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Health, safety and household energy

Boiling Point

PRACTICAL ACTION

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Back issues of Boiling Point

In this edition . . .

This edition is my last . . .

This edition is my last as Boiling Point editor, and I want to thank many people for all they have done for the journal over the past few years. Firstly, thank you to Practical Action for supporting the journal, and for making it possible for you to receive it. Secondly, to GTZ, who have so loyally shared in both content and funding, bringing a real strength to the journal. Thanks too, to the other organizations which have part-funded individual editions, we could not have functioned without them. A big thank you to all who have provided material to create such a useful resource. Finally, a special thank you to the theme editors who have ensured quality and accuracy. The good news is that you will all continue to receive Boiling Point – it is now formally joining the HEDON Household Energy Network (www.hedon.info), with which it has been associated for some years. The journal will be co-ordinated by Eco Ltd, collaborating with both Practical Action and GTZ to continue bringing you the latest household energy information and news.

Contributions to Boiling Point

NEW ADDRESS FOR ALL BOILING POINT CORRESPONDENCE

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- **BP53: Technologies that really work**

In the last five years, many effective new technologies have been developed. This edition is the first for some time that is unashamedly technology-oriented. Ideally, we would like to include a wide range of proven technologies for cooking, lighting, institutional use, which have been used in households successfully for at least several months/years, and also tested to ensure that they do what they are intended to do – reducing fuel use, reducing smoke, costing less etc. Ideally, each article should include: a good description; how and where it has been tested; the cost of the technology; the level of complexity for construction and maintenance; a couple of photographs; information on where people can get more details – drawings, support, further information, and permission to use the design. For those without access to the web, please include non-web ways of accessing technical drawings (if at all possible).

- **BP54: Improved energy access for local institutions**

Where groups of people find themselves gathered, institutional stoves and lighting can be important to their well-being. Clean and efficient institutional stoves can provide food for schools, hospitals, prisons and can assist where communal facilities are needed in emergency situations. Bread and other staple foods can be cooked on a community basis. Street lighting can allow markets to trade for longer and for people to feel safe. Generators owned by the community can allow people to light their homes. Hospitals and clinics need a 'cold chain' to keep vaccines in good order. This edition is not only interested in the technologies, but also in the infrastructure to make them work: tariffs, energy efficiency, impacts, communal responsibilities and maintenance etc. If you have experience of these issues, HEDON would love to hear about them.

Articles should be no more than 1500 words in length. Illustrations, such as drawings, photographs, graphs and bar charts are essential. Articles can be submitted on disc, email or typescript.

Opinions expressed in contributory articles are those of the authors and not necessarily those of Practical Action. We do not charge a subscription to Boiling Point, but welcome donations to cover the cost of production and dispatch.

Cover photo: Woman and child cooking over open fire in street, Nairobi, Kenya (photo Practical Action/Nigel Bruce)

THEME EDITORIAL

Household energy for life

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Up to 4000 deaths a day may be prevented by providing the world's poor with access to modern household energy. Yet, in the year 2003, 52 percent of the world's population – more than three billion people – used solid fuels for cooking. The United Nations Millennium Project highlights the role of energy services as a prerequisite for development, and calls on countries to adopt the following additional Millennium Development Goal (MDG) target to pave the way for achieving all of the MDGs:

> *By 2015, to reduce the number of people without effective access to modern cooking fuels by 50 percent, and make improved cookstoves widely available.*

For this target to become a reality, 1.7 billion people will need to gain access to liquefied petroleum gas, biogas, and other modern fuels – as indicated by the arrows in Figure 1 (Source: WHO, 2006). The challenge is enormous: Every day between now and 2015, access to cleaner fuels will need to be extended to 485 000 people. And, reaching the target would still leave 1.5 billion people cooking with solid fuels and exposed to harmful pollutants in ten years' time. These numbers illustrate the urgent need for action to address this neglected public health and development issue. Data for 2015 are based on:

- a *business-as-usual* scenario that looks at the annual increase in the number of people with access to cleaner fuels from 1990 to 2003 and uses it to predict the period 2003 to 2015;
- the additional *MDG target* which was proposed by the UN Millennium Project to halve, between 1990 and 2015, the number of people without access to modern cooking fuels.

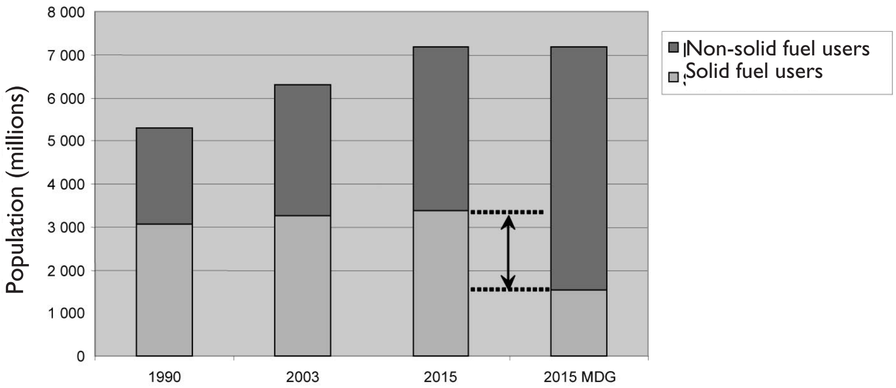

Figure 1 Trends in solid fuel use

Cooking with solid fuels has many direct and indirect impacts on health. Respiratory diseases, as illustrated in Davidzo Muchawaya's overview of the situation in rural Zimbabwe, continue to be of greatest public health concern, as is the lack of awareness about the health implications of traditional cooking practices reported from this study. Pneumonia among children under five, chronic bronchitis and other chronic respiratory diseases among adults and lung cancer (where coal is used) formed the basis for WHO's first comparative assessment of health risks conducted for the year 2000. This assessment brought to the world's attention the health burden that results from cooking with solid fuels, ranking it as one of the top ten global health risks. An update for the year 2002, published in the new WHO publication *Fuel for Life: Household Energy and Health*, confirms that indoor air pollution from solid fuel use is responsible for approximately 1.5 million deaths every year.

As described by Nathan Johnson and Mark Bryden, burns and scalds resulting from use of open fires or unsafe stoves represent another important threat to health, resulting in deaths and life-long disfigurement and handicap. Hospital records, however, do not habitually report the underlying causes of such injuries, and there is an urgent need to document the links between household energy use and burns and scalds. Finally, there is an increasing recognition of the special risks associated with fuel collection in circumstances of social instability. Cheryl O'Brien's interviews with women living in the Kebrebeyah refugee camp in Ethiopia provide sad testimony of girls and women being assaulted when they leave the relative safety of their homes, but her article also highlights that solutions are being put into practice with success.

In his update on the health and climate impacts of household solid fuels, Kirk Smith implies that although somewhat fewer childhood pneumonia deaths than previously thought may be due to indoor air pollution, our growing knowledge about links between indoor air pollution and other health outcomes that affect very large numbers of the world's poor, such as tuberculosis, cataract and low birth weight, means that the overall estimates of the burden of ill health can be expected to remain very substantial.

Overall, this issue of Boiling Point is a source of optimism for all those concerned about household energy and health, as it illustrates the variety of approaches available to reduce indoor air pollution. In the short term, outdoor cooking and improved ventilation may represent no-cost or low-cost alternatives to traditional practices, at least until technical interventions become available and affordable. Brendon Barnes and colleagues demonstrate that outdoor cooking is associated with substantially lower carbon monoxide exposures among South African children than indoor cooking. Burning charcoal in a test kitchen, Dean Still and Nordica MacCarty are able to show that better ventilation, in particular opening the door or a small hole in the roof, lead to reduced concentrations of both carbon monoxide and fine particles.

In the longer term, improvements to stoves and switching to cleaner fuels will lead to the most substantial reductions in pollution levels. Besides a switch from biomass fuels to kerosene or liquefied petroleum gas (Figure 2), other modern renewable energy products may represent options that are both healthy and environmentally friendly. Darwin O'Ryan Curtis answers the most frequently asked questions about solar cooking and concludes from project evaluations that many of the barriers to the cultural acceptance of solar cooking can be overcome. Joe Obueh describes how a pilot study will introduce the CleanCook methanol stove among households in the Delta State of Nigeria, where absolute energy poverty is widespread despite the oil and gas wealth of the country and this State in particular.

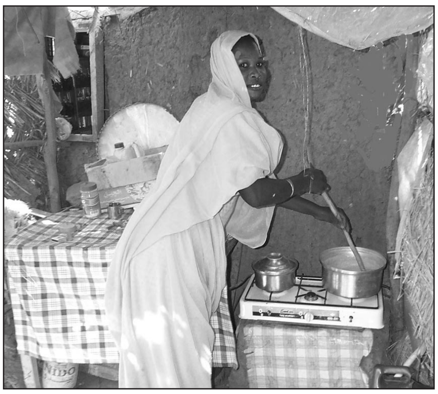

Figure 2 Liquefied petroleum gas can lead to substantial reductions in pollution levels (*photo: Practical Action*)

Past and ongoing household energy and health initiatives provide a wealth of important insights. Yet, at least two major constraints need to be overcome for their more widespread implementation. First, most interventions have been implemented locally and, while several market-based approaches to take such interventions to scale are underway, as exemplified by Laura Spautz and colleagues in China, we currently lack the experience of well-documented successful programmes. Making sure that the poorer and more vulnerable households and communities are not left behind will be critical. Second, the lack of a thorough evaluation of intervention impacts on indoor air pollution levels, health outcomes, the socioeconomic situation of the household and the environment remains a barrier to their acceptance among policy-makers as a means to improve health and stimulate development. The article by Klas Heising and colleagues about the Ayamachay community in Northern Peru is very encouraging. Following the introduction of the rocket type *Inkawasi* stove, an evaluation by trained health professionals reported substantial reductions in respiratory symptoms and illness among young adults living in homes using the improved stove. These results, as well as those of other past and ongoing work, will feed into a systematic review of the impacts of household energy and health intervention projects and programmes being conducted by WHO and the University of Liverpool.

In view of the dramatic gap between the additional MDG target and 2015 projections of patterns of energy use by the poor (see front cover), what is required to accelerate the pace of change in sustainable adoption of modern household energy practices? Critical ingredients will be a substantial increase in awareness of the problem at international, national and local levels, inter-sectoral policies that bring together health and development efforts, and – last but not least – funding support from governments, donors and the private sector. With the new World Bank investment framework for clean energy and development and the European Union Energy Facility's call for proposals, funding sources that place emphasis on access to modern cooking energy are finally becoming available.

Health is a winning argument and we should use it to make the case for scaling up household energy interventions. In particular, health system staff should be made more aware of the health consequences of IAP and energy use, and translate this actively into practice through – for example – advice given in clinical settings and in community health activities. Also at the local level, social marketing can utilise, among other arguments, the concerns about children's and women's health as a motivation for adoption. At the national level, better energy for better health may be an important entry point for introducing access to modern cooking fuels and improved stoves into Poverty Reduction Strategy Papers or National Sustainable Development Plans. Moreover, it should be highlighted that modern household energy practices do not only contribute to reducing child mortality and improving women's health but are also essential for tackling poverty and achieving the Millennium Development Goals overall. Finally, as exemplified by the joint WHO/GTZ/Practical Action/PCIA/USEPA side-event at the 14th session of the UN Commission on Sustainable Development (see full article in this edition, and also: http://www.who.int/indoorair/policy/hhhcsd14/en/index.html), evidence on the health impacts of household energy and the potential benefits of interventions is making an increasingly effective contribution to raising the international profile of this issue.

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World Health Organization. Fuel for life: household energy and health. Geneva: World Health Organization, 2006.

Theme

Update on the health and climate impacts of household solid fuels

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Background

It has been estimated that nearly half the world's population still uses solid fuels (biomass and coal) for household cooking and space heating, mostly in developing countries. In the proper conditions, biomass (wood and agricultural residues) can be burned quite cleanly, producing mostly carbon dioxide and water. Such conditions are difficult to achieve in inexpensive household stoves, however, and the actual emissions of health-damaging pollutants are quite large per unit of fuel, although the total emissions are not large in the context of overall fuel use.

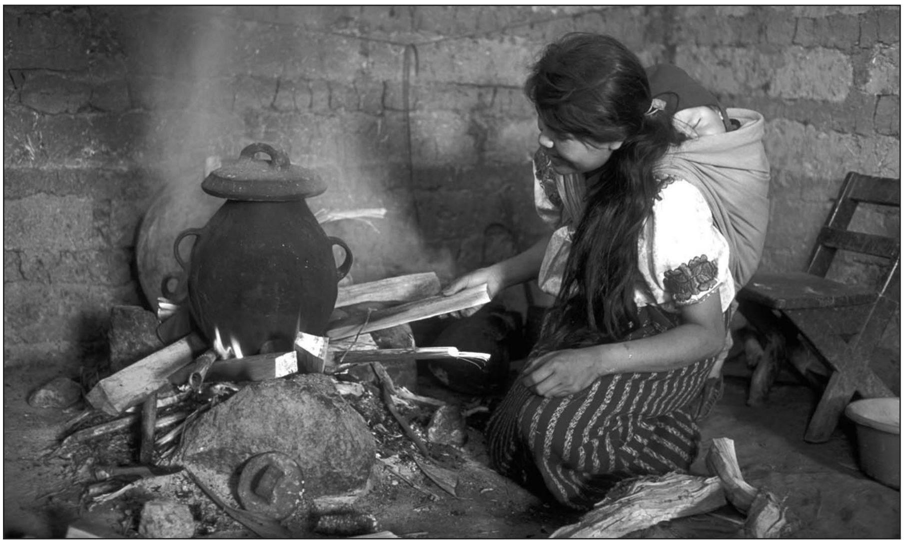

Figure 1 Poor women and their young children are most often exposed to smoke (*photo: Nigel Bruce*)

Combustion of fuel

Studies in India and China, for example, show that the percentage of fuel carbon fully burned to carbon dioxide is typically only 90 percent, with some fuel/stove combinations doing as poorly as 80 percent. This means that 5–20 percent of the fuel carbon is diverted into products of incomplete combustion – primarily carbon monoxide, but including benzene, butadiene, formaldehyde, polyaromatic hydrocarbons, and many other compounds posing health hazards. The best single indicator of the health hazard of combustion smoke is thought to be small particles, which contain many chemicals. Household coal use, largely found in China today, can present additional hazards because of the toxic contaminants in some coals, including sulfur, arsenic, fluorine, mercury, and selenium.

Exposure to smoke

Millions of people inhale significant amounts of seriously health-damaging pollutants from household stoves on a daily basis. The exposures are highest in poor women and young children of developing countries, both rural and urban, who are the groups most often present during cooking with solid fuels (Figure 1).

Evidence for ill-health

Since the mid-1980s, and more frequently since the mid-1990s, there have been many dozens of published epidemiological (population-based) studies examining a range of health effects from indoor air pollution due to solid fuel use. Because of the difficulty and expense of exposure assessment in households, however, most have used a *surrogate* (or proxy) for true exposure, often simply whether the households are using solid fuels or not. Even with such an imprecise measure, however, health effects of several sorts have repeatedly been found. The best evidence is for (a) acute lower respiratory infections (pneumonia) in young children, the chief killer of children worldwide and the disease responsible for the most lost life years in the world; (b) chronic obstructive pulmonary disease, such as chronic bronchitis and emphysema, in adult women who have cooked over unvented solid fuel stoves for many years; and (c) lung cancer, though the best evidence is only for coal smoke.

Comparison with other health risks

The World Health Organization, in a risk assessment that combined the results of many studies, compared the burden of illness and premature death from solid fuel use along with other major risk factors, including outdoor air pollution, tobacco smoking, hypertension, etc. The results indicate that solid fuel use may be responsible for 0.8–2.4 million premature deaths each year. As shown in Figure 2, using the central ('best') estimates for the risk factors examined puts solid fuel use approximately tenth among major health risks in the world in terms of potentially preventable healthy lost life-years (DALYs – a measure that combines healthy years lost due to premature death and healthy years lost due to ill-health). Of this data, those marked * are based on outcomes in the Global Burden of Disease database of the World Health Oganization (WHO). The remaining estimates are from the Comparative Risk Assessment managed by WHO (Ezzati et al., 2004).

More recent studies indicate that the past studies of solid fuel use and pneumonia in young children probably overestimated the risks due partly to confusion of *upper* and *lower* respiratory infections. Upper respiratory infections do not result in a risk of death but are quite difficult to distinguish in field research from dangerous

Theme

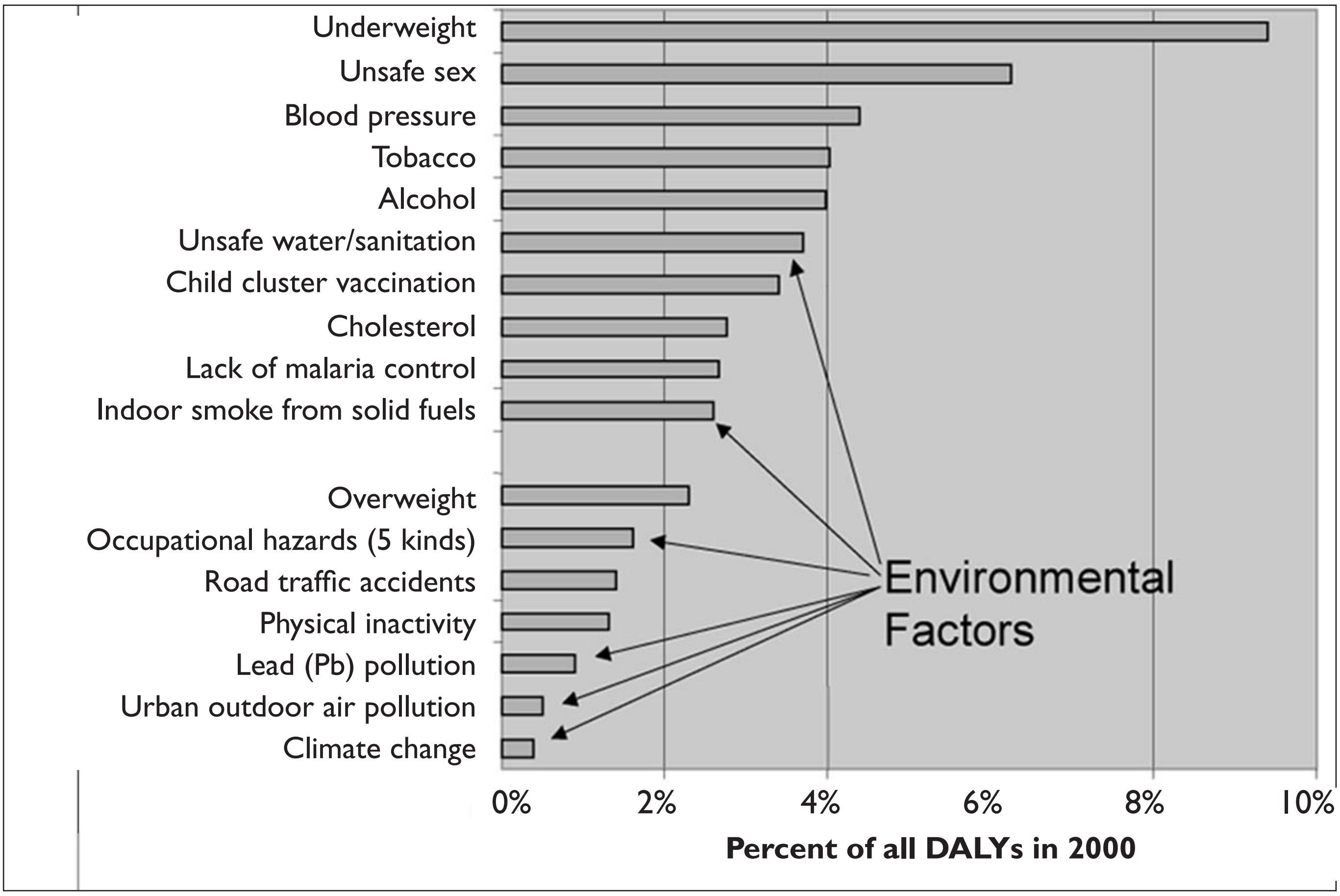

Figure 2 Global burden of disease from top 10 risk factors plus selected other risk factors

lower respiratory infections. On the other hand, there is now growing evidence of health effects of other kinds in women, including tuberculosis, cataracts, several other cancers, and low birthweight, each of which has been found associated in at least three studies in different parts of the world with indoor air pollution. Smaller but significant effects in men are also being seen. Given what has been seen in studies of outdoor air pollution and active and passive tobacco smoking, the risk of heart disease could also be expected to rise with exposure, but no studies seem to have been done in developing-country households. Thus, while the estimated impact on childhood pneumonia may decrease in future risk assessments, the impact of other diseases will add to the burden of illness and premature death from solid fuel use.

