation. More than half of all the deaths and 83 percent of DALYs lost from solid fuel use occur as a result of acute lower respiratory infection (ALRI) in children under age 5.

Impact of Solid Fuel Use

Biomass and coal smoke give off many unhealthy pollutants, including particulate matter that may damage the lungs by causing inflammation, reduced ciliary clearance, and impaired immune response. Oxygen-carrying capacity of the blood may be reduced through exposure to carbon monoxide during pregnancy, and can retard the growth of fetuses.

There is conclusive evidence that indoor air pollution is a substantial risk factor for ALRI, chronic obstructive pulmonary disease (COPD), and lung cancer. In addition, indoor air pollution may also increase the risk of low birth weight, tuberculosis, cataracts, cardiovascular disease, and several other health outcomes.

Solid fuel use has other negative household effects:

- Inefficient stoves waste fuel and drain disposable income for fuel purchases where biomass fuels are not freely available for collection;
- Collection of biomass fuels often takes many hours each week, and can place those collecting it in potentially hazardous situations, vulnerable to landmines, snake bites, and violence;
- Inefficient household energy practices hinder the productivity of household members because they impact how women and children use their time. Such practices can keep children from attending school or mothers from home-based income generating activities like producing handicrafts.

Solid fuel use has broader environmental consequences—it contributes to outdoor air pollution and may place stress on forests and contribute to deforestation. Subsequent forest damage means longer distances to travel for fuel or results in the use of freshly cut wood, dung, and twigs that are more polluting and less efficient sources of fuel.

Energy Improvements Are Important to Millennium Development Goals

Reducing indoor air pollution is key to several of the Millennium Development Goals:

- Eradicating extreme poverty (Goal 1), through health improvements, time saving, and better environments for learning and income generation;
- Promoting gender equality and empowering women (Goal 3), by alleviating drudgery from fuel collection and inefficient stoves, and involving women in implementing change;
- Reducing child mortality (Goal 4), by decreasing deaths from ALRI; and
- Integrating sustainable development into country policies and programs (Goal 7), by decreasing the proportion of population using solid fuels.

Interventions to reduce indoor air pollution should aim to achieve a range of benefits, including:

- Reduced levels of indoor air pollution and human exposure;
- Increased fuel efficiency;
- Reduced time spent collecting fuel and using inefficient stoves;
- Reduced stress on the local environment;
- Increased opportunities for income generation; and
- Contribution to an overall improvement in the quality of the home environment—especially the working environment and conditions for women.

Cost-Effective Interventions

Although the development of new energy technologies is important in addressing the problem of indoor air pollution, many effective interventions are already available. The single greatest challenge is to increase dramatically poor households' access to cleaner and more efficient household energy systems. Interventions can be grouped as those acting on the source of pollution, those improving the living environment, and those changing user behavior (see Table 1).

EFFECT OF IMPROVING STOVES

Improved wood- or charcoal-burning stoves without flues, popular in East Africa, can reduce kitchen pollution by up to 50 percent, although levels still remain high. Charcoal gives off much less particulate matter, and stoves, such as the Kenya *jiko*, yield levels of particulate matter that are around 10 percent of those from wood fires. In Asia and Latin America, adding a flue can bring about large reductions in pollution, although this does depend on good design and regular cleaning and maintenance. Studies from Nepal show that improved stoves with flues reduce pollution by about two-thirds. In Latin America, the *plancha*-type stove (made of cement blocks with a metal plate and flue) has been shown to reduce levels of particulate matter by 60 to 70 percent.

TABLE 1. INTERVENTIONS FOR REDUCING EXPOSURE TO INDOOR AIR POLLUTION

ACT ON SOURCE OF POLLUTION	IMPROVE THE LIVING ENVIRONMENT	CHANGE USER BEHAVIOR
Improved cooking devices	*Improved ventilation*	*Reduced exposure*
Improved biomass stoves without flues	Hoods, fireplaces, and chimneys built into the structure of the house	Dry fuel
Improved stoves with flues	Windows and ventilation holes (such as in roof), which may have cowls to assist extraction	Use pot lids to conserve heat Properly maintain stoves, chimneys, and other appliances
Alternative fuel and/or cooker combinations	*Kitchen design and placement of the stove*	*Avoiding smoke*
Briquettes and pellets Charcoal Kerosene Liquid petroleum gas Biogas, producer gas Solar cookers (thermal) Other low-smoke fuels Electricity	Kitchen separate from house to reduce exposure of family (less so for cook) Stove at waist height to reduce direct exposure as cook leans over fire	Keep children away from smoke—for example, in another room (if available and safe to do so)
Reduced need for the fire		
Insulated fireless cooker (haybox) Efficient housing design and construction Solar water heating		

Source: Modified from Ballard-Tremeer and Mathee, 2000.[2]

IMPACT OF CLEANER FUELS

Kerosene and liquid petroleum gas (LPG) can reduce pollution levels substantially when used for the majority of thermal energy requirements in the home. Studies from India show dramatic reductions in the level of particulate matter, from 1500-2000 micrograms per cubic meter using wood and animal dung to 76 and 101 micrograms per cubic meter using kerosene and LPG, respectively. In addition, although electrification can decrease exposure to particulate matter and carbon monoxide, it unfortunately has little potential to bring about substantial reductions in indoor air pollution: it is too expensive to be used for purposes beyond lighting and/or powering a radio among most of the rural and urban poor. However, South Africa is one of the few countries that could convert more substantially from biomass to electricity in the rural areas because it has sufficient infrastructure.