Linking reduced exposure with improved health

It is one thing to determine that ill-health is associated with a particular risk factor, but quite another sometimes to show that reduction in the risk factor will actually produce an improvement in health. There have been two very large cases to date, one in south China with coal and another in Guatemala with wood. The China study, done in retrospect, showed reduction in lung cancer and chronic obstructive pulmonary disease due to the introduction of improved stoves in the late 1970s. The other, a randomized trial of improved stoves in highland Guatemala, is just now being completed. It focused on childhood pneumonia, but also examined heart and lung effects in women.

Finding a solution to indoor air pollution

Although the risk estimates will continue to be refined and new health effects probably will be added, the challenge for development practitioners is to find a viable intervention that can be relied on to reduce exposures and improve health cost-effectively. Improved fuels, such as liquefied petroleum gas (LPG), undoubtedly produce fewer emissions and exposure themselves, but are expensive and, at least at first, populations generally do not completely switch away from solid fuels but continue to use them for some tasks. Well-designed, built, and operated improved stoves with chimneys do reduce kitchen pollution substantially, but produce much lower reductions in human exposures because the smoke is still released in the vicinity of the household. In addition, successful dissemination of well-operating and durable stoves in large populations has not been easy. That such stoves may also have social and economic benefits, however, encourages further work to find ways to disseminate them widely

Stoves and greenhouse gases

It is perhaps surprising that biomass stoves also contribute to global warming even when the fuel is harvested renewably and is thus ‘carbon neutral’, i.e., the fuel carbon released into the atmosphere is captured by re-growth of the biomass. This is because the products of incomplete combustion are more powerful greenhouse pollutants than carbon dioxide (CO_2), the primary greenhouse gas. In addition to methane and other gases, a particularly powerful greenhouse pollutant from small-scale biomass combustion is now thought to be black carbon particles. Thus, the 5–20 percent of carbon that is not converted into CO_2 adds to global warming even if the CO_2 is completely recycled by re-growth of biomass. To be truly greenhouse-neutral, a biomass fuel cycle must not only be renewable, but also be based on efficient combustion, which is not the case in simple biomass stoves. With much of the carbon being converted to powerful greenhouse pollutants in many household biomass stoves, it is even possible to argue that an efficient clean-burning fossil fuel such as LPG could be introduced as a way of reducing greenhouse gases. The attractiveness of this approach, however, depends on assumptions related to discount rates (the way pollutants which take effect over different time periods are compared) and the amount of atmospheric warming for which each of the different pollutants is responsible.

Benefiting the poor and reducing greenhouse gases

This is not to say that the growing risk of global climate change is due to the stoves of the poor. Far from it! To slow down global warming, it is the world's use of fossil fuels that needs to be addressed. However, since small inefficient stoves are responsible for both high greenhouse emissions and health-damaging pollutants (incomplete combustion), there is scope for introducing improved stoves and fuels that reduce both risks at once, i.e. produce substantial '*co-benefits*'. A stove that burns fuel efficiently is said to have high *combustion efficiency.* The costs of reducing carbon emissions from stoves with higher combustion efficiencies look to be well within those now being considered in various carbon trading or Clean Development Mechanism (CDM) schemes. These schemes work by funds from wealthy nations paying other countries for reducing the amount of carbon dioxide that they produce. Thus, it may be possible to purchase carbon savings at a reasonable price and achieve substantial health benefits as a side product, or vice versa. What has not been shown, however, is whether it is possible to introduce high-efficiency stoves to large populations such that they are built, operated, and maintained for long-term reliable performance. In addition, current rules for official CDM projects do not seem to allow for inclusion of stoves.

The only large-scale successful improved stove effort to date was in China, which facilitated the introduction of perhaps 180 million improved stoves in the 1980s and 90s without any foreign involvement. It focused on fuel savings, but did apparently achieve some reduction in pollution air pollution levels as well, by use of chimneys, although there was little if any improvement in combustion efficiencies. Nepal is currently engaged in a national programme that promotes improved stoves as well as biogas plants, but no air pollution or health assessments of the results have been done to date. Since better standard methods and new equipment for assessing the pollution and health implications of improved stove programmes are now being developed and field-tested, however, there should be reliable information soon about the actual changes produced by this and other improved stove and fuel programmes around the world.

A national competition is now under way in China to find the best of a new generation of biomass 'gasifier' stoves that are now starting to be sold in the country. These are designed to produce extremely low emissions as well as having chimneys. The designs promote internal secondary combustion of the partially combusted smoke (see Spautz et al. in this edition). Designing these to be reliable in household use as well as inexpensive is a challenge, but these stoves show promise as a second generation of improved stoves that not only have high energy efficiency but the potential to substantially reduce air pollution exposures. Measurements in households over time, however, will be needed to verify these benefits.

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Spreading innovative biomass stove technologies through China and beyond

by Laura Spautz[2], Dana Charron[2], and JoAnn Dunaway[2] , Hao Fangzhou[1] and Chen Xiaofu[1]
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Theme

A new partnership

In May 2005, a new partnership between China's Association for Rural Energy Industry (CAREI), the Center for Entrepreneurship in International Health and Development (CEIHD) at University of California, Berkeley, Shell China, and the Shell Foundation was formed to speed the spread of highly improved biomass stoves. The partnership's main goals include:

- Identifying the most promising high-efficiency, low emissions biomass stoves technologies and the best enterprises innovating in the field;
- Recognizing and publicizing these stoves and enterprises in China through an industry award;
- Strengthening the capacity of the selected enterprises, as needed, by providing business development support and access to capital; and
- Identifying export opportunities for these stoves and promoting the selected enterprises to fill appropriate market niches in other developing countries.

Fostering the spread of innovation

The partnership is delivering a project that has three phases.

Phase 1

The partners collaborated with a team of Chinese and foreign experts to draft a set of impartial criteria for an industry award recognizing superior biomass stoves (Table 1). Criteria focus on the energy-efficiency, emissions, ease of use, and product durability, as well as the overall management quality of the stove enterprises.

Table 1 Stove competition criteria for health, safety and performance

Performance & emissions	Thermal efficiency (%) Combustion efficiency (CO/CO_2 Emissions (g PM/kg fuel) Room concentrations of CO (ppm)
Qualitative standards	Safety Combustion stability Flame adjustability Ignition convenience Fuels adaptability Pots adaptability Product quality Training and maintenance

Phase 2

Entrepreneurs have been invited to compete for the awards through an application process that includes the testing of their stoves using standard protocols in a specially designed facility and the evaluation of their products and manufacturing processes by a team of independent experts. Phase 2 will conclude with an award ceremony where the winners will receive a cash prize and publicity.

Twenty stoves entered the competition and nine were selected as qualifying to proceed through the evaluation process. In March and April all nine stoves were tested (burning crop residue and briquette fuels) in the Beijing laboratory for thermal efficiency, combustion efficiency, emissions, and room concentrations of CO. Factory site inspections were conducted in April and May 2006. Final results were scheduled to be compiled in June.

Identification and evaluation of foreign markets

Another aspect of Phase 2 of the project is the identification and initial evaluation of foreign markets suited to the Chinese stoves. Populations in many other developing countries in Asia, Africa, and Latin America also suffer from indoor air pollution exposure from household solid fuels, which is estimated by the World Health Organization to claim 1.5 million lives annually around the world. The Chinese stove industry could play a role in meeting the need for high-efficiency, low-emissions biomass stoves beyond its borders.

Phase 3

The final phase, yet to be committed, will focus on capacity building of the Chinese enterprises both for domestic markets and for entry into foreign markets. Activities would include development of strategy and marketing plans, market research, manufacturing capacity expansion, and partnerships with foreign producers and distributors.

The development of stove innovations in China

In rural China, most families depend on solid fuel, such as wood, coal, straw, and other crop residues, for the majority of their household energy needs. The specific characteristics of household heating and cooking systems vary widely according to season, region, and household economic status. A recent rural survey in three provinces found everything from simple hand-built stoves to sophisticated, commercially engineered and manufactured units, and catalogued more than 30 stove/fuel combinations in common use, many simultaneously (Sinton et al). The norm in rural China is that most solid fuel is burned

GTZ HERA convened the African 'stove community' for a second meeting on Household Energy

In early 2006 the second meeting initiated by the GTZ Household Energy Programme (HERA) was held in Johannesburg, South Africa. Representatives of all fourteen GTZ-supported household energy projects in Africa met with GTZ HERA and the team from the GTZ programme Energising Development (EnDev) – (Figure 1). The EnDev team used this opportunity to present the main objectives of their programme and to exchange experiences with the other projects. The main subjects of the meeting were:

- the different successful 'scaling up approaches', which allow ongoing projects to support mass production and dissemination of stoves
- the monitoring system set up by EnDev and HERA.

Jointly the projects, HERA and the EnDev team brought together lessons learnt from their work, and developed further steps for scaling up of stove dissemination and for monitoring.

The EnDev programme aims to supply 3.4 million people world-wide with sustainable and modern energy within the next three years. For household energy the term 'modern energy' is defined as a reduction of the consumption of fuel and resulting purchase costs and/or time for fuel wood gathering by approximately 50%. Also indoor air quality should be significantly improved. Within this programme, not only cooking energy used by households is considered, but also large scale cooking in social institutions (e.g. schools, hospitals and prisons), as well as providing process energy in small and medium scale enterprises (e.g. bakeries and tobacco curing). In addition, all energy saving devices disseminated by the programme must be produced on a sustainable basis.

Figure 1 Delegates at the meeting in South Africa (*photo: GTZ*)

To achieve this goal, 20 million Euro is being provided by the Dutch Directorate for International Co-operation (DGIS) and the German Federal Ministry for Economic Co-operation and Development (BMZ). Since the programme focuses on the number of people served with household energy – instead of stoves disseminated – a new monitoring system was required, which was presented and discussed by the projects.

Scaling up of stove dissemination was another main area of the workshop. Three successful approaches from Ethiopia, Uganda and Malawi were discussed and analysed for common features.

In Ethiopia the project uses a commercial approach to reach mainly urban households. It started with the selection of an appropriate technology (MIRT stove). Stove producers were identified and selected according to specific criteria by the project and local government officers. After training the stove producers acted as independent entrepreneurs. They were only supported by an intensive promotion campaign at all levels (mass media, sensitization campaigns, flyers, leaflets, development of a logo etc.) which created a wide-spread public awareness and also set high quality standards for the stoves. In addition, to stimulate the market, the project promotes the stoves with coupons handled by micro-finance institutions. Certification of trained producers by the project has created new employment and increased income generation. The current state of dissemination of stoves can easily be followed by a highly effective monitoring system developed by the project.

By contrast, Uganda's scaling up approach concentrates on rural households. This requires more decentralised production using local materials as well as a stronger co-operation with NGOs. Again, stove producers were carefully selected. A training of trainers approach involving NGOs created a highly efficient growth system. Taking advantage of the effect where each trainer trains several others, this approach led to a high coverage rate in a short period of time. Like in Ethiopia, the stove producers act independently after training. They can achieve a profit up to 15 Euro per stove, however, prices are negotiable and occasionally stoves are produced for free if the family is very poor, thus also reaching the poorest households. The costs of stoves are kept to a minimum by involving the family in its construction. The quality of work is assured by a rigorous monitoring system; whereby producers who do not match up to the quality required are re-trained and are replaced if they do not improve the quality of their stoves. The results are impressive: over 100,000 mud rocket stoves, 1,000 metal rocket household stoves and 200 institutional stoves have been disseminated by the project within one year.

Like Uganda, the Malawi project targets low income rural households and its approach also includes decentralised production using local material. The technologies range from clay stoves disseminated in rural areas at a very low price, to rocket stoves used by households, social institutions and small enterprises at a higher price. During the course of the project, training of stove producers, monitoring and quality control were gradually taken over by the partner institutions. For scaling up, the project uses a mainstreaming approach. Partners for mainstreaming are food security projects, health and environmental programmes, school feeding and other relief programmes. Recently, tea estates and tobacco companies have become important partners.

A comparison of approaches revealed that the following factors appear to be important for successful scaling up:

- reliable partners
- selected and qualified producers
- a set of qualified trainers and manuals
- strict monitoring and quality control
- promotion and establishment of a good product image

All projects pursued a strict commercial approach involving the private sector.

To improve knowledge exchange between the different household energy projects, a specific tool, the 'Knowledge and Innovation Matrix' was developed by the participants to facilitate exchange of ideas and experiences. This exchange will be coordinated by HERA.

In addition, a new monitoring system tailored to the requirements of DGIS, was established and applied by the projects for the first time. Since sustainable access is the main goal of EnDev, the participants developed indicators for monitoring sustainability and impacts of commercial approaches for stove dissemination.

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The Inkawasi Stove: A Success Story in the Peruvian Andes

Edited by Agnes Klingshirn

GTZ

Ayamachay is a typical indigenous community of the Sierra Lambayecana in northern Peru. The scattered community of 60 houses lives at an altitude between 2600m and 3200m in the Andes Mountains. The Quechua speaking inhabitants earn a living mainly from agriculture. While the men are working in the fields, the women, besides helping the men, take care of the household and the children. More than half the households have children less than five years of age.

In 1999, GTZ and the Pan American Health Organization (PAHO) were initiating an environmental health project to improve access to, and quality of, potable water, latrines and sanitary education in Ayamachay.

Very soon they were confronted with another problem, which had not previously been considered; that of indoor smoke from cooking. Carrying out a survey among women about their practices of water boiling and sanitation, the interviewers themselves could not stand the smoky kitchens for more than a few minutes.

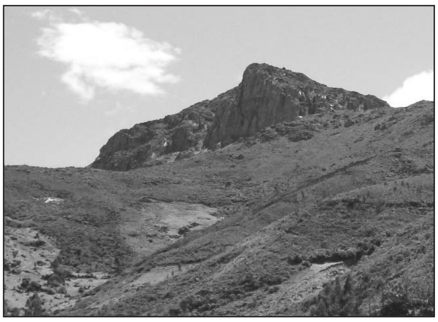

Figure 1 Ayamachay community landscape, northern Peru (*photo: GTZ*)

Exposed to thick smoke, women and young children spend five hours daily in the kitchen, which has a serious impact on their health. In the Inkawasi district, where Ayamachay is located, acute respiratory infections (ARI) are the most common illnesses. The causal connection with indoor smoke has been proved in many studies.

As a result, GTZ and PAHO decided to include improved stoves in their project, with the objectives of reducing smoke, saving fuelwood, and increasing the likelihood of people boiling water for drinking.

Background: The use of biomass energy in Peru

In Peru, almost 40% of the population rely on biomass, mostly fuelwood, agricultural residues and dung, for cooking. Most of these nine million people live in conditions of poverty and extreme poverty in rural areas, and the majority of them are indigenous. Especially in the Andes, the kitchens have only small windows and almost no air circulation due to the climate. Because of the inefficient burning of biomass, the levels of indoor air contamination recommended by WHO are often far exceeded. Hence, respiratory infections are quite common among poor and rural people.

The Inkawasi stove

Working with the local population, four prototypes of improved stoves were developed, tested and evaluated in order to get the best solution. Each of these stoves was compared with the traditional three-stones-fire with regard to fuelwood consumption, smoke emissions and cooking time. The new stove 'Cocina Inkawasi' proved to be the best both in these tests and in user satisfaction, and therefore was chosen by the villagers to be installed and disseminated.

The stove is inspired by the rocket elbow stoves of the Aprovecho Institute and is characterized by an adobe stove-body, concrete platforms and two sunken potholes that allow the two pots to be placed inside the recess. While the first pot has direct contact with the fire, the second pot is heated by the gases and the remaining heat. The second pot is usually used to heat up water for drinking and personal hygiene. Reducing rings can be used for different sized pots.

Table 1 Characteristics of various stove models in the village of Ayamachay – Inkawasi

Model	Max Power (watts)	Energy Efficiency %	Wood consumption (kg/h)
Three-stone fire	1144,00	16,27	1,608
Non-rocket improved stove	1441,81	10,93	1,973
Inkawasi Stove	1876,70	28,19	1,367

Source: José Humberto Bernilla

The air in the kitchen is improved due to the Inkawasi's construction technology, which provides efficient combustion and evacuates the dangerous emissions via the chimney. It is mainly built from local materials such as adobe and clay; however there are some metallic components, e.g. the chimney. (The Peruvian Andes being a prone to earth tremors, a metal chimney was preferred over an adobe one.)

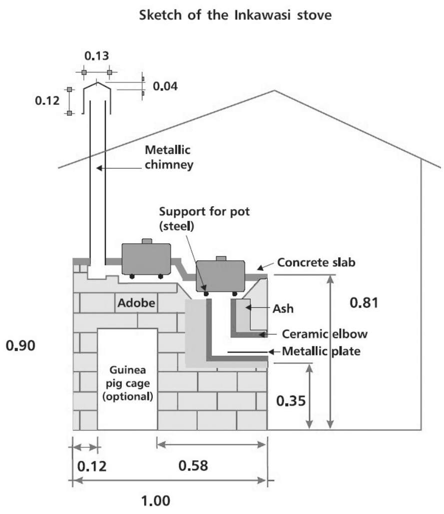

Figure 2 Inkawasi stove (measurements in metres) (*image taken from publication cited in reference*)

Overwhelming outcome

In 2004, an indoor air pollution and health monitoring indicated reductions of over 80% in indoor carbon monoxide and small smoke particles compared to the traditional fire. Decreases were also measured in the symptoms of respiratory illnesses among persons under 30 years of age. During the study period, the number of persons affected by cough and phlegm over a prolonged period of time fell by nearly two-thirds in the households with the Inkawasi stove. Those suffering from pneumonia were reported to have eight times less among the persons who used the new Inkawasi stove (GTZ-PAHO/WHO).

The success of the Inkawasi stove is proved as well by its high acceptance, considering the demand-driven approach: 90% of the households in Ayamachay are now using the improved stove.

Conclusions

Studies carried out by the Caetano Heredia University in Peruvian districts, have measured direct correlations between respiratory infections and the years of exposure to smoke from traditional fires. Usually it is the women who are affected most: particularly the older women who have been exposed to this indoor air pollution the longest suffer from respiratory illnesses such as bronchitis, cough and chronic obstructive pulmonary diseases. These findings suggest that the risk of developing a chronic bronchitis later in life is connected with the exposure to smoke from biomass burning during childhood. Infants under 5 years often are affected by acute respiratory infections that are responsible for almost 20% of all deaths in this age group.

Reference

GTZ – PAHO/WHO: Improved cookstoves as a Key Intervention to Enhance Environmental Health in the Andes: Lima and Eschborn 2005. Report of the GTZ-PAHO/WHO project 'Improvement of Environmental Conditions (Water and Sanitation) in indigenous communities (English version: March 2006).

Mass dissemination of Rocket Lorena stoves in Uganda

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A combination of strategic planning and enthusiastic beneficiaries can yield great results. In Bushenyi district in Western Uganda, over 110 000 Rocket Lorena stoves were built in just twelve months. Over 20 000 have so far been built in Rakai where the construction phase started three months ago.

A serious problem

Firewood scarcity is a severe constraint in Western Uganda just like it is in the rest of rural Uganda. The land available is not enough for settlement, save for subsistence farming. Small plots of trees are privately owned. Wood scarcity has had big implications on the health of women. It ranges from back problems due to carrying heavy loads to risks of rape, beating, injury and snakebites.

Malnutrition is evidently on the increase as nutritious but dry-preserved foods like beans and peas are avoided because they require a lot of energy for cooking. A single meal a day is a common thing in many homes. 'We walk over 20 km in search of wood,' says Jane K., a mother of eight children. She owns one acre of land. 'I would have loved to plant trees where I could harvest firewood but it is not possible. The land is too small for trees and my subsistence.'

Women and children are exposed for up to seven hours a day to pollution concentrations above accepted safety levels.

The solution

The Ministry of Energy and Mineral Development, with the support of the German Technical Cooperation (GTZ) through the Energy Advisory Project (EAP), has partnered with community based NGOs and the private sector to promote the improved Rocket Stoves for households and institutions. The rocket stoves for households have been modified to fit the socio-economic setting of the poor by using locally

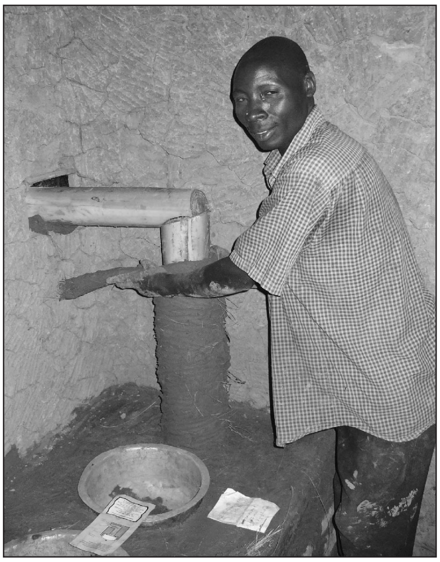

Figure 1 Locally available stove materials can be used (*photo: GTZ*)

available materials that can be obtained cheaply or even without a cost (Figure 1). Such materials include clay mixed with grass, ant-hill soil and sawdust.

The technology

During a water boiling test, it was proved that the Rocket Lorena Stoves are 30% more efficient compared to the traditional open three-stone fire stove, which has an efficiency of merely 15.6%. The improved Lorena stove thus saves 50–70% of energy compared to the traditional three-stone fire. This is possible because of the shape of the combustion chamber that is specially designed to ensure correct fuel-air mixture and properly insulated to minimize heat loss, hence maximizing the temperature of the combustion chamber (See *Boiling Point* 47, page 36). These improvements result into a high combustion efficiency and an almost smokeless burning. Further, the stove design ensures that the pot sits right inside the shielded fire chamber, hence maximizing heat transfer efficiency. The combined effect of complete burning and good heat transfer make the Rocket Lorena a highly fuel saving stove.

The strategy

In the dissemination of the improved Rocket Lorena stoves, GTZ has followed a ‘pyramid’ strategy that starts with a few coordinators at the top and ends up with hundreds of stove builders at the village level (see Figure 2).

In this strategy, the EAP builds the capacity of an NGO in a chosen district so they can technically and administratively manage the program. The NGO appoints a number of district coordinators for the scaling up dissemination process. Since the district is divided into sub-counties, the NGO staff likewise build the capacity of selected sub-county stove coordinators. Given that a sub-county is divided into many parishes, selected potential stove builders from every village are trained at parish level by visiting trainers. Every parish is given a proven artisan to train the potential stove builders. This parish coordinator also ensures that the stove builders are organized into operational groups that can disseminate stoves. The sub-county coordinator is responsible for selection of trainees organizing the training in every parish in the sub-county. He also gives them secondary training that perfects their skills. This strategy has gone through several modifications to become what it is. Though it may not be replicated in every area, it can still be modified to suit most of the districts in the country and it is currently one of the most successful innovative schemes ever designed in Uganda.

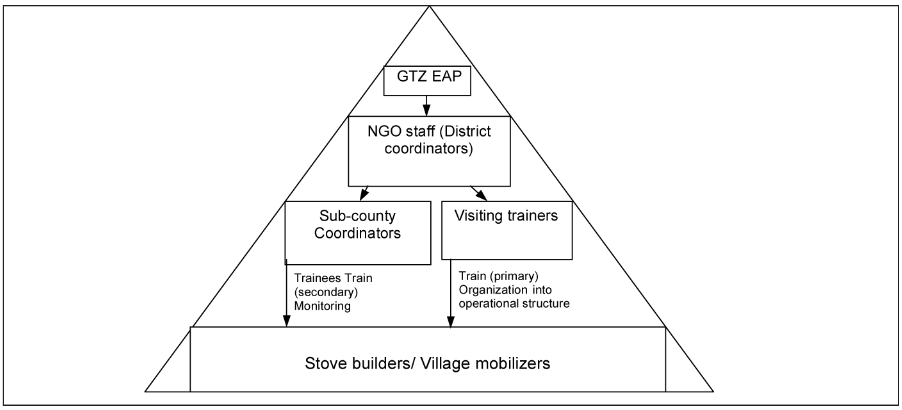

Figure 2 Pyramid strategy

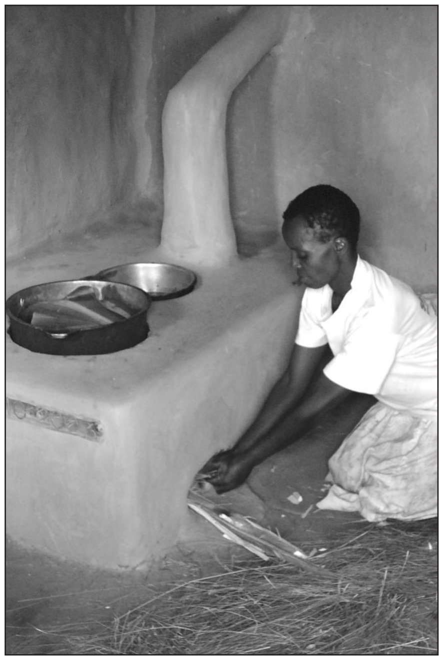

Figure 3 Satisfied cook tending her new stove (*photo: GTZ*)

Sustainability

The approach could be classified as ‘semi-commercial’. One success of stove dissemination in Uganda was the integration of non-commercial incentives like, for instance, the positive image in the community. A big part of the programme was based on voluntary contributions. In the meantime stove construction has become a common ‘skill’ of many villagers comparable to the construction of houses, in other words, knowledge that can be passed on to the next generation. The large number of trained stove producers and – perhaps more important than anything else – the satisfaction of the users with the new stoves (Figure 3), assures the sustainability of the approach.

Beneficiaries

Residents and commercial artisans have already been trained in the production and use of Rocket Lorena technologies in the wood-scarce districts of Rakai, Kanungu, Mbale, Kabale, Masindi, Kampala and Bushenyi. The low-cost design of the stoves makes them affordable even for the poorer households in these areas. During the next few months, the EAP will extend the large-scale dissemination to additional districts of the country, thus allowing an even larger share of the Ugandan population to benefit from the advantages of the Rocket Lorena stove.

Household energy, indoor air pollution and health at the 14th session of the UN Commission for Sustainable Development

On May 11th 2006, WHO, GTZ, Practical Action and the Partnership for Clean Indoor Air organised a joint side event at the UN Commission for Sustainable Development entitled *'4000 deaths a day from cooking fires? Lets prevent them!'*

By drawing attention to the severe risks of using inadequate technologies burning biomass and coal for cooking and heating in developing countries, the side-event made the case for the urgent need to improve access to household energy among the poor.

Established by the United Nations in 1992 to ensure effective follow-up to the Rio Earth Summit, the CSD is the high-level forum for discussing sustainable development within the UN. Energy for sustainable development is the main theme of CSD-14 and CSD-15.

Arno Tomowski, Director of the Department of Environment and Infrastructure at GTZ, who moderated the panel discussion, and Susanne Weber-Mosdorf, Assistant Director General, Sustainable Development and Healthy Environments at WHO, welcomed more than 70 participants. Drawing on the new WHO report *"Fuel for life: household energy and health"*, Maria Neira, Director of Public Health and Environment at the WHO, laid out the challenge: Every year, indoor air pollution (IAP) is responsible for more than 1.5 million deaths, mostly among children and women (Figure 1) . To achieve the Millennium Development Goals nearly 500 000 people will need to gain access to cleaner fuels or modern cooking technologies every day between now and 2015.

Andrew Scott, Director of Policy and Programmes with Practical Action, highlighted the various low-cost technologies which successfully reduce indoor air pollution levels, but emphasized the need for building capacity at the country level, both with respect to supply chains for the delivery of improved cooking technologies and with respect to raising awareness about the dangers of smoke.

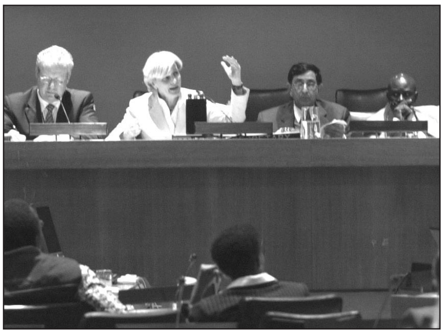

Figure 1 Maria Neira emphasizing that IAP is a neglected health and development issue (photo: IISD/Earth negotiations bulletin)

High-level panellists from different countries were asked to respond to the challenge. Jafrul Islam Chowdhury, State Minister of Environment and Forests in Bangladesh, Paul Mubiru, Commissioner for Energy in Uganda, and Surya Sethi, Energy Advisor in the Planning Commission of the Government of India, gave an overview of the situation in their countries as well as efforts to address the problem. Notably, Uganda has successfully reached more than 150 000 households with improved stoves over the past 18 months. Based on the Indian experience, subsidies on liquefied petroleum gas or other cleaner fuels are essential if the poorest households are to be reached. Finally, the representative of the Dutch Directorate General for International Cooperation (DGIS), Ton van der Zon, stated that household energy was a key element of Dutch development policy. He argued that donors will need to restructure their development aid by setting concrete targets for providing modern energy services to poor families in developing countries.

Following the statements, a lively discussion ensued and further highlighted the significance of the health burden as well as difficulties in scaling up effective solutions. Notably, a Danish Member of the European Parliament, Britta Thomson, argued for increasing the attention given to household energy and health in the framework of European development assistance, and pledged to raise this issue in the European Parliament. In his closing remarks, Arno Tomowski reiterated the daunting challenge ahead, but showed himself confident that through working together existing knowledge and experiences can be translated into real changes to transform people's lives on a large scale.

Overall, household energy, indoor air pollution and health featured prominently at CSD-14. UN Secretary General Kofi Annan called attention to the problem in his welcome address, and the issue was raised in the statements of several governments throughout the two weeks. The commitment of the European Commission as well as European Union member countries, in particular the UK and the Netherlands but increasingly others, such as Germany, is clear. In preparing for CSD-15 in 2007, WHO, GTZ, PCIA and Practical Action are working together to appeal for more international action to tackle indoor air pollution and to scale up best practices.

Practical Action was also involved in a photo exhibition and stand highlighting the dangers of smoke to all the delegates

For further information:
CSD:
http://www.un.org/esa/sustdev/csd/
WHO: http://www.who.int/indoorair
Practical Action: http://www.practicalaction.org/?id=smoke_index
GTZ: http://www.gtz.de/hera
PCIA: http://www.pciaonline.org/

The effect of ventilation on carbon monoxide and particulate levels in a test kitchen

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Abstract

Concentrations of carbon monoxide (CO) and particulate matter were monitored in a test kitchen when differing levels of ventilation were introduced to the building. These included: all windows and doors closed; door open; a small hole cut in the roof; cross-ventilation to the hole in the roof provided by a small window. Each configuration was tested three times with a constant pollution source. Increasing amounts of ventilation significantly reduced the levels of carbon monoxide and particulate matter.

Introduction

Smoke from the combustion of biomass is found in nearly half of the kitchens in the world. Exposure to smoke has been associated with chronic obstructive lung diseases and acute lower respiratory infections. The WHO has estimated that, every year, about 1.5 million people die prematurely due to breathing smoke from this source. Although breathing carbon monoxide is dangerous, inhaling particulate matter is probably the single most important health-related constituent of wood smoke. (Naeher et al, 2005)

Data from a comprehensive study of 236 houses in Bangladesh suggests that fuel choice has a significant effect on the level of indoor air pollution. Cooking with cleaner burning liquid fuels results in generally lower levels of household emissions. However, the authors also report that:

> *'. . . household-specific factors apparently matter more than fuel choice in determining PM_{10} concentrations (PM_{10} is a measure of the concentration of tiny particles in the air smaller than ten microns that can damage the lungs.) In some biomass-burning households, concentrations are scarcely higher than in households that use natural gas. Our results suggest that such variation between households is strongly affected by structural arrangements: cooking locations, construction materials, and ventilation practice . . . poor families may not have to wait for clean fuels or clean stoves to enjoy significantly cleaner air. Within our sample household population, some arrangements are already producing relatively clean conditions, even when 'dirty' biomass fuels are used. Since these arrangements are already within the means of poor families, the scope for cost-effective improvements may be larger than is commonly believed'. (Dasgupta et al, 2004).*

Kitchen ventilation study

In this study 20 briquettes of charcoal were burned in an approximately 15 cubic metre test kitchen building with a measured air exchange rate of approximately 3 air exchanges per hour when closed. Testing was only done on calm days. Charcoal was used instead of wood because it burns consistently without tending, reducing variability in the concentration of pollution introduced to the building. The emissions monitoring equipment consisted of 6 HOBO carbon monoxide monitors and one Airmetrics Minivol pump and filter particulate meter,

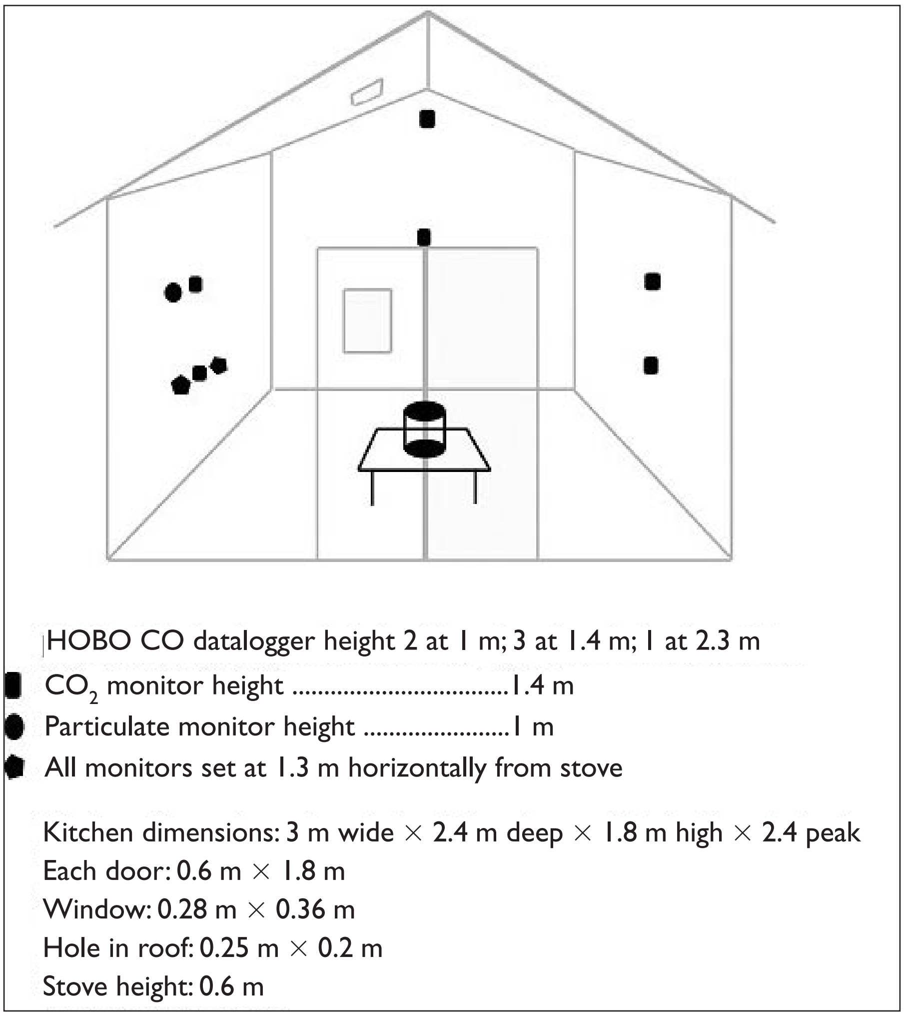

Figure 1 Diagram of test kitchen for ventilation study

drawing room air at 5 litres per minute though a filter collecting particles 2.5 microns in size or smaller ($PM_{2.5}$).

Three tests were performed for each configuration:

1.) All windows and doors closed,
2.) One 0.6 m by 1.8 m door open,
3.) One 20 cm by 25 cm hole in the roof,
4.) Opening a small 28 cm by 36 cm window along with the 20 cm by 25 cm hole in the roof.

The kitchen diagram (Figure 1) shows the size and location of openings as well as the placement of monitoring equipment.

The charcoal was left to burn vigorously for 30 minutes. It was then quickly removed through a small opening, which was then closed. The test continued for another 30 minutes as levels of carbon monoxide and particulate matter declined. Measurement was started at the time the fire was lit, and continued for a total of one hour.

Results

Figure 2 shows both the peak concentration of carbon monoxide reached after the half-hour of burning, the average level throughout the test, and the average concentration of particulate matter during the four levels of ventilation from the room being completely closed. Increasing amounts of ventilation significantly lowered levels of both types of emissions.

Figure 3 shows the average CO concentration at the height of 1.4 m above the floor for the duration of each test: Each configuration was tested three times with a constant pollution source

Table 1 summarizes the variability and potential reduction in IAP resulting from the four configurations:

Levels of both CO and $PM_{2.5}$ doors and windows closed were highly elevated, as can be expected. Opening the door was highly effective in this study, reducing pollution levels by 96%. Opening a small hole in the roof also appears to significantly improve air quality. Simultaneously opening a small window did little to reduce levels of pollution, possibly because it did not add much flow to the movement of CO and particles through the smoke hole in the roof.

Stratification of CO and $PM_{2.5}$ in the test kitchen

Three additional tests were run to study stratification in the closed kitchen using 6 HOBO CO data loggers and 6 MiniVol PM monitors at three different heights on opposite sides of the room. The HOBOs and MiniVols were located across from each other at 1 meter, 1.4 meters, and 1.8 meters in height. Some horizontal stratification was observed. It was apparent that both the CO and $PM_{2.5}$ tended to collect in higher concentrations near the ceiling and to taper off to lower levels near the floor.

Conclusion

Inhaling even small amounts of particulates can lead to increased mortality. A national study in the U.S. concluded that there is a 0.5 percent increase in the relative rate of death from all causes for each increase in the PM_{10} level of 10 µg /m^3. The estimated increase in the relative rate of death from cardiovascular and respiratory causes was 0.68 percent for each increase in the PM_{10} level of 10 µg /m^3 (Samet 2000). The very high levels often found in houses using biomass for heating and cooking are therefore of major concern.

More than 30 stoves have been tested for emissions in the Aprovecho test kitchen. In the unventilated (3 air exchanges per hour) test kitchen when burning five different fuels, levels of $PM_{2.5}$ were between 50 and 25,000 µg/m^3.

Theme

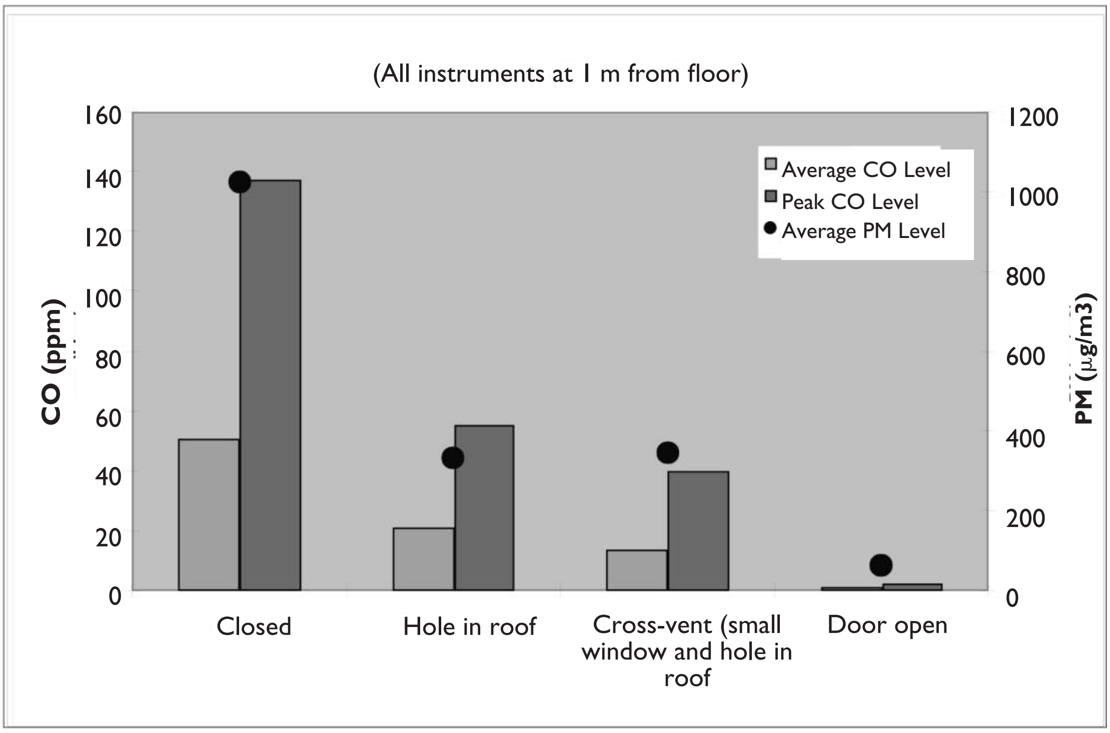

Figure 2 CO and $PM_{2.5}$ concentrations in the test kitchen; the effects of differing ventilation

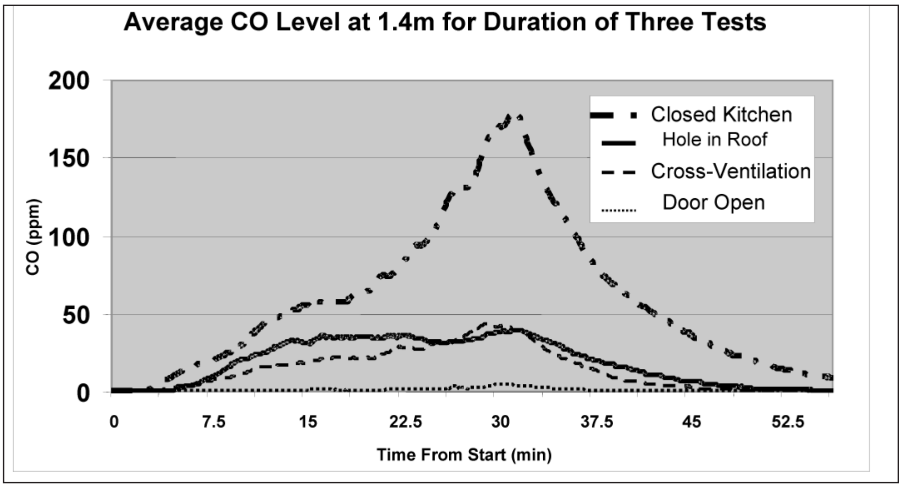

Figure 3 Average CO concentrations at 1.4m height

Table 1 CO and average PM reduction caused by ventilation

		Average	Variation of Three Tests	% Reduction from Closed Kitchen	IAP Reduction for This Ventilation
Closed Kitchen	CO Average (ppm)	54	19%		
	CO Peak (ppm)	160	38%		
	PM Average (μg/m3)	1025	47%		
Hole in Roof	CO Average (ppm)	18	61%	67%	
	CO Peak (ppm)	41	75%	75%	
	PM Average (μg/m3)	334	69%	67%	70%
Cross-Ventilation	CO Average (ppm)	14	48%	75%	
	CO Peak (ppm)	44	65%	73%	
	PM Average (μg/m3)	345	62%	66%	71%
Door Open	CO Average (ppm)	1	40%	97%	
	CO Peak (ppm)	6	37%	96%	
	PM Average (μg/m3)	66	23%	94%	96%

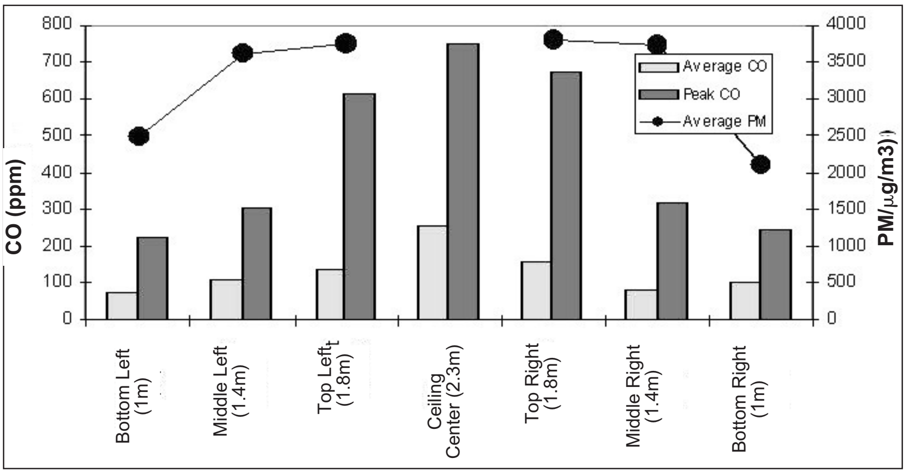

Figure 4 Stratification of CO and $PM_{2.5}$ by height in an unventilated test kitchen

An effective strategy for decreasing indoor air pollution in houses using charcoal (which may also be valid for other solid fuel burning stoves), seems to be increasing the ventilation. Some of the interventions tested which increased ventilation resulted in a reduction of both carbon monoxide and particulate matter. Opening the door was especially effective. Opening a small hole in the roof seemed to assist the removal of the smoke from the kitchen as it rose up to the ceiling. Other successful methods of ventilation include opening spaces in the eaves and using the stove under a simple smoke hood built within the home.