Best Buy for Indoor Air Pollution

Experts writing in *Disease Control Priorities in Developing Countries*, 2nd edition *(DCP2)*, suggest that while cleaner fuel interventions yield the greatest gain in healthy years overall, **an improved biomass stove is the most cost-effective intervention for South Asia and sub-Saharan Africa, the two regions with the highest solid fuel-related disease burden. This improvement costs only US$20 per healthy year gained in sub-Saharan Africa, and only US$13 per healthy year gained in South Asia** (see Table 2), when 95 percent of the population is covered. Cleaner fuels (especially kerosene) are the most cost-effective options for East Asia and the Pacific, the other region with a high burden of solid-fuel-related disease.

Lessons Learned Should Drive Future Plans

Much valuable experience has been gained from successful–and unsuccessful—programs in household energy over the past three to four decades, in particular from the Indian national stove program, the Chinese national stove program, and LPG promotion. Key lessons are that:

- It is important to involve users in assessing needs and developing sustainable interventions;
- Sustainable adoption should be promoted through greater availability of a choice of appropriately priced interventions through local commercial outlets;
- A combination of user involvement and market approaches is needed, supported by the promotion and availability of targeted subsidies or micro-credit facilities or both;
- Local initiatives must be led by national and subnational policy that acknowledges the contributions of a range of actors and sectors, and that results in coordinated action.

Despite this experience, coherent, evidence-based policy is lacking in most of the countries concerned, where the lessons from experience now need to be implemented. Implementation will require greater awareness of the problem at international and national levels, provision of support for national collaborative action, and a focus on supporting appropriate, mainly market-based interventions.

But More Research is Needed

Better information is crucial to this effort, including strong evidence of the health impact of indoor air pollution exposure; assessment of the social, economic, and environmental benefits of interventions; and indicators to monitor progress.

Economic analysis can help bring the case for action to the attention of policymakers, but it needs to be applied at the country level and to include a wider range of benefits. Results

TABLE 2. US$ PER HEALTHY YEAR GAINED

INTERVENTION	SUB-SAHARAN AFRICA	LATIN AMERICA AND THE CARIBBEAN	MIDDLE EAST AND NORTH AFRICA	EUROPE AND CENTRAL ASIA	SOUTH ASIA	EAST ASIA AND THE PACIFIC
LPG	518	814	762	1,321	314	100
Kerosene	60	106	95	167	36	12
Improved Stove	20	1,101	368	N/A	13	327

Source: Nigel Bruce et al., "Indoor Air Pollution." In *Disease Control Priorities in Development Countries*, 2nd ed. D. T. Jamison et al. (2006).

from analysis at the regional level show that interventions can be cost-effective, particularly improved stoves, as long as these interventions can substantially reduce exposure to indoor air pollution in practice. This conclusion is important given the expectation that biomass will remain the principal household fuel in many developing countries for more than 20 years. The balance of efforts and resources put into promoting cleaner biomass interventions rather than cleaner fuels, or vice-versa, will be an important policy issue for many countries and for the international community.

Inefficient and polluting household energy systems hold back social and economic development through ill health, constraints on women's time and income generation, detrimental environmental impacts, and other factors. With a range of innovative projects and programs under way in a number of countries and regions of the world, it is now important to focus attention and efforts on achieving the health, social and economic gains that should result from improvements in household energy systems in developing countries.

For More Information

Nigel Bruce, Eva Rehfuess, Sumi Mehta, Guy Hutton, and Kirk Smith. 2006. "Indoor Air Pollution." In *Disease Control Priorities in Developing Countries*, 2nd ed. D. T. Jamison, J. G. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills, and P. Musgrove, 591-603. New York: Oxford University Press.

1 DALY (disability-adjusted life year) is a composite measure that combines the number of years lived with a disability and the number of years lost to premature death.

2 Ballard-Tremeer, G., and A. Mathee. 2000. "Review of Interventions to Reduce the Exposure of Women and Young Children to Indoor Air Pollution in Developing Countries." (paper prepared for USAID/WHO International Consultation on Household Energy, Indoor Air Pollution and Health, Washington, DC, May 4-6, 2000).