In the Bangladesh study, ventilation factors also accounted for large differences in PM_{10} concentrations across households. Unvented smoky fires used inside houses will create dangerous conditions injurious to health. Merely increasing the amount of ventilation will not solve this problem. However, increased ventilation may be a partial remedy that was found in this laboratory study to be effective in reducing levels of CO and $PM_{2.5}$.

Both carbon monoxide and particulate matter seem to stratify by height in a kitchen, collecting densely at the ceiling and decreasing gradually towards the floor. Levels were lowest near the floor suggesting that exposure could also be reduced by remaining seated or by squatting while cooking.

This study was funded by a grant from the Shell Foundation supporting the development of an accurate, inexpensive method for monitoring indoor air pollution.

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Methanol stoves for indoor air pollution reduction in Delta State, Nigeria – addressing the needs of people for clean energy

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Background

Delta State, one of five states that make up the Niger Delta, is possibly the richest place for oil and gas wealth in sub-Saharan Africa. Endowed with 40% of Nigeria's total oil and gas resources, or some 10 to 16 billion barrels of oil and some 160×10^{12} cubic feet of natural gas, Delta State is awash in oil and gas wealth. Despite this enormous wealth in energy resources, the vast majority of the population, some 5 million people or 1 million households, are not only extremely poor economically, but energy poor as well. An estimated 98% of households lack access to quality cooking and lighting fuel. This situation compels families to depend wholly on inferior and health-damaging fuelwood and kerosene fuels. The people of Delta State are desperate for energy.

The problems with woodfuel

As one travels throughout Delta State, wood gathering from the tropical forest together with long queues of people waiting to purchase kerosene is in evidence everywhere. For the most part, women are seen in the afternoon returning home carrying enormous bundles of fuelwood on their head after a full day's drudgery of wood gathering. Some of these bundles weigh up to 70 kg. The task of wood gathering also falls to young children and to old men who can no longer obtain waged labour for cash earnings. Some of the men own bicycles, which they load with great bundles of fuelwood.

It is estimated that a typical rural woman in Delta State spends six hours gathering fuelwood. The community forests are being depleted of valuable trees. Back home, she spends another six hours exposed to smoke as she chops up and cooks the firewood on a smoky and inefficient traditional 3-stone open fire called a *mgbaebo*, or at best she uses the tripod-supported rim stove, which wastes fuelwood that is already in short supply. The stove is usually in the corner in a poorly ventilated kitchen. The stove emits dangerous particulate matter, carbon monoxide, nitrous oxide, sulphur dioxide, formaldehyde, acetaldehyde and benzene.

Fossil fuel issues

In the peri-urban towns, of low to medium income families, up to 9% of the households depend on kerosene to supplement fuelwood. In the cities, about 1% of families depend on LPG. The use of kerosene in the peri-urban towns has been hampered by a corrupt distribution system, poor quality kerosene that burns with high emissions of soot and volatile organic compounds (the kerosene is high in toxic aromatics including benzene, toluene, xylene, sulphur and olefins), as well as prohibitive pricing occasioned by the government's withdrawal of subsidy beginning in October of 2003 in its effort to deregulate petroleum products in Nigeria. Contaminated kerosene (often adulterated with gasoline when this fuel is cheaper) has, since 2001, become an issue of national concern, having claimed more than 2000 lives in Nigeria, with Delta State worst hit.

All refined petroleum products sold in Nigeria today are imported, because Nigeria's refineries are shut down or operating at a fraction of capacity. Nigeria's refineries were built to refine Nigerian crude, which is extremely low in sulphur. Because Nigeria's low sulphur crude commands a premium on the international market, the federal government sold its oil abroad and purchased high sulphur Venezuelan crude to process in its refineries for the Nigerian market. This aggravated maintenance problems at the refineries and resulted in their deterioration. Maintenance was neglected in the 1990's and renovation ('turn around maintenance') of the refineries has been stalled in recent years. As a result, the Nigerian refineries have become virtually inoperable.

This placed the Nigerian government in a difficult position. It had to purchase all of its refined products abroad for its domestic market. The government has and continues to ship crude to other African countries for refining and return to Nigeria. All of this has created economic pressure on Nigeria to deregulate its domestic fuels pricing and remove fuel subsidies, a decision which the Obasanjo government has now pushed through. Before deregulation, kerosene prices hovered around 30 cents US. After deregulation kerosene was set at various prices, now around 64 cents. But with the scarcity of refined products and no domestic production, product scarcity has pushed kerosene into the informal market and prices in this market are normally at or above US$1.00. The temptation in this unregulated market to adulterate the fuel has also resulted in poor product quality. While these problems are not new, the rapid price inflation has occurred since early 2004.

These problems are compounded by pollution from years of uncontrolled gas flaring from an estimated 50 gas flare sites scattered over Delta State. Emissions from the flares impact nearby homes and communities. Most communities situated around the gas flare sites in Delta State are inhabited by poor families whose means of subsistence are fishing and farming. These families are constantly impacted by emissions from the flare sites and oil flow stations. An estimated 80% of the 2 billion standard cubic feet of natural gas that Nigeria flares is flared daily from the gas fields of Delta State. It is ironic that the people of Delta State must cut down their valuable forests to cook, literally in the sight of the oil rigs and flow stations! (Figure 1)

CEHEEN indoor air pollution interventions in Delta State

Prompted by a 1997 World Health Organization (WHO) report, which revealed that the greatest exposure to air pollution occurs indoors in the kitchen in developing countries, the Centre for Household Energy and Environment (CEHEEN) embarked on a two-year study of household energy in Nigeria, looking particularly at human health, the environment and gender. The results showed that Nigeria is in a crisis. Topics covered by baseline study monitoring questionnaire are shown in Table 1.

Table 2 shows the average monthly cost of different types of fuel *before price deregulation*. Most houses that used kerosene also used fuelwood.

Table 1 Baseline monitoring survey in Delta State, Nigeria

Section 1	
Household and home characteristics	Identity of primary cook Type of home structure Age of cook Educational qualification of cook Kitchen characteristics Income of house
Section 2	
Fuel purchased and fuel gathered	Types of fuel used for cooking Amount spent on fuel if purchased Time spent if fuel is gathered
Section 3	
Energy supply and end use pattern	Stove technology Cooking habits Cooking utensils
Section 4	
Household health	Indoor air quality perception Household energy route towards improved indoor air quality Primary cook's perception of her family's health Primary cook's perception of indoor air quality in the home

Fuels

Fuelwood use

In 1998 CEHEEN developed and promoted an improved version of the traditional *egaga* stove to help address this crisis (Obueh, J, 2001 – BP 47). It piloted this stove with 1000 families. The results were favourable, showing reduced emissions, reduced fuel use and some savings in cooking times. In 2002, a health evaluation involving clinical and laboratory tests showed that symptoms suggestive of acute respiratory infection and chronic obstructive lung disease were reduced for people in households using the *egaga* stoves as opposed to households using three-stone open fires. Prevalence of symptoms of smoke-related diseases among families using *egaga* stoves was measured at 32% versus 68% for families in households using three-stone open fires. Thus, *egaga* was apparently able to reduce the symptoms of smoke-related diseases very substantially, but this still left more to be done.

Table 2 Indicators of stove and fuel costs

Average monthly cooking cost	
Cost per person per month – fuelwood	US$0.34
Cost per person per month – kerosene	US$1.42
Cost per person per month – LPG	US$4.34

Figure 1 People must cut down their valuable forests in sight of the gas flares, Delta state (*photo: Project Gaia*)

Kerosene use

The original data showed that 61% of the study households (total 132) used kerosene as their primary fuel. A further 31% used it as their secondary fuel, and 9% used it both for primary and secondary use. Now, persistent scarcity of kerosene has led to the product selling at an all-time high of US$1.00 per litre, an amount grossly unaffordable for 80 per cent of our sample households. Thus, the cost of fuel to cook food is marginalizing the lower income group (and perhaps even the middle income group) unless they purchase or collect fuelwood. Table 3 shows the likely monthly cost of kerosene for an average household.

Our new baseline surveys conducted during the first quarter of 2006 for our up-coming 150-stove pilot study have shown a consistent trend away from kerosene back to fuelwood. Thus, the use of the one improved fuel that was in reach of Nigerian consumers is now declining and people are returning to primary or complete reliance on fuelwood. In oil-rich Nigeria, this is indeed an irony.

Theme

Table 3 Monthly cost of kerosene for an average household

Kerosene used per person per month	5.1 litres
Average household size	5.94 persons
Fuel use per household per month	29.76 litres = about US$30.00

Methanol stoves

It is true that by use of well-operated chimneys and hoods, smoke can be put outside the house. But in densely populated villages and towns this can lead to heavy neighbourhood pollution. Even families using cleaner fuels suffer from exposure to wood smoke. Therefore, we reasoned that unless truly clean-burning biomass stoves could be developed, the best course of action would be to eliminate the use of unprocessed solid fuels altogether. This made perfect sense for Delta State and the other states of the Niger Delta, since energy resources other than fuelwood are close at hand. The technology CEHEEN selected for further study is the alcohol-fuelled CleanCook stove (Figure 2). Table 4 shows the relative cost of this stove compared to a kerosene stove.

Table 4 Comparison of CleanCook and kerosene stoves

Stove type	Cost	Lifespan
Kerosene stoves	US$8–12	~ 1 year
CleanCook alcohol 2-burner stove	US$50	~15 years

Methanol stove project

A promising 'mini-pilot' study with 15 CleanCook methanol stoves in 2002, supported by Winrock International, led to a Ceheen and Delta State full-scale pilot study of 300 stoves. Funding for this was obtained from Delta State Government and from the USEPA under the Partnership for Clean Indoor Air. A team of surveyors, all university graduates, was recruited and trained. They compiled baseline data for 132 households in three locations: Asaba, the capital of Delta State, Abraka, the Governor's town, which is afflicted, like so many towns, with the pollution from uncontrolled flares, and Warri, the famous oil town.

Our full scale pilot study will begin by placing 150 stoves in homes in Delta State in the communities of Abraka, Asaba (the state capital) and Warri. The cost of the pilot study in Nigeria is being underwritten by the U.S. Environmental Protection Agency, Government of Delta State, Dometic AB, Stokes Consulting Group, and other partners.

The alcohol fuel used will be methanol with a colorant and a bitter agent to clearly identify it among other household fuels in order to render it unpalatable. To make the fuel completely safe for use in the household, the project uses a *denaturing protocol* that involves the addition of a special dye that colours the methanol without affecting the chemical constituents and performance of the fuel. The protocol also involves the addition of Bitrex (Denatonium Benzoate NF), an extremely bitter tasting agent that renders the methanol bad tasting and physically intolerable to swallow.

It will be distributed to the families in special canisters that do not allow people to come in contact with the fuel but only use it in the stove. Trained fuel distributors will deliver the canisters, which will be dispensed in a similar way to bottled gas – in a container that must be returned for refilling. The containers hold 1.2 litres of methanol. Each family will, for now, have four fuel containers, as weekly usage in our pilot studies has been running six to seven litres, one litre per day, and our surveyors will be visiting the houses at least twice per week. A container of fuel provides about 4½ hours of cooking at full power.

Eventually a family might have seven to eight fuel containers that transport conveniently in a sack designed for that purpose. One would expect that they would trade their empty containers in once a week for full containers. When the containers are charged with methanol, a foil seal will be placed over the evaporative surface or mouth of the container, to be peeled away when the container is ready for use. This avoids any loss from the container, however small, by evaporation.

Given the high use of kerosene and its cost in Nigeria, it seems that alcohol fuels – safe and clean-burning – may be the natural replacement for the low-quality kerosene in Delta State.

Figure 2 CleanCook stove after three years of constant use (*photo: Project Gaia*)

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Obueh, J. Boiling Point 47: Using a household energy technology to promote small scale enterprises in rural communities in Nigeria – The egaga stove experience

Joe Obueh is the Director of the Centre for Household Energy and Environment (CEHEEN), a Nigerian household energy organisation. He is also the Project Director of Project Gaia – Nigeria, a partner of Project Gaia International working in several developing countries to promote the use of safe, efficient and clean burning alcohol fuels for household cooking and other related uses.

Theme

Solar cooking and health

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Theme

The good news is that it is possible to breathe fresh air at the same time as cooking – using a solar cooker. Solar cooking produces no smoke at all.

In the past, the main reason for people adopting solar cooking was to reduce the environmental degradation caused by using too much fuel wood. More recently, respiratory diseases caused by toxic smoke from cooking fires have been recognized as a major health problem. They kill 1.5 million women and children each year, according to the World Health Organization (WHO). Solar cookers address these major threats to health as well.

Solar cooking technology has been around for decades, but has been poorly understood and has not been widely disseminated. Here are some ideas on what solar cooking is about, and its capabilities – as well as its limitations.

Overcoming barriers to acceptance

Solar energy was promoted as an alternative cooking fuel from the 1980s. Two principal barriers blocked its initial acceptance, however:

- Cultural resistance; people have used wood to cook since the inception of the domestic fire. Acceptance of so radical a change as cooking with solar energy can only happen where there is real need. With ever-increasing desertification on one hand and population increases on the other, the need is growing rapidly.
- The other initial barrier to solar cooking's broad acceptance was the indifferent quality and/or high cost of available solar cooking equipment, and the lack of experience introducing it. Today, several efficient solar cookers are available at relatively modest cost; experience has sharpened advocates' understanding of how to achieve cultural acceptance.

Where is solar cooking practical?

A major requirement of solar cooking is, of course, plenty of sun. The US space agency, NASA, created a database for those wishing to cook with solar energy. This database helps people determine where there is adequate sunshine. The term '*insolation'* is a measure of the amount of sunshine and thus is a measure of how much energy is available for solar cooking. As a technical rule of thumb, monthly insolation should exceed 4 KwH/meter squared/day on average, to merit consideration for solar cooking promotion.

Another requirement for successful introduction of solar cooking is the pressing need for alternative energy. (Places in the world where solar cooking is done as a matter of preference are few. They occur where there is a well-educated population and rising prices of traditional biomass fuels.) Otherwise, the greatest demand is where biomass fuel shortages are most severe. Considerations of health should one day become another strong incentive.

Solar cooking seasons are much longer and the need for alternative energy generally much more urgent in tropical and semi-tropical areas. These include most of Africa, South Asia, Australasia, Central and Northern South America. Solar cooking may also be a useful alternative in a band running from Turkey through the Middle East to the Himalayas and southern North America. For example, for eight months of the year solar cooking is practical as far north as Mazar-e Sharif in northern Afghanistan. There, critical shortage of household energy could make its adoption worthwhile. We have counted 67 countries where abundant insolation and varying degrees of need coincide.

Benefits to health

Here are some health problems, apart from respiratory diseases, and ways in which solar energy is being used to alleviate them:

Polluted drinking water

Dr. Mercy Bannerman won a World Bank Development Marketplace prize in 2002. With this funding she distributed 1600 solar cookers in northern Ghana and provided training in their use to pasteurize water. She noted an immediate and lasting reduction of endemic water-borne diseases like guinea worm.

Glaucoma

Glaucoma is the name for a group of eye conditions in which the optic nerve is damaged at the point where it leaves the eye. This is identified as a major health problem, and it is believed that people are considerably more at risk when exposed to toxic smoke.

The danger from open fires

Thousands of small children are maimed each year through falling into cooking fires. For example the Burn Unit of the Red Cross War Memorial Children's Hospital, Cape Town, South Africa admits almost 1000 patients a year, ranging from newborn babies to 13-year-old children (Children's Hospital Trust).

Violence

Wherever there is political unrest, as in Darfur and Somalia now, women are at high risk of rape and murder when they leave their villages to forage for fuel wood. And, because of the environmental degradation caused by this practice, they have to go ever farther to find it.

Insufficient and unsafe diet

Increasingly, the diets of people in the developing world are being adversely affected by shortages of fuel wood. Improving food safety, through making it cheaper and easier to cook food so that it contains less pathogens, can improve health. In some places, people are forced to barter some of their limited food supplies to obtain fuel with which to cook the rest. Reducing the cost of fuel increases money for food.

Cultural acceptance of solar cooking

There are very large numbers of reports of uses of, and demands for, solar cookers. For example, we have letters from village officials in Bolivia pleading for more solar cookers; similar letters from women's groups in Senegal; the assertions of Haitian women that they often solar cook two meals a day; pictures of a solar restaurant in northern Chile, and so on.

In addition, there are scientific evaluations of solar cooking education and distribution programs. For example:

- In 1995, Solar Cookers International conducted a training program at the Kakuma refugee camp in northwestern Kenya. In 1998, the program was evaluated. A random sampling of the women who had been trained three years before continued to solar cook 54% of their meals. A similar evaluation conducted at the Aisha refugee camp in Ethiopia in 2001 determined that fuel wood usage in the camp was down 32% following the introduction of solar cookers.
- In 2005, an evaluation was completed in a series of Bolivian villages. It assessed promotions conducted by David and Ruth Whitfield in preceding years. It found that solar cooking families had reduced their fuel expenses 40% in the dry season and 35% in the wet season.

Unlike photovoltaic solar devices that convert solar energy to electricity, passive ones simply catch solar energy and convert it directly to heat. They are much simpler and much less costly. Other 'passive' solar devices contributing to good health include: food driers, through-the-wall solar ovens permitting access from indoors, autoclaves which sterilize equipment for rural hospitals, and ovens that can burn medical waste. In India there is a giant solar oven, designed by Wolfgang Scheffler, that cooks for 20,000 pilgrims a day! The fuel, of course, is free.

The utility of a solar cooking device should be judged by what it can do in the location in which it is set to work. In the right location, it can reduce exposure to toxic smoke, protect from the dangers of fire, improve women's quality of life. It can also reduce fuel costs and alleviate stress on the environment. What solar cookers won't do is cook in the dark, or under overcast or rainy skies. (Thus, it will not prepare one's morning tea unless, of course, one stays in bed till very late!)

Many people say that solar cooked food is better because little or no water needs to be added, which would otherwise dilute the taste. Try it and see.

Frequently asked questions

Growing realization of a need for alternative ways to cook has stimulated new interest in solar ovens. Here are answers to some of the things people want to know:

How fast does it cook?

Many things affect cooking speed: closeness to the Equator, altitude, time of year, time of day, weather conditions, type of food. To give some idea, assume you need about twice as long as if cooking over flame. (However, when the time required to obtain fuel wood and tend the fire are considered, solar ovens demand less of the cook's time.) Solar-cooked food will not burn on the bottom of the pan, so stirring is unnecessary. Pots require no scrubbing, nor are they covered with soot. Furthermore, solar energy in the tropics and at high altitudes is so powerful that cooking speed is not necessarily an important issue. Considerations of simplicity, durability, ease of use, pleasant appearance, and low cost are considered of comparable importance.

How quickly will it boil water?

Parabolic solar ovens can do that in a matter of minutes. Box and panel ovens take longer – but will in fact boil water. It should be noted that cooking does not even require boiling in most cases – food cooks at 82C, and water is pasteurized at only 65C.

What if the main meal is eaten after dark?

There is an elegant solution. It used to be called the 'hay box' but today, the more descriptive 'retained heat cooker' or 'fireless cooker'. It is simply a container lined with insulation in which a pot of cooked food can be kept hot for several hours. It was once in common use in Europe and the U.S. Figure 1 shows a model that Wietske Jongbloed designed for use in the Sahel.

How do you solar cook in the early morning or when the sky is overcast?

You don't. Solar cookers can be an important, sometimes main, means of cooking, but never the *only* one. There must be another way to cook, and low-emission, fuel-efficient stoves are best. However, it is as unnecessary to burn fuel under a blazing sun as it is foolish to deploy a solar cooker at night.

How can people cook when there isn't any sun?

They have to use combustible fuels. The percentage of time a solar oven can be used varies widely with factors like weather, skill of the cook, and the urgency of the need. (The GTZ conducted a solar cooking project in South Africa and concluded that solar cookers were used an overall average of 40% of the time. Solar cookers will never be THE solution. They are an important addition to the kitchens of the world.

What are the problems associated with solar cooking?

With some cookers, even though tough, tempered glass is usually used,

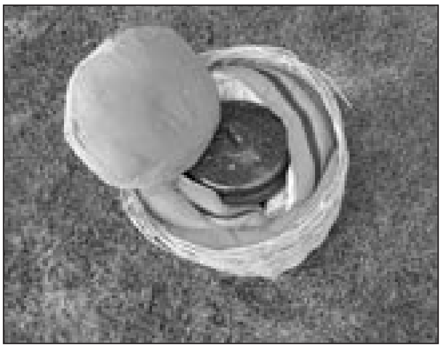

Figure 1 Retained heat cooker (*photo: Darwin Curtis*)

Theme

there is the possibility of breakage. This danger must be compared to the risks presented by open fires. There is a possibility of a burn if the black cooking pot used for solar cooking is touched while hot; but this is true of any cooking pot. There is no danger of burns from the other components of solar cookers. There are undoubtedly places where it is inadvisable to leave a solar cooker unattended because of animals or children or thieves or, as has been suggested to us, poison. The same problems confront those who cook outdoors over three stone fires. We know of no solution but to keep an eye on the cooker from a shady place nearby.

Are solar ovens affordable in the developing world?

Not by the people who need them the most – virtually nothing is. However, there are now durable, efficient modern designs which can retail for $50 or less. There are continuing efforts to reduce that cost further. Creative financing will always be necessary to achieve the widest possible distribution. This includes micro banking, lay away plans, barter arrangements and subsidies. And since solar energy is free, people eventually pay for their ovens with the money they have saved by reducing their need for traditional fuels.

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The basics of solar oven design

There are three practical models of solar cookers.

The box oven was introduced in the 1950s by Dr. Maria Telkes. A popular model has a hinged, transparent top of glass or plastic and the inside of the box is black. Sunlight passes through the glass, strikes the black-painted inside of the box and the light is converted into heat, which cooks whatever is in the box. Box cookers can be of any size and can contain several pots. They can be hand made, even out of cardboard, and work well. The way they work is very similar to ovens (Figure 2).

Figure 2 Box oven, Bolivia (*photo: David Whitfield*)

The most powerful solar cooker is composed of a paraboloid reflector and a bracket to hold a pot. The reflector bends the rays of light so that they are concentrated at a *focal point* under the pot, making it very hot indeed. The focal point is so hot that this kind of solar cooker can fry food, unlike the other types of solar cooker. These cookers work like the burner on an LPG stove. Dr. Dieter Seifert developed a series of very efficient cookers of this type that are now in use around the world. Wolfgang Scheffler designed an 11-square meter reflector that concentrates intense solar energy onto an area about 30 centimeters in diameter. It is used for solar cooking on an institutional scale. (Figure 3)

Figure 3 Scheffler cooker (*photo: Heike Hoedt*)

The third and most recent design is the panel cooker. Its major features are low cost and increased portability, as the panels are hinged and can be folded up. Invented by Dr. Roger Bernard, it was initially adapted by Solar Cookers International for use in refugee camps. A commercial model developed by Solar Household Energy, Inc. is now available. In this model, called the HotPot, a black steel cooking pot with a wide flange is suspended inside a transparent glass bowl with a space of 1.3cm between the two. This assembly is covered with a glass lid and placed in front of a foldable reflector designed to deliver solar energy through the glass bowl to the black pot. The resultant heat is retained between bowl and pot by the pot's flange (Figure 4).

Figure 4 HotPot panel cooker (*photo: Christine Danton, SHE Inc*).

Fuel briquettes from wastes

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Background

More than two billion people globally use biomass for cooking food. Smoke from burning biomass is one of the fourth leading causes of death and disease in the world's poorest countries (WHO, 2002). We are both suffering from indoor air pollution because of excessive use of fire wood in traditional stoves, whilst heavily depleting forest, converting it into deserts. The time is right for creating sustainable livelihoods in rural communities, through providing options to the traditional cooking habits of the people in Nepal which are incompatible with natural resource management, and are ineffective, costly and unhealthy.

The Foundation for Sustainable Technologies (FoST) has introduced a wide range of easily applicable, sustainable technologies to meet the daily needs of the urban and rural communities in Nepal. Due to shortages in kerosene, liquefied petroleum gas (LPG) and fire wood, resulting in substantial price rises, people are experiencing hardships in purchasing fuel. Since 2002, FoST has been designing, developing and disseminating sustainable technologies to relieve such hardships in a cost-effective way. *The process described in this article was demonstrated during the Sustainable Resources 2004 Conference in Colorado by the Legacy Foundation (see BP 49, 2003). FoST has taught this method to 60 women in the villages of Gamcha, Matatirtha and Machhe Gaon in Kathmandu in 2005. Of the 60 women trained under the programmes, one third of them have started producing briquettes for their use (Figure 1). FoST has interacted with the briquette producers in these villages to form a briquette cooperative in each village in order to run the briquette businesses smoothly.*

Figure 1 Women displaying a tray of briquettes (photo: FoST)

Availability of raw materials

According to the Solid Waste Management and Resource Mobilization Center of Kathmandu, there are about 600 tonnes of waste generated in Kathmandu and Lalitpur districts each day. The wastes contains 3% clothing, 4.5% construction materials, 8.5% paper, 9.5% plastic, 2.5% glass, 70% organic and 2% others. A briquette business using only paper wastes will have about 20,000 tonnes of raw materials in a year from which 16,000 tonnes of briquettes can be produced without mixing any other materials as binders. If sawdust is added in a 20:80 ratio, 100,000 tonnes raw material is available, which produces about 80% of this weight in finished products. Ultimately, ash produced from burning briquettes is used in enriching soil in farming. This activity generates lot of employment opportunities in the urban cities, reduces outdoor air pollution from burning the paper wastes, reduces garbage problems, minimizes possibility of blocking drains, reuses and recycles paper wastes into energy efficient fuel, and minimizes costly cooking fuels – kerosene and LPG.

The above data does not cover paper wastes generated by the publishing houses, printing presses, government and donor offices, or trading houses, because they are mostly collected by the scrap traders. So, there is an abundant source of paper wastes in the capital that is more than enough to set up a major briquetting plant in order to meet growing demand for alternative fuels in the Kathmandu Valley and also to create jobs.

An alternative energy source

Fuel briquettes are treated as an alternative energy source for household use. They are made from grass, leaves, saw dust, rice husk and any type of paper, all of which are compressed after processing in a lever press into the required sizes. Unlike charcoal, these fuel briquettes are made without polluting the environment, they are environmentally-friendly as they utilize waste materials (Figure 2). They provide an energy-efficient and cost-effective alternative energy source for cooking, water heating and room heating. *The briquettes can be used in any of the fan-operated stoves available in the market to reduce smoke. Using a gasifier stove is even more efficient*

Figure 2 Environmentally friendly drying of briquettes (*photo: FoST*)

Figure 3 Heavy-duty gasifier stove for cooking and room heating (*photo: FoST*)

than the fan-operated stoves to reduce indoor air pollution in the kitchen. This type of stove costs Rs.1200 to 1500 per stove.

Cost effectiveness

There are various types of briquettes produced in Nepal, mainly of two types: log briquettes from rice husk and bee-hive briquettes from charcoal. Log briquettes cost Rs.16 per kg, whereas bee-hive briquettes cost Rs.36 per kg. The briquettes from wastes described in this article cost Rs.12 to Rs.16 based on estimated wages of Rs.80 per day for women in the villages and paper waste costing Rs.4 per kg, dung Rs.2/kg, saw dust Rs.3/kg, and biomass (agri- and forest residues) Rs.2/kg. For cooking purposes, the average family of 4–6 people would need about 1.5 kgs briquettes in a day, which costs about NRs.22. If they used kerosene, they would need 750 ml – costing about NRs.38, and for gas they would pay NRs.32 for about half a kilogram. Thus communities see these new fuel briquettes as an environment-friendly, easily applicable modern fuel, and a good technology for generating employment in the community level.

Skills' training

No prior technical training is required other than a basic knowledge of accounting for starting the business. The process is one that rural women in the community can easily learn, and the briquettes can be used initially for cooking food, and subsequently for income generation once their skills are sufficiently developed. To date, the project has targeted deprived women of all ages, particularly those in the villages who have dropped out of education. Once they are trained at FoST, they will be the trainers in their locality.

Raw materials

There are plenty of sources for the necessary raw materials in the cities and in the rural areas to start a business locally. If the paper wastes are not sufficient in the villages, entrepreneurs can buy them in nearby cities or from scrap traders. Similarly, sawdust and rice husk or grasses are usually available locally or in surrounding villages.

Potential markets

There are plenty of potential markets for fuel briquettes in the cities and in the rural areas (Figure 4). The potential customers for the briquettes are initially the producers themselves, secondly, kerosene and LPG users, local small businessmen, tea shops, restaurants, thirdly, pop-corn bakers, barbeque stalls, trekking lodges, resorts, picnic spots, departmental stores, trekking stores, highway restaurants, boarding schools etc.

Once the women groups are trained on briquette making process, they will be able to produce briquettes by using their own resources first, later collecting wastes from their neighbours and from other surrounding villages and cities. There appears to be a ready market for the briquettes, and the women themselves test the products and improve the quality to bring it to the market and make profitable business.

Figure 4 Briquettes for sale (*photo: Fost*)

Impacts of the programme

- Proper use of household and agricultural wastes for producing fuel briquettes
- Paper waste will be well utilized in an economic way
- Consumption of costly kerosene and LPG will be heavily reduced
- Fire wood consumption at household level will be reduced
- Financial companies and cooperatives will be more active with the increased number of micro-enterprises based on briquette business
- A healthy environment in the villages and in the cities through proper management and earning from the waste can be achieved
- Less possibility of getting fire when cooking because of more controlled flame
- Reduction of indoor air pollution making the family free from smoke-borne diseases.

FoST believes that such a briquetting technology, which is new to Nepal, will spread rapidly as a small industry throughout the environs of the Kathmandu Valley and beyond to meet the daily energy needs for cooking in a cost-effective way. The small level of support for transferring the technology at community level will play a vital role in improving the quality of life for people in the rural areas.

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Charcoal making from agricultural residues

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Charcoal making

Traditionally, charcoal is made from forest wood cut into pieces and partially burnt. However, charcoal can be made from agricultural residues such as stems and twigs that would otherwise be left in the field and burnt away as waste. Some of the common crops whose stems are suitable for charcoal making are soyabean and red gram. Any kind of wood can be used to make charcoal. However, if softwood is used, it will make soft charcoal and therefore burn more quickly. Also, the method used for softwood would not be applicable for hard wood as the latter is denser and tends to burn slowly. The process described in this article is one that uses the heat given off from the wood or residues as it becomes charcoal to make the charcoal itself. The rate of combustion is controlled by regulating the amount of air allowed into the burning chamber, and when all the volatiles have been given off and the charcoal itself begins to burn, the process is stopped by keeping out all the air. This process is developed from the age-old method used by colliers to make charcoal in a pit, pile (clamp) or, more recently, in metal or masonry chambers (kilns).

In this direct burning process of converting agricultural residues, the charcoal produced weighs about 20–25% of the weight of raw material. Many factors are responsible for the quality and yield of the char, such as initial moisture content, composition of the biomass, and ambient temperature and humidity. The resulting charred biomass generally consists of small black pieces of very lightweight and low density charcoal which are compressed into briquettes. The charcoal burns hot and clean; and it can be easily ignited.

The combustion process

When wood is burnt in the open, with an adequate supply of air, its constituents, mainly, carbon, hydrogen and nitrogen, get oxidised, giving out heat and light. The smoke consists of volatile and particulate matter. The resultant product of such uncontrolled combustion is generally ash, which is rich is potassium carbonate. Charcoal is made when the fuel is not completely burned – called *incomplete combustion*. In this process, all the volatile matter in the woody matter is driven out and only carbon, in the form of charcoal and a small quantity of ash, is retained.

When woody matter is heated to a temperature of 259°C or higher, it decomposes to yield gases, vapours and solids. Incomplete combustion of wood is achieved by restricting the supply of air, and volatile elements are driven off as smoke. The smoke consists of non-condensable gases and condensable vapours. The principal gases are carbon monoxide, oxygen and nitrogen. The vapours are water-acids, alcohols, tars, oil and other organic compounds. A small amount of these gases and vapours remain in the charcoal. Controlled and proper burning of the woody matter can yield charcoal comprising 75% to 95% of carbon. With the escape of most of the gases and vapours in the smoke, a charcoal fire is a clean, efficient and safe source of heat, both from the environment and health points of view. Conversion to carbon starts at a temperature of 250°C: in the case of fire where the air is not controlled, the temperature may rise to nearly 400°C and carbonisation and subsequent conversion to ash is very rapid.

Construction of a charcoal kiln

In designing the kiln, both the requirements of a controlled rate of combustion and the need to stop the process when all of the agricultural residues have been converted to char have been addressed. The charcoal kiln consists of a cylinder made of mild steel (ms) sheet or modified from a ready-made oil drum. The schematic is shown in Figure 1. At one end the cylinder, an L-shaped chimney is formed from two pipes of diameter 100 mm, joined at an elbow and attached close to the top. The other end of the cylinder has a fixed lower half and the upper half is a hinged door. The lower half of this end has a small opening of 50 mm diameter to accept a bent pipe, which serves as the air inlet for the lower portion. The 50 mm bent pipe has a number of holes drilled along it, and this perforated section is pushed some way into the kiln to permit the entry of air into the fuel mix (see Figure 2). The other end is bent away and juts above the surface of the soil when the kiln is buried, as described below.

The whole unit is buried in soil so that only the chimney and the air inlet pipes jut out. In this manner, the unit

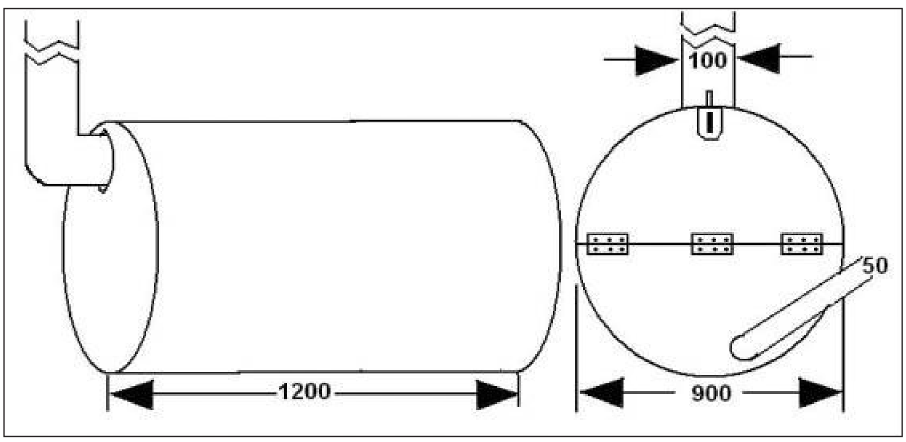


Figure 1 Schematic drawing of charring kiln for agricultural residues (dimensions in mm)

Theme

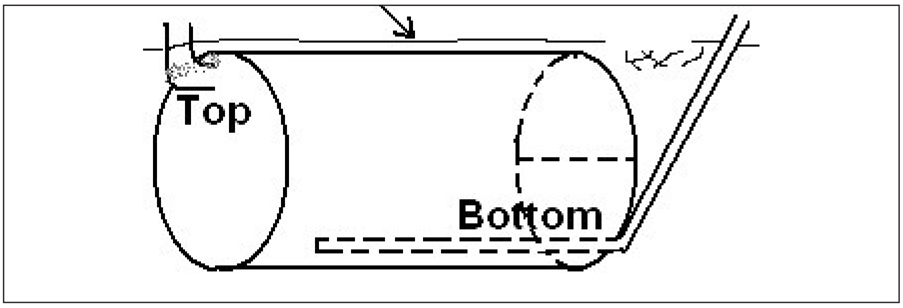


Figure 2 Schematic of the kiln buried ready for use

is insulated from all sides and the heat of combustion is conserved to a large extent. After burying the unit, a small slope is made on the hinged side so that the hinged door can be opened for easy feeding of raw material; this is left unfilled. The unit is ready for making charcoal out of agricultural residues. Wherever it is not possible to weld in the pipes (e.g. lack of electricity), it will suffice to make the holes using a chisel and hammer into which the pipes are pushed. To prevent leakage of air, the joint may be covered with thick mud paste. Since the whole unit is buried, problems of air leakage and over burning of the soft wood are minimised.

Some of the exposed portions of the kiln may become very hot and caution must be exercised to avoid burning one's hands and feet. The chimney should be extended to a height of 1500 to 1800 mm above the ground so that the operator is not directly exposed to the smoke emitted by the kiln. The extension pipe is made detachable so that the outlet can be covered once the burn process is completed. A spade with a long handle is needed to unload the charcoal once it is ready in the kiln.

Figure 3 Initial burning of waste in the kiln (*photo: CIAE*)

Loading and firing the kiln

Agricultural waste in the form of dried stems and twigs are collected and kept ready. The semi-circular door on one side is opened and a small quantity of the agricultural waste is pushed into the kiln so as to cover the whole length. A piece of flaming paper or grass is lit and pushed into the kiln so that the material catches fire and starts burning. This is allowed to burn till all the material turns into red hot embers. This state is shown in Figure 3.

At this point, additional material is pushed into the kiln with the help of a stout pole till the drum is completely filled. It will be seen that the kiln starts to emit thick white smoke indicating the escape of volatile gases in the raw material. The hinged door is now closed and the kiln left to burn away the material inside it. Since the door is not fully airtight and the small air inlet pipe also allows some air into the kiln, air is available for the combustion process to continue, which can be seen from the smoke coming from the chimney.

For a fully loaded kiln with agricultural residues derived from red gram stems, it has been found to take between 90 to 120 minutes for complete conversion of the biomass into char. The right time for stopping the combustion process is determined from the colour of the smoke from the chimney. As the material inside the kiln burns away and the volatile matter escapes away as exhaust, the colour of the smoke turns from white to grey and then to black gradually. This state is shown in Figure 4.

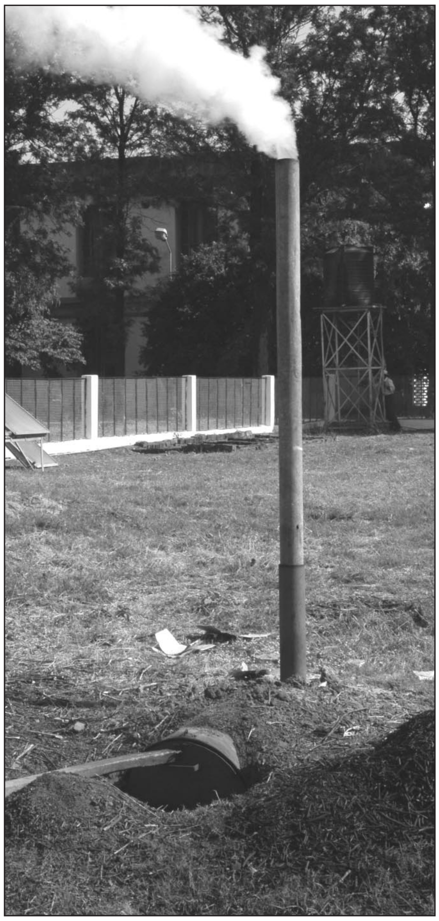


Figure 4 Fully loaded kiln giving white smoke (photo: CIAE)

Stopping the process

It is necessary to have about 2–3 bags of sand for this operation, and the same amount can be held in reserve nearby. Insulated gloves are also needed. When all the material inside the kiln gets converted to red hot embers, the smoke completely vanishes and only colourless convection of hot gases can be seen. At this stage, all entry of air into the kiln is stopped. Firstly, the sand kept near the feeding end is pushed with a spade to cover the opening completely. The sand seals off the closed semicircular lid. The extension to the chimney is removed with the help of insulating gloves and the open end is closed with a slab of stone or a lid made especially for this purpose. The small air inlet pipe at the feed end is also closed off in a similar way. Thus the whole kiln is made airtight. If there is a leak around the kiln, all the material will turn into ash. It is left to cool for 5–6 hours. It is advisable not to open the kiln to remove the material whilst it is hot, as hot char may catch fire and cause accidents. After a few successful runs, it is possible to judge and operate the kiln without any difficulty. Sometimes, it may be necessary to chop the twigs into smaller pieces for easy feeding.

Char from the kiln

The woody content of dry agricultural residues contains about 50% carbon, and 15% moisture. In some cases, it may be drier. The remaining matter is unwanted tar, alcohols, lignin etc. Even when the kiln appears to be fully filled, there will be lot of space around the pieces of fuel. Therefore, after complete conversion, there will be considerable reduction in volume, as the long twigs will have crumbled to smaller pieces. Even after a successful burn, there will be a small portion that has been converted to ash and also some woody mass in the corners that did not get enough air or heat to convert to char. These can be separated at a later stage. Some of the charcoal will have turned to powder. These products are quite acceptable. The charcoal produced in this way is shown in Figure 5.

Briquettes

The charcoal produced in the above process is of very low density and very brittle with large quantities of powdery material. It does not burn efficiently or produce much heat in a stove in this state. Therefore, it is necessary to convert it into briquettes of a suitable size and shape with reasonable density. The charcoal obtained by the above process is ground to a powder using a small grinder. A *bonding agent* is needed to make the briquettes stick together, and this can be boiled starch or fresh cow dung. Starch is preferable for a more smoke-free fire, whilst fresh cow dung as bonding agent creates slight smoke during the initial 8–10 minutes. Nevertheless, cow dung is locally available and the briquettes are less smoky than the cow dung cakes used by the villagers for cooking. It has been found experimentally that no more than 5% by volume of binder is sufficient for adequate bonding that withstands handling without crumbling. Briquettes are made using a screw type extruder to which the char and binder mixture is fed gradually. A flow chart of the briquette making process is shown in Figure 5.

The wet briquettes are laid out in the open sun to dry out completely. Depending on the weather, it may take two to three days to dry all the way through. Thus no charcoal is wasted in the drying process, and the resulting briquettes have high calorific value. The briquettes thus produced are quite convenient and occupy considerably lower volume than the original agricultural residues.

Acknowledgements: The authors are grateful to the Director, Central Institute of Agricultural Engineering, Bhopal for the facilities provided to undertake this work.

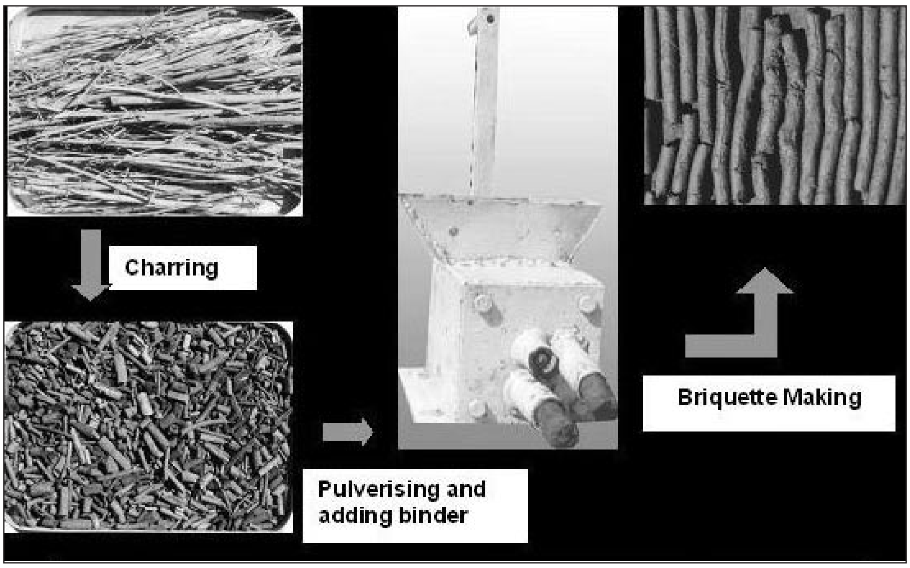


Figure 5 Flow chart of the charcoal briquette-making process

Theme

What's happening in household energy?

HEDON

Nepal's first CDM project

A project that is bringing clean, efficient energy to rural communities in Nepal is Nepal's first under the Kyoto Protocol's Clean Development Mechanism, which allows industrialised nations to offset some of their emissions by investing in clean energy projects in developing nations. The Nepal Biogas Project promotes the use of underground digesters that use bacteria to generate methane gas from cattle dung. Using methane instead of wood or kerosene to power stoves or lamps can reduce a household's greenhouse gas emissions by five tonnes a year. Under an agreement signed on 3 May 2006, the World Bank's Community Development Carbon Fund will pay Nepal US$7 per tonne of avoided emissions to reduce them by one million tonnes over the next seven years by increasing the use of biogas units.

The money will be used to build more digesters, which will be sold for no profit to poor households. Since 1992, the project has constructed 145,000 biogas units and aims to install about 83,500 more units by 2009. The project will bring additional benefits by attaching latrines to the biogas units to improve sanitation. Farmers will be able to use the residual material from the digesters as a fertiliser, and women and children will not have to collect as much firewood.

Source – SciDev: http://www.scidev.net/News/index.cfm?fuseaction=readNews&itemid=2852&language=1

Need for support to tropical forestry

The largest ever survey of tropical forests released in May 2006 by the International Tropical Timber Organization (ITTO) indicates that 95 per cent of tropical forests are unprotected or not being managed sustainably. Of 353 million hectares of forest earmarked by governments for sustainable timber production, only 25 million are actually being managed sustainably, says the report. It adds that governments have enacted management plans for only 2.4 per cent of the 461 million hectares of forest that are supposedly protected. The report urges the international community to create incentives for tropical nations to protect their forests.

Trees contain and absorb vast quantities of atmospheric carbon dioxide – the main greenhouse gas. The Coalition for Rainforest Nations wants international carbon trading schemes to include payments to countries that preserve their forests. The Association for Tropical Biology and Conservation, a scientific society with 1,200 members in 70 countries, has officially endorsed the call. On a more positive note, the ITTO report says that sustainable management of forests has risen from one million hectares of tropical forest managed sustainably in 1988 to 36 million hectares today.

Source – SciDev: http://www.scidev.net/content/news/eng/report-urges-rethink-on-value-of-forest-resources.cfm

New energy journal to be launched

The *International Journal of Energy Sector Management*, to be launched in 2007, will be a peer-reviewed, interdisciplinary international platform for disseminating results of research related to and/or relevant for the management of the energy sector.

The journal aims to focus on holistic, applied research on energy sector management and to disseminate practical solutions of difficult decision-making problems by providing a common forum for wider interaction, information sharing and publication of relevant applied research, thereby trying to bridge the gap between industry and academia.

The journal is scheduled for launch as a quarterly journal in 2007 and is seeking contributions in terms of full papers, short notes, case studies, industry insights, and papers from doctoral theses for publication in the journal. Please refer to the Journal Statement, Author Guidelines, and paper review guidelines, available at http://www.hedon.info/goto.php/view/224/library.htm, for additional information on the scope of the journal, manuscript preparation and paper review process.

Submissions should be sent, preferably by email (for email address go to HEDON website), or by post to Ms Vicky Williams, Managing Editor, Emerald Group Publishing Limited, 60/62 Toller Lane, Bradford BD8 9BY, United Kingdom.

The 5th Better Air Quality (BAQ) workshop September 13–15, Yogyakarta, Indonesia

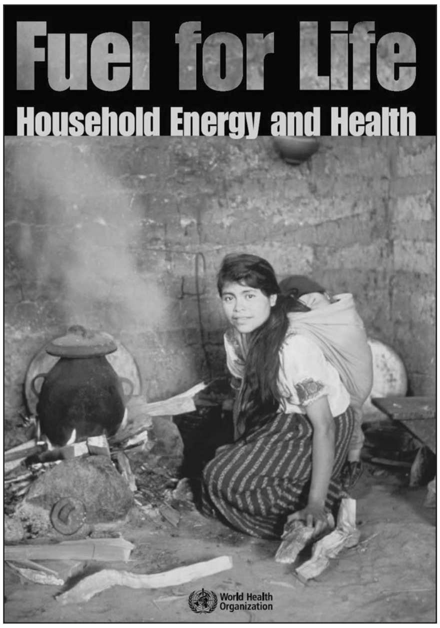
The 5th Better Air Quality (BAQ) workshop will be held 13–15 September 2006 in the historic city of Yogyakarta in Central Java, Indonesia. The theme of BAQ 2006 is called a "Celebration of Efforts" to highlight the success stories that Asian countries, cities and communities have achieved over the last years in addressing air pollution while at the same time highlighting the efforts that are still ahead in improving air quality in Asia. *Source PCIA website: http://www.pciaonline.org*

Further information: http://www.baq2006.org

Publications

Fuel for life: household energy and health
Eva Rehfuess

This new publication gives an overview of the health impacts of indoor air pollution from solid fuel use and describes solutions to promote health and development in the context of the household energy challenge. Innovative policy approaches and a rigorous acceleration of investments is needed now to save lives and enable development.



The publication concludes with the following key points:

- Cooking with wood, dung, coal and other solid fuels is a major risk factor for pneumonia among children and chronic respiratory disease among adults
- To halve, by 2015, the number of people without access to clean fuels, 485 000 people will need to gain access to modern energy services every day for the next 10 years.
- Health and productivity gains can more than pay for lifting people out of energy poverty. For example, investing US$ 13 billion per year to halve, by 2015, the number of people worldwide cooking with solid fuels by providing them with access to liquefied petroleum gas shows a payback of US$ 91 billion per year.
- Taking household energy solutions to scale will overcome a major barrier to achieving the Millennium Development Goals. Improved household energy practices promote education, empower women, save the lives of children and their mothers and benefit our forests and our climate.
- Evaluating the impacts of household energy projects and programmes will shed light on how different technical solutions could be fine-tuned to maximize their health, social and environmental benefits. Learning from their experience will provide a recipe for putting into action successful, large-scale programmes.

The book is available at no cost on line at:
http://www.who.int/indoorair/publications/fuelforlife/en/index.html

Printed copies can be obtained from:

World Health Organization 2006, ISBN 92 4 156316 8, CHF 15.00/US$ 13.50

In developing countries: CHF 10.50/US$ 9.45, Order no. 11500665

To order a copy, please contact: World Health Organization, WHO Press, 1211 Geneva 27, Switzerland, Tel: +41 22 791 3264, Fax: +41 22 791 4857, Email: bookorders@who.int or order on line at http://www.who.int/bookorders

Disease Control Priorities in Developing Countries – chapter: Indoor Air Pollution
Nigel Bruce, Eva Rehfuess, Sumi Mehta, Guy Hutton, and Kirk Smith
The second edition of this major work (DCP2), written by more than 350 specialists in diverse fields from around the world, provides the results of in depth research and analyses, and proposes policy recommendations to reduce significantly the burden of disease in developing countries and to improve the quality of life for all people. The chapter 'Indoor Air Pollution' can be downloaded from the web: http://www.dcp2.org/pubs/DCP/42

Disease Control Priorities in Developing Countries (2nd Edition), ed., 793–816. New York: Oxford University Press. DOI: 10.1596/978–0–821–36179–5/Chpt-42.

Electricity Services in Remote Rural Communities
The Small Enterprise Model
Teodoro Sanchez
This book describes an innovative model for the organization of electricity services, developed and tested by Practical Action as part of its research and development into access to electricity services in remote rural areas and the sustainability of these services.

This small enterprise model was designed with the clear objective of ensuring efficient financial and technical management to take into account the social and economic environment, and to encourage the committed participation of the community. The concept of private management is introduced, where a micro-enterprise is responsible for the running of the system and receives payment in exchange for the management of the service.

To date, the model has been piloted in five small hydroelectric plants in the north of Peru, with very positive results. It is proposed that this model could also be used successfully in other energy-generating systems (diesel, solar, wind-powered) with only minor changes.

This book will be of interest to all stakeholders in rural electrification: rural electrification organizations at government and private level, researchers on sustainable energy, implementers of rural energy schemes, policy makers, and also students and teachers of courses related to rural energy.

ISBN 1–85339–620–6, ITDG Publishing GBP £17.95, USD $31.95, Euro €24.95, Paperback 104 pages, 234×156mm. Available at 10% discount from
www.developmentbookshop.com

Energy news from Practical Action

Boiling Point now and into the future

Liz Bates, Practical Action, Schumacher Centre for Technology and Development, Bourton on Dunsmore, Rugby CV35 9HP, UK.

In 2004, Boiling Point sent out a survey to every reader. This was partly to see if the high cost of sending out print copies was -effective, and partly to see how people felt about the journal. Each edition contained a single two-sided questionnaire and an envelope – so those choosing to return the form had to fill in the form and put postage on the envelope. Filling in the form was intended to take around ten minutes maximum.

Of those who responded, 54 were in the North and 108 were from the South. At present these audiences receive a printed copy of the journal and the readership was asked whether they could access it electronically. A summary of the survey results is presented in Table 1:

Table 1 Access to electronic versions of *Boiling Point*

Question (Total population: 162)	No answer	Yes	No
Do you need a printed copy of BP because you don't have access to a computer?	30	North: 4 South: 51 Total: 55	North: 35 South: 42 Total: 77
Could you download PDF files sent to your email?	30	North: 35 South: 20 Total: 55	North: 7 South: 70 Total: 77
Would you find a searchable CD ROM version acceptable?	33	North: 21 South: 44 Total: 65	North: 15 South: 49 Total: 64
Do you have access to the Practical Action website from which to download Boiling Point?	31	North: 36 South: 29 Total: 65	North: 7 South: 59 Total: 66

This sample suggests that although several readers (particularly in the North) are able to access the information electronically, roughly a third of the readers have no access to computers and would not benefit from receiving information electronically – these are primarily Southern NGOs, CBOs and government bodies.

Readership

The respondents were asked to classify their organisation by a tick-list and it was noted that a high number of respondents were either from NGOs or from academic institutions. The number of academic institutions does not mirror the general readership that is largely NGOs and CBOs – who are also well represented, as shown in Figure 1. It could be argued that the high number of academic institutions taking the trouble to answer the questionnaire is a good indicator of the interest that Boiling Point generates in universities and colleges.

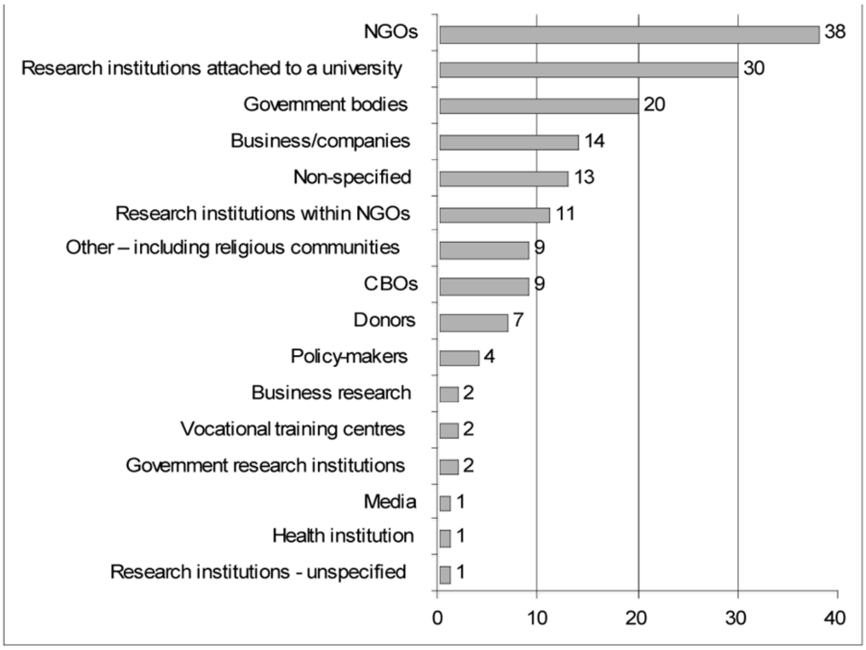


Figure 1 Institutions responding to the survey

Of the 106 responses which provided data on the number of people reading the journal, a surprising number suggested that more than 10 readers per copy; this probably reflects the high number of academic establishments responding to the survey who wrote down the numbers of students with access to the journal.

Comments

Perhaps the most interesting part of the survey for an editor was the diverse comments coming from our readers. The most negative responses we received were; 'Please discontinue my subscription' and 'People don't read English'. On the positive side, there seem to be a strong feeling of ownership and desire for the journal.

Technical & socio-economic articles:

- When designing a cookstove I had to go through many issues to see if a better design could have been produced to avoid duplication

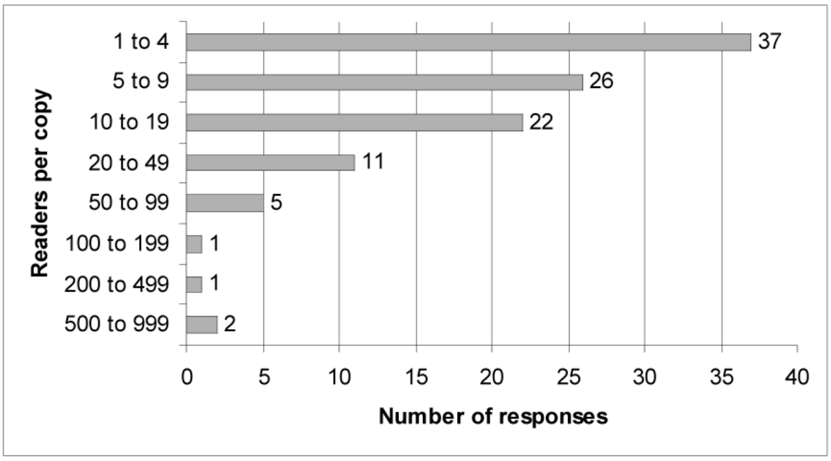


Figure 2

- Explanations accompanied by illustrations. Vast case studies that have a bearing on many other situations and a number of lessons to be learnt by the reader
- . . . have helped me to fabricate a briquetting machine for converting charcoal wastes into briquettes
- BP was helpful during our work on Economic Analysis of Rural Pollution in Northern India
- Experts on rural women affairs and rural development technology read it
- Articles related to gender / women and energy have been used / circulated amongst network members
- Practical articles [. . .] provided information of value to resource-poor farmers visiting the information centre
- We need a hard copy to show people who visit our facility that efficient stoves are real and air quality is a world problem, not something we are making up
- The new ideas, case studies and the resources it mentions. I prefer the print version because I share it with volunteers who don't have access to computers. It lacks colourful pictures, but we understand about the cost. We often make copies of articles and use them in our training events and also share with Moroccan counterparts
- We have used BP to answer practical questions from our farmers
- We pass the information on to our grassroots partners in developing countries. BP is a resource tool for us to share with our partners

On readership

- The research and training unit library which is my responsibility services a number of programmes. Most are rural based or remote and they look forward to the Boiling Point magazine
- I copy articles for partners in rural areas in East Africa who have no access to internet nor fax, sometimes I would have more articles for illiterate women in villages, even a poster for a women's group how to do this and that
- I pass the printed copy around to workers in our organization that do not have computer access
- We have an information centre of technology. Maybe 5–10 persons read our copies
- Over 500 people as it is placed in a library
- 1300 people for reading of Boiling Point
- All 13 staff of my NGO with a multiplying effect of 5

Future plans

As those of our readers with computer access will know, the HEDON Household Energy website (www.hedon.info) provides a wealth of information on household energy. In the future, Boiling Point will not only deliver the same quality of information in the paper edition, but will have the following additional features:

- An electronic version of the journal distributed to those who would prefer this format
- An online interactive version of Boiling Point articles as part of the HEDON Knowledge Base, allowing everyone to make comments and suggestions on the articles.
- The articles will also be linked to the author's profiles and other relevant documents and projects on the site.
- For those without web access, there will be a section in the subsequent issue of Boiling Point for comments and feedback and news from the household energy community

HEDON is committed to reaching those without access to computers as well as those who can use the web. This is a time of transition, and as editor for the past few years I would urge everyone who enjoys *Boiling Point* to think about what they can do to make it even better in the coming years. If you have not written for the journal before, then why not disseminate your work to a worldwide audience.

If you have used the journal in the past in one of your projects, why not write a letter to the new editor describing what has been achieved.

Additional funding is always welcome as sending it out at no cost is very expensive indeed.

Boiling Point has been going now since 1982, with ongoing support from both Practical Action (then ITDG) and GTZ. I would like to sign off by wishing HEDON every success, and paying tribute to the original editor Ian Grant whose vision and dedication led this journal from two pages of A4 paper stapled together in the corner into a journal very similar to today's version.

directly and inefficiently, leading to fuel wastage, poor indoor air quality, and significant health risks.

In the early 1980s, biomass shortages led to the development, through the government-based National Improved Stove Program (NISP), of fuel-saving stoves that focused on more complete combustion (Figure 1). To achieve better performance, NISP staff made several changes to conventional stoves:

- lowered the combustion chamber and decreased its volume
- reduced the size of the stove door
- added a grate
- added a flame baffle
- added a smoke-recirculation duct, air duct, and chimney.

They found that when the height of the chimney was more than three meters, they achieved thermal efficiencies of 30% or more based on simple water-boiling tests. However, recent research indicates that these efficiency rates may not be consistent across fuel types and may not have held up over time (Sinton et al).

As NIPS progressed, a semi-fabricated approach was adopted to improve the performance of hand-built stoves. A standardized cast iron secondary air ring could be purchased and installed by a trained technician into the hand-built stove body. This further improved performance: for example, 1.9 kg firewood could heat 35 kg of water in 28 minutes with a thermal efficiency of 39% during the temperature rising phase. Today in rural areas, several types of household stove combustion units can be purchased and installed in hand-built bodies. One of these models, the NG-1, won the golden price at the 1985 World Expo in Tsukuba, Japan.

This successful programme, run by the Minister of Agriculture, was responsible for installing energy efficient stoves in 60 to 80% of rural households, raising national awareness of the need for cleaner household energy solutions, and creating regional and local infrastructure for an improved stove industry. While NISP has been less active in recent years, there are government and multilateral initiatives to promote sustainable rural development and improve living conditions in more remote rural areas.

Stove commercialisation

Chinese stove entrepreneurs are now designing highly efficient biomass stoves that employ densified, compressed, or *pelletized* fuels and *gasification* technologies (Figures 2 & 3); (gasification is when the gases in solid fuel are driven out of the fuel and these gases are burnt cleanly to produce the heat.) These innovations are driven and financed by a stove industry that is successfully selling more than 10 million improved cookstoves annually, in areas that are becoming more urban, and where standards of living are rising. The industry is worth 240 million RMB ($29.6 million US) and growing at rate of 10% per year. Currently 90% of its revenue comes from coal stoves, but some innovative manufacturers see the opportunity to increase the sales of biomass stoves.

Figure 2 Luoyang gasifier stove installed in kitchen (*photo: CEIDH*)

Some Chinese companies have now developed a range of cast iron gasifier and semi-gasifier biomass stoves. Biomass fuel is converted to gas fuel, resulting in greater fuel quality and efficiency. Theses stoves have thermal efficiencies of 65%–80%, and their emissions have been tested using the Ringelmann test (which compares the darkness of the smoke against a standard scale). This test shows that the smoke density is less than 50mg/Nm^3 and thus they meet the strictest environmental protection standards in China. Due to the current government emphasis on sustainable development, it can be highly beneficial to the company's reputation, brand, and image to develop low-emissions stove technologies, and 60 000 units are currently manufactured annually.

Despite these significant gains, millions of poor rural households, especially in western China, continue to use inefficient stoves that emit health-damaging pollutants. The scaling up of production, marketing, and distribution of new biomass stove technologies targeted to this market segment is key to improving health and well being in rural China.

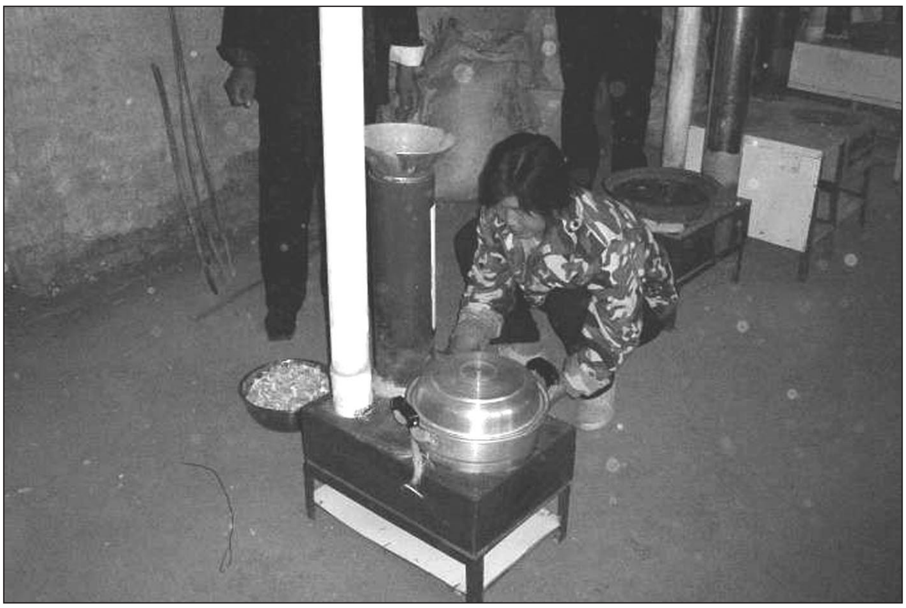


Figure 1 Improved non-gasifier stove being tested in factory (*photo: CEIDH*)

Theme

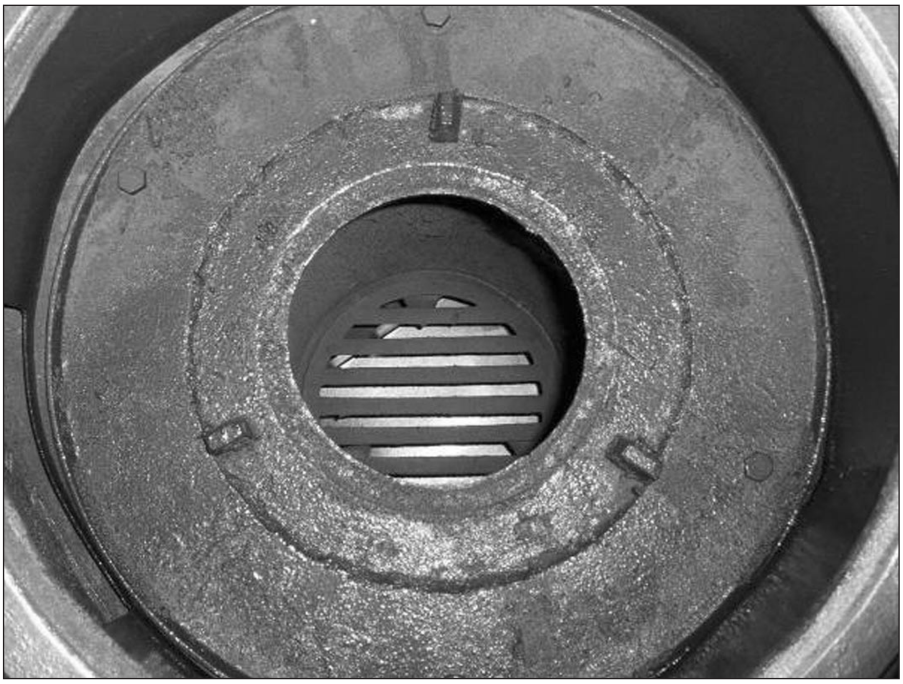


Figure 3 Looking down into the cast iron combustion chamber (*photo: CEIDH*)

Fuels for stoves

The stoves with the lowest emissions and the best gasification results burn either block-pressed or pelletized biomass fuels, which provide a more uniform feedstock than raw biomass. The cost of the block-press biomass cubes or briquettes is about RMB 250 per tonne ($30), while fuel pellets average 400 RMB per tonne ($50), depending on the region. Since these fuels are more expensive than unprocessed biomass, they are currently only affordable to wealthier farmers. However, these fuels are generally cheaper than coal, which costs approximately 500 RMB per tonne ($62) and, like coal, they can be used for heating the home in winter, as well as for cooking throughout the year. The distribution networks for these processed biomass fuels are currently limited, but production and distribution are both expected to expand rapidly, creating better availability and lower prices.

Some manufacturers are targeting less affluent farmers with gasifier stoves designed to burn unprocessed fuel such as twigs and straw. The farmer cuts the fuel into segments before feeding it into the stove. The gasification efficiency of this kind of stove in laboratory tests is more than 60%, with thermal efficiency of 45%. Although these stoves do not emit dark smoke, their total emissions of small particles and other unhealthy pollutants has not yet been established under field conditions. These stoves have yet to be manufactured and marketed on a large scale.

Current challenges to spreading innovation and adoption

While the need for the clean household energy provided by gasifier technology is great, there are currently significant barriers to dissemination and adoption.

- The producers of gasifier technologies are primarily smaller companies with limited resources. They lack the capital and management capacity to expand production and distribution over a vast geographic area.
- Rural populations are not aware of the importance of indoor air quality to human health. They lack familiarity with these stoves and do not recognize the need for cleaner burning technologies. This need will only be turned into demand once the dangers are understood.
- The ease with which a person can use the stove on some household biomass gasifier stoves still needs to be addressed. Stove producers need to conduct additional research to identify consumer product preferences. Stove design standards would ensure that the industry achieves uniform product quality.
- The transportation and commercial infrastructure in rural areas does not easily support stove distribution.
- Facilities for producing pelletized or briquette fuels need to be established in areas where such stoves are to be sold.
- The industry lacks channels for distributing advanced stove technologies in other developing countries

Future partnership activities

In the final phase of the project, Phase 3, the project will focus on building the capacity of the winning enterprises and promoting the award-winning stoves outside of China. It will aim to identify market and export opportunities for these stoves elsewhere in Asia, and in Latin America and Africa. Currently evaluation of potential markets in Asia is underway. The first venue is India, where indoor air pollution is widespread and where there are a number of ongoing programmes which might benefit from a Chinese stove in the growing portfolio of improved biomass cookstoves.

This project is intended to serve as the pilot for a permanent award programme that would stimulate ongoing innovation and highlight to governments and the public the important role that cleaner-burning stove technologies play in sustainable rural development and improved quality of life in rural communities. In China, the programme could also be expanded to other energy products, such as household coal stoves.

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Theme

Pollution factors affecting health and safety in rural Zimbabwe

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Background

Households in developing countries are characterised by the use of inefficient and polluting energy sources. The implications of such on the health and safety of family members in rural households is rarely explored with the commitment it deserves.

Smith (2002); Cecelski (2005); Mishra (2003) and Charron (2005) are some of the scholars who have written on indoor air pollution. Charron (2005:12) draws attention to the fact that indoor air pollution is now rated by the World Health Organization as the second most dangerous environmental health risk in rural areas (after dirty water and poor sanitation).

This article is based on qualitative fieldwork done by the author in rural areas of Zimbabwe from September 2005 to the end of January 2006. The study was done to examine energy consumption patterns in rural Zimbabwe, as part of a project on rural electrification and its impacts. The rationale behind the study was to find out the knowledge, attitude, behaviour and practice of rural people in Zimbabwe with regards to issues of indoor air pollution within the context of energy consumption. This was based upon the reasoning that the *way* people consume household energy has a bearing on indoor air pollution. Pollution levels were not monitored scientifically.

Indoor air pollution in Zimbabwe is an area that is largely ignored and understudied compared to other health risks. Consequently occupants of rural households in Zimbabwe are inhaling large amounts of polluted air in kitchens and bedrooms; far above the recommended WHO levels.

The participants of the study were drawn from rural children (aged above 10 years); rural women and men; rural health workers; community leaders, policy makers and workers in the energy; health, environment and development sector. It examined energy consumption patterns in rural Zimbabwe, as part of a project on rural electrification and its impacts.

Research design

Various qualitative methods were used in this research:

- In depth interviews
- Life histories
- Participant observation
- Focus Group Discussions (FGDs)
- Photographs
- Case studies

Indoor air pollution in Zimbabwe

Whilst the debate on indoor air pollution has been mainly centred on the kitchen, this project work in Zimbabwe has looked also at effects of levels of pollution in the rest of the house.

Biomass use

Biomass (including agricultural residues) is the principal source of energy used in rural Zimbabwe. Biomass is used for cooking, space heating and lighting. According to the CSO (2002: 133), the percentage of rural people using biomass as an energy source is 94% although other energy sources such as paraffin, electricity, dung and solar are also used. It was noted that due to fuel wood shortages, the use of dung as an energy source is growing popular, however the use of electricity, paraffin and solar is insignificant because of prohibitive costs.

Paraffin use

Prior to paraffin (kerosene) shortages, lamps called *zvibani* were used for lighting using unadulterated paraffin. Whilst these lamps emitted smoke, they were better than the current survival strategies employed due to the current paraffin scarcity discussed in the following paragraphs.

Zimbabwe has serious problems with indoor air pollution because of the unavailability and lack of affordability of paraffin. Paraffin is currently pegged at $Z 200 000.000 a litre (approximately US$1) which is unaffordable for most people.

Key factors associated with ill health

Some key factors for continued high levels of ill-health associated with indoor air pollution are highlighted below:

Households that cannot afford the list price of paraffin often buy it from unscrupulous dealers: in some instances households buy paraffin that is mixed with water. This further exacerbates the danger of indoor air pollution.

Rural households that can no longer afford to buy paraffin have improvised other energy sources for lighting in the evenings. Some now use diesel, oil, rubber tyres in place of paraffin. Worse still, households that cannot afford all the above use burning firewood sticks as a source of light. The options given above pose serious indoor air pollution for rural households in Zimbabwe.

House construction

The type of houses that are normally constructed in rural Zimbabwe worsen the indoor pollution problem. Both kitchens and bedrooms are not well ventilated. Some do not have windows and the small houses are such that smoke gets trapped in the kitchen. In buildings that have windows, the windows are small, V-shaped and less than 30cm in diameter. Sometimes, sacks are stuffed into the small windows further inhibiting the circulation of air. Figure 1 shows an external view of the type of unventilated kitchen normally seen in Zimbabwe.

Cooking in the kitchen is the norm in rural Zimbabwe. People do not cook out doors unless if it is for a very big function and they are using big pots when the heat in the kitchen would be too great. Cooking indoors is cultural; the kitchen is the point focus for all the household members and also for socialisation and relaxing. Other rea-

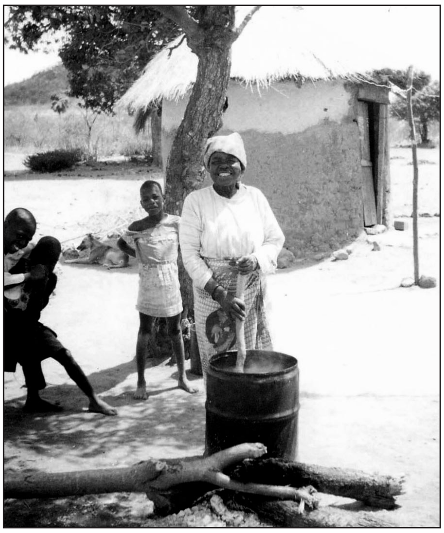

Figure 1 Woman standing in front of typical unventilated kitchen, Zimbabwe (*photo: Muchawaya*)

sons that are given for cooking in the kitchen include: the smoke protecting the thatch; smoke deters cockroaches, insects and rats: smoke preserves food: and cooking is a private affair and the kitchen provides such privacy.

HIV/AIDS confining people to the home

With the prevalence of HIV/AIDS in Zimbabwe, home based care activities are now very common in rural households, exposing the patients to indoor air pollution that exacerbates their medical conditions.

Lack of knowledge on the dangers of indoor air pollution

Are rural people aware of the effects of indoor air pollution and do they take them seriously? It is saddening to note that many of those people who suffer from symptoms of respiratory infections do not seek medical attention. This is because such symptoms are considered to be normal and are not taken seriously in the community. This study found the following:

- Rural dwellers are not aware of the effects of indoor air pollution other than the fact that it causes some mild headache and sore eyes
- They do not take indoor air pollution as a serious health threat so do not seek medical attention for respiratory problems caused by indoor air pollution.
- House ventilation is not considered important; hence households opt not to install means of ventilation.

Are messages reaching the grassroots?

It can be argued that years after the dangers associated with indoor air pollution emerged, the *language* of indoor air pollution is still circulating among researchers, professionals and academics. The message has not yet reached the intended beneficiaries; hence they continue to suffer from indoor air pollution without recognising its dangers. People cannot act unless they have knowledge. Hence if rural dwellers do not know about indoor air pollution and its dangers, they do not have an incentive to reduce or to come up with strategies that reduce it.

Indoor air pollution is not accorded in terms of danger, the same position as that given to malaria, cholera or tuberculosis just to mention a few. People do all they can to prevent and seek attention for the latter health conditions but not for those caused by indoor air pollution.

The failure to take indoor air pollution as a serious health threat is largely a problem of policy at national level rather than at household level. Indoor air pollution has not been taken seriously as a public health issue in Zimbabwe and as a result people in rural areas do not also consider it as such.

Campaigning at grassroots level

Raising awareness on indoor air pollution remains one of the most pragmatic ways that can work effectively in preventing and mitigating the effects of indoor air pollution in Zimbabwe. Effective methods include:

- Social mobilisation campaigns in rural areas by both the government and the NGOs. The government of Zimbabwe can use the already existing health systems (for example rural community health outreaches) run by health centres. These outreach programmes have proved very effective in preventing and combating other diseases.
- While rural health centres run health education meetings every morning. such meetings can be used as a platform for dissemination of information on indoor air pollution.
- The Government and NGOs can play their part using the methods they use for raising awareness for other diseases; for example: using Radio Zimbabwe which has an audience of more than 80% in rural areas. The print media can also be used to raise awareness through pamphlets and flyers in local languages.
- It is important for the government of Zimbabwe to consider including indoor air pollution in the school curriculum.
- Churches in rural areas can be used to raise awareness on indoor air pollution in rural areas.
- Posters can be put on walls in shops were people normally go to buy basic commodities as such places are popular.

Recommendations

- There is need for widespread indoor air pollution campaigns to raise awareness among the grassroots about indoor air pollution and its effects.
- Rural households need to participate actively in defining local strategies for mitigating indoor air pollution.
- Indigenous knowledge systems need to be promoted in the fight against indoor air pollution.
- Rural households should be educated on the advantages of improving air quality.
- Governments and the international community should put more political commitment towards indoor air pollution.

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Protecting children from indoor air pollution exposure through outdoor cooking in rural South Africa

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Introduction

Over half the global population is reliant on solid fuels such as wood, coal, crop residues and animal dung for their domestic energy requirements.[1,2] This results in high concentrations of pollutants such as particulate matter (PM) and carbon monoxide (CO) in the peoples' homes[3,4] when such fuels are burned indoors in open fires or rudimentary appliances. Amongst other health problems, indoor air pollution exposure has been associated with acute lower respiratory infections (ALRI) (such as pneumonia) amongst children younger than five years old.[5,4]

Figure 1 Outside view of segotlo (*photo: Brendon Barnes*)

By the late 1990s, there was a growing consensus of the probable links between indoor air pollution and child ALRI to call for studies to measure the effects of interventions on health.[6] Changing the way people behave has been identified as a possible strategy, particularly where people are unlikely to benefit from improved technologies in the short term. Despite this, no published studies have evaluated how changes in behaviour can relate to the way that children are exposed to indoor air pollution.[7] To address this shortage of information, this article reports on the effectiveness of promoting outdoor cooking in a poor rural South African community to reduce ill-health caused by kitchen smoke.

Figure 2 Outdoor cooking inside the segotlo (*photo: Brendon Barnes*)

The study was conducted in two poor rural villages in the Mafikeng local municipality, North West province of South Africa. Over 98% of households were reliant on a combination of wood and cow dung, collected free of charge, for their domestic energy requirements. In this region, every household had a square-shaped outdoor burning area (*segotlo*) in the homestead, which was enclosed by a wall of interwoven dried sticks approximately 1.6 m in height (Figure 1). It typically had a small entrance with a door (usually a piece of corrugated iron) that could be closed, thus creating a roofless kitchen. Inside is found a place for fuel storage (dried wood and cow dung), tables and chairs, pots, crockery and utensils (Figure 2). Outdoor cooking was widespread during summer but less so during winter when open fires are burned indoors where space heating is needed (Figure 3). At the start of the project, only one

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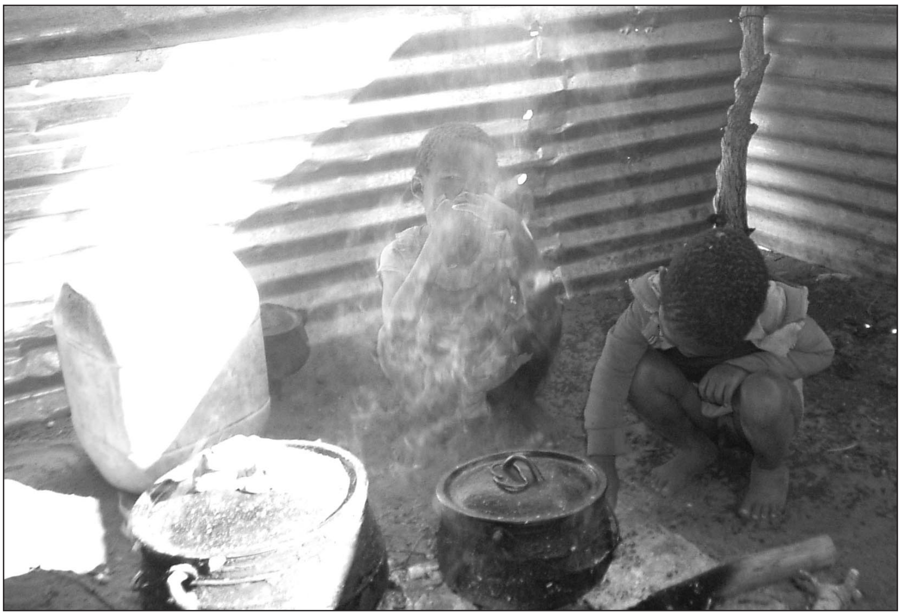

Figure 3 Children experience high levels of indoor air pollution when fires are brought indoors (*photo: Brendon Barnes*)

third of households (see below) reported using the *segotlo* for cooking during winter.

Aim and objectives of the study

The aim of the study was to evaluate the effectiveness of a low-cost '*intervention*' affecting peoples' behaviour. The *intervention* in this case involved *promoting the health benefits of outdoor cooking on the exposure of children to indoor air pollution*. Two alternative behaviours – improving ventilation and keeping children away from fires – were promoted amongst people who found it difficult to burn outdoors. However, this paper focuses mainly on outdoor burning. The objectives were to determine the impact of:

- Using the fire out-of-doors
- Exposure of children to carbon monoxide (CO)

Methods

The study involved monitoring households before and after the intervention, amongst an 'intervention group' in one village, and comparing these households to a 'control group' (in a village some 40 km distant) that did not receive the intervention.

In the intervention village, a member of the project field staff provided information about the health effects of breathing in smoke with the person responsible for childcare in the household (the 'caregiver'). This was followed by a discussion of how that person currently dealt with household energy and possible ways in which she (or he) could change her behaviour to reduce the dangers of smoke. Each household was visited one week later to determine how household members were coping with the agreed changes in behaviour, and encouraging them to continue.

Baseline data were collected in August 2003 (late winter) in both the intervention and control group. The household visits were implemented immediately thereafter in the 'intervention group' only with no further contact with the two groups until 12 months later when post-intervention data were collected from both groups in August 2004.

Participants

The study obtained baseline and follow-up information from 219 households (98 households in the intervention group and 121 households in the control group). Baseline and follow-up data on child exposure to CO was obtained from a random sample of 74 (36 in the intervention and 38 in the control group respectively) study children. Measurements were made on the following:

- Location of the fire (indoors versus outdoors).
- Child CO exposure.
- Child age and sex.
- Caregiver age and formal education
- Household characteristics: monthly income, number of people, dwelling type (traditional versus formal) and dwelling size.
- Ambient temperature.

Process

Caregivers were interviewed (using a questionnaire) to find out the location of the fire, information on the household, and characteristics of both caregiver and child. Researchers carried out the interview in the local language, and filled out the appropriate responses in the questionnaire. Exposure of the child to carbon monoxide (CO) was measured using tubes that change colour with exposure to CO (Dräger passive diffusion tubes). The carbon monoxide (expressed as parts per million) was measured over a 24-hour period. The CO tubes were attached to the clothing of the youngest child or close to where the child was sleeping, being bathed or changed. Ambient temperatures were obtained from the South African Weather Bureau, measured at a weather station near to the villages.

Results

Comparisons of the background information between baseline and follow-up showed that only household income and ambient temperature changed significantly in both intervention and control groups. *Despite colder winter temperatures at follow-up, both the intervention and control groups showed an increase in the number of households burning fires out of doors.* In the intervention group, the number of households that burned outdoors was increased from 24.5% at baseline to 45.9% at follow-up. Similarly, in the control group, the number of households burning outdoors increased from 25.6% at baseline to 42.2% at follow-up. Table 1 summarizes the location of the fire for the intervention group and control group.

In terms of child exposure (Table 2), children living in outdoor-burning homes showed significantly lower (88%–90%) levels of exposure to CO

Theme

Table 1 Number of households that burned outdoors

	Group	
	Intervention (n=98)	Control (n=121)
Baseline	24 (24.5%)	31 (25.6%)
Follow-up	45 (45.9%)	51 (42.2%)

Table 2 Mean child exposure to CO by burning location

	Burning location	
	Indoor burning	Outdoor burning
Baseline	4.2 ppm hrs (n=56)	0.5 ppm hrs (n=18)
Follow-up	3 ppm hrs (n=40)	0.3 ppm hrs (n=34)

compared to indoor-burning homes at both assessments. Interestingly, amongst those that brought a fire indoors at both assessments (i.e. those that found it too difficult to burn outdoors), child CO was reduced by 26% in the intervention group but increased by 15% amongst the control group (discussed in more detail elsewhere).

Discussion and conclusion

This study provides support for outdoor burning as a strategy to reduce air pollution exposure to children in poor rural areas during winter in this specific context. However, the fact that the control group also improved suggests that exposure to the intervention, and by implication the way that caregivers think about the *health* effects of indoor air pollution, was not the *only* reason for a shift to outdoor burning. Other factors emerged from qualitative interviews that may have influenced caregivers' decision to burn outdoors or remain indoors during the study period.

While health concern was the main reason for outdoor burning in the intervention group, amongst the control group a small group of participants mentioned that they tried to create a good impression to the study team with the expectation that they would get services such as electricity sooner (called a 'Hawthorne effect'[9]), while others perceived outdoor burning to be a symbol of higher social standing (there was often stigma attached to the dirt/soot and smell generated by burning inside homes) and this is why they chose to burn outdoors. In relation to warmth, participants who burned outdoors said that they dressed more warmly and heated themselves next to fires outdoors. After dark, participants used candles to provide light indoors. They mentioned that children do not care where fires are located as they usually play outdoors and only heat themselves for at intervals for a very short time.[10]

Amongst those who found it too difficult to burn outdoors and burned indoors, the space heating benefits of indoor burning often outweighed any other motivations. In addition, amongst certain participants (particularly in the control group) the belief that indoor smoke was not harmful to health was a major barrier to change. For example, some participants said that smoke was an acceptable part of rural life, that their parents and grandparents inhaled wood smoke with no health effects and questioned why they should be concerned about it. Certain female participants also mentioned that even if they wanted to burn outdoors, their male partners would often not allow it.

Changes in behaviour are not intended to replace technical interventions in poor rural households, but to provide an alternative until such interventions are feasible. The fact that having the fire out of doors, which reduced child exposure substantially even after 12 months, suggests that it may be an effective and sustainable option for between 42–46% of the rural households in this study. A proportion of those cooking out of doors were possibly doing so as a result of participation in the study. In addition, many of the non-health factors identified in the study are very difficult to change e.g. the need for indoor space heating, and the status of women in the family. Nonetheless, the study highlighted the potential role of behavioural change in reducing exposure of children to indoor air pollution in a poor rural context. Further studies are needed to explore behavioural change in more detail. There is a need for bigger studies to explore the impact of all kinds of interventions (not just changes in behaviour) on child ALRI and other health problems. It is equally important for large-scale efforts to continue to promote improved technologies, and to address the poverty-related issues that are the underlying causes of excessive levels of indoor air pollution in developing countries.

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Direct contact hazards of cookstoves: Burns, cuts, and scalds

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Theme

Background

Cooking with biomass often results in significant injuries in the forms of burns, cuts, and scalds. Though much research has been conducted in the fields of air pollution and respiratory infection, there has been little work done that investigates methods to reduce injuries from direct contact with stoves. As these direct contact injuries can be severe and life threatening, there is a need to produce safer household stoves. To address this need, guidelines have been developed to pinpoint hazardous areas and provide options for producing safer stoves. With easy-to-use and standardized procedures, these guidelines provide designers and manufacturers with effective methods for evaluating stove safety. Even non-technical persons can evaluate stove safety and improve stoves by using the guidelines.

Developing the safety principles

Forty-seven stove models from around the world were examined during the development of the stove safety principles. From this analysis several hazards were found to present dangers to stove users. These hazards can result in personal injuries such burns, cuts, and scalds; and also in loss of property due to house fires. The hazards and their severities were used to create ten guidelines corresponding to the many potential areas of harm. With each guideline comes four levels of safety that pinpoint and rate hazardous areas for inspection by designers. Further, the ratings can be used to demonstrate stove safety improvement as designers make modifications and retest their stoves. In this manner the guidelines give standardized methods for testing and improving the safety of stoves.

Burns

Burns are the most common form of injury. They vary in severity and can occur through contact with hot surfaces or flames. Less severe burns, such as redness and minor blistering, are prevalent with stoves that have excessively hot exterior surfaces near the combustion chamber or chimney.

Three of the safety guidelines describe the temperature ranges likely to give rise to burns. In addition, these guidelines take into consideration the way some structural materials (metals) produce burns more quickly than others (clay, mud). Furthermore, stoves nearer to the ground have more stringent guidelines because they present a greater risk of injury for children (Figure 1). To test for the hazard of hot surfaces, thermocouples or thermal sensitive paints are used to evaluate temperatures.

More severe burns are the consequence of contact with open flames. As women in the South are traditionally responsible for cooking; they are often the victims of accidents when skirts and hair catch on fire from open flames (Figure 2). These injuries are characterized by charred skin or muscle tissue and can result in loss of limb or eye function. Minimizing open flames is central in preventing injury (Figure 3). Testing is done by inspecting the amount of open flames surrounding the cookpot or coming out of the fuel loading area. Greater risk comes with greater amounts of open flames. These ratings are strict since even small flames can produce serious injuries.

Scalds

Scalds present a safety hazard to both cookstove users and children in the vicinity of a stove. Boiling liquids are easily spilled with stoves that are lightweight and close to the ground, as is often the case with hand-made stoves. These characteristics present the greatest hazard to children playing in small kitchens. However, even taller models have the potential to cause scald injuries if the main construction of the stove is far from the ground so that it overturns easily. Safety testing within a laboratory for scald injuries includes

Figure 1 Burn to hand from falling on to fire (*photo: Don O'Neal*)

Figure 2 Third degree burns from skirt fire (*photo: Don O'Neal*)

tipping a test stove slightly away from upright and finding the angle at which the stove will tip over on its own accord. Stoves with most of their weight higher from the ground will tip sooner and thus present greater risk.

Scalds also occur when pots are being moved from a stove. As pots are moved they can collide with small protrusions, such as handles on the stove or a sunken cooking surface, and result in a pot being overturned. The size of this risk is calculated using the height of vertical protrusions near the cookstove surface.

House fires and their prevention

Though not itself an injury, a house fire is highly undesirable. One concern involves when a stove is overturned and burning fuel is spilled onto the ground or surrounding materials that can catch fire. Additional concerns arise with stoves that do not enclose the combustion chamber and leave the burning fuel exposed. A problem arises when cooking with non-dried wood that can 'crackle' and send small pieces of fuel flying. This flying fuel can in turn set other things on fire, including clothes. To rate the safety of the stove against this hazard, the size of the opening through which fuel can be seen (and could thus fly out) is measured. Further risks for property loss arise when poorly insulated stoves are put close to the walls of a home. Intense heat from stove surfaces can ignite surrounding combustible materials just as open flames do. If stoves are placed near a wall, the temperatures of this wall are taken and measured against acceptable levels to prevent house fires.

Figure 3 Open flames are dangerous, and can lead to severe burns and cause house fires (*photo: Don O'Neal*)

Cuts and abrasions

Cuts and abrasions (scratches) are the least severe injuries but can still cause much discomfort and can lead to infected wounds. Often hand-made metal stoves have sharp edges and points resulting in harm to stove users or children playing near a stove. Evaluation of this risk is done by counting the number of hazardous points and sharp edges present on a stove. Rubbing a cloth along the surfaces of a stove and inspecting areas where the cloth becomes caught or ensnared easily finds these.

Making safer stoves

The development and implementation of the safety guidelines has taken place over the past three years. Continued development of the procedures is done with help of stove researchers at the Aprovecho Research Center, at Trees, Water & People in the United States, and in the field by workers at the Asociación Hondureña Para El Desarrollo (translated as 'The Honduran Association for Development'). Additional discussions take place each year among over 100 stove specialists at the international conference of Engineers in Technical and Humanitarian Opportunities of Service (ETHOS). Through their assistance these guidelines have become an instrumental and effective resource for rating cookstove hazards and increasing safety. Further use and development of these guidelines is occurring in Latin America, West Africa, China, and the Philippines, leading to thousands of safer stoves. To discuss how to implement safer stoves in your community, please contact Nathan Johnson (atlas@iastate.edu) or download the tests with full explanations at *www.vrac.iastate.edu/~atlas/safety.htm* You may also request guidance or copies of the tests via mail by writing to Nathan Johnson, 1620 Howe Hall, Iowa State University, Ames IA 50011, USA.

Introducing alcohol stoves to refugee communities; a case study from Kebrebeyah, Ethiopia

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Theme

Project Gaia in Ethiopia

Project Gaia's pilot study of the ethanol-fuelled CleanCook Stove seeks to bring an alternative cooking fuel to refugees in order to alleviate the environmental and health and safety problems related to fuelwood gathering. The work is being funded by the Shell Foundation with assistance from the United Nations High Commissioner for Refugees (UNHCR) Regional Liaison Office and the United Nations Development Programme (UNDP).

A total of 130 ethanol stoves are being tested in the Kebrebeyah camp. The camp is divided into seven administrative zones. A team comprising two team leaders, two field surveyors and translators attended a UNHCR Kebrebeyah meeting in Jijiga and visited a total of 20 study households, and neighbouring homes without ethanol stoves, selected from six of the seven zones in the camp. The team asked about the CleanCook stove, cooking and fuelwood gathering.

This report outlines some of the findings on how the project is addressing needs through the introduction of this ethanol stove (Figure 1).

The Kebrebeyah refugee community

The UNHCR Kebrebeyah Camp, established in 1991, is home to approximately 13,000 Somali refugees from various communities. Some households have a small kitchen separate from their sleeping quarters; most families cook and sleep in the one building. The refugee community is situated on arid and semi-arid land. Deforestation and subsequent soil erosion appears to be the cause of the absence of most forms of vegetation and scarce natural water sources in the areas surrounding the camp (Protti-Alvarado 5).

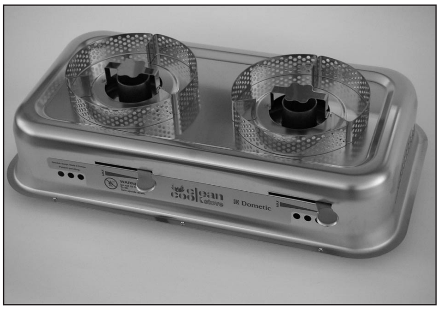

Figure 1 Ethanol-fuelled CleanCook stove

Risk of physical assault and injury

In October 2005, staff from Project Gaia attended a UNHCR Kebrebeyah meeting in Jijiga. The camp's Protection Officer stated passionately that most of the problem is caused by the need for firewood, which takes from six to ten hours a journey to collect (often four or more times per week), as people need firewood three times a day. Women and children have lots of problems with farmers. Women and girls find it difficult to describe to a male doctor the kidney pains and backaches from gathering firewood; likewise, rape victims are reluctant to discuss what has befallen them. They ask for a separate woman doctor or nurse, and they ask for counselling for rape and women's issues.

A spokesperson for the Administration for Refugees and Returnees Affairs (ARRA) noted, 'Girls and children spend 8 to 10 hours a day journeying to get firewood. The farmers take the wood from them. I believe the biggest challenge in the camp is the fuelwood gathering and charcoal production with the locals and refugees.'

The UNHCR Assistant Program Officer in Jijiga, reported, 'The biggest challenges I find for the camp are: child labour, the rape of girls, and physical abuse while collecting firewood, especially for women and children. We need to ensure physical protection.'

In addition to the demand for fuelwood, the collection of wood for building dwellings was the major challenge to the housing issue according to one attendee, who stated, 'Since the women make the homes, there is the problem of rape and assault.'

The camp doctor observed: 'There is the issue of energy, tremendous physical energy being lost when gathering fuel (Figure 2). They go for long hours. There is the rape of fuel gatherers. If a woman is in the camp for a long time, the locals target her, because they know she is from the camp. There is no time for education or for income-generating activities. There are insufficient well-educated women here to provide female social workers. Out of fifteen social workers, only three are female due to a lack of education among girls.' Other attendees mention that it is difficult for the girls to go to school when they have to help gather fuelwood or fetch water.

As evidenced by the statements above from those who work closely with the Kebrebeyah refugees, addressing the problems associated with fuelwood gathering is paramount to improving the lives of refugees in the UNHCR Kebrebeyah Camp.

Narratives from refugees living in Kebrebeyah

There are many serious issues identified by those living in the camp. The problems they indicate and the changes brought about by the ethanol stove are illustrated by quotations from the women themselves; many of these observations were common to

Figure 2 Woman sitting beside a load of wood she has recently collected

several of those being interviewed. Note that the team were only asking about the stove, cooking and fuelwood gathering. Thus, the benefits of children not breathing in polluting fuels, and the improved cleanliness of the stove were evident to those visiting the households, but did not feature highly in the responses.

Fuel collection – physical assault

Beatings, rape, risk of death, fuel taken away

- The landlords hit the women with sticks. 'I was beaten by farmers. I had marks and bruises on my body; I felt a lot of pain. The farmer owns the land. There is some rape. Women and girls are raped.'
- 'The farmers beat you and take your wood.' When asked if she had ever been beaten while gathering wood, G. . . exclaimed, 'Yes, they beat me! They punched me and hit me with sticks. I had bruises on my back and legs.'
- When asked how they try to protect themselves when gathering fuelwood, the woman crouched down and tip-toed, saying, 'We sneak like this and hide in groups.'
- 'There's no problem with males collecting wood, because males can fight back. So the farmers don't bother us like they do the women and girls,' one man stated.
- R . . . pointed to the horizontal scar on her forehead caused by the beating and motioned her hand around her head, saying, 'They [the medical staff] put a bandage around my head.' R . . . added, 'After they beat me, they stole my firewood.'
- 'There is rape sometimes of girls and women by the locals. Sometimes the place where you collect wood belongs to the locals. They say they'll kill you, they'll rape. Sunnis have been raped.'
- 'Landlords can kill you and take your wood.'
- 'They are killing and beating the women and girls who collect wood.'
- 'These women [neighbours without stoves] spoke in agreement about women and girls being raped and beaten when gathering fuelwood.'
- 'We [the women] gathered fuelwood together for safety.'
- J . . . said that she and her sister know someone who was raped – this was not confirmed by her sister, however . . .
- . . . based on testimony from the camp's doctor and other advocates at the UNHCR meeting a day earlier, it is possible that the sister did not confirm the statement because of the stigma of rape and because the sister may herself have been the victim. Also, it is often difficult for women and girls to speak of rape to male translators or doctors.

Dangers from the terrain – pain and injuries

- Fuel gatherers carry several kilos of firewood on their backs and walk many miles, causing dehydration, physical pain and injuries, especially to their back, legs, and kidneys, according to the doctor in the Kebrebeyah camp.
- Amar's hands and wrists are badly injured from a fall sustained when carrying a large load of fuelwood when it was rainy. Dried up blood was visible on her hands. Amar said, 'My hands are broken, so my son is cooking for me. I cannot cook with my hands.
- 'I fell down one time carrying wood, and I have a scar on my head.'
- 'I had pain in my back, kidneys, and legs.'
- 'I collected wood before, and it was heavy on my back and it left marks on my neck.' A . . . showed us where she had marks from her collarbone over her shoulder due to the ropes that are tied to the load of wood. She adds, 'I collected wood 4 times each week for 5 hours each time. My 3 daughters also collected wood.
- 'Also, I get backaches and leg pain from collecting wood.'
- 'Before we had this stove, I had coughing and eye irritation. I had back pain from collecting wood.'
- 'When I collected wood, I had back and kidney pain.'

Fuel collection – time impacts

Time collecting fuel

- 'When I gathered wood, I was very tired. I had to walk very far. I left in the morning and returned at 3 pm. I gathered wood for 5–6 hours.'
- 'I collected wood before the Clean-Cook Stove 2 times each week. Most times I was gone from 7 am to 8 pm. Sometimes I was only gone for 5 to 8 hours. The problem is scarcity of wood. It takes a long time to search for wood.'
- 'Before, we used wood. It took us 7 hours, 3 days each week to collect wood.'
- 'Before I used wood. I had back pain from collecting wood 8 hours, 4 times each week.'
- 'Before we had the stove, my two daughters collected wood three days each week. They would make two trips each time [day] from morning until 7 pm. The wood lasts about 5 days for 10 people.'
- 'I collected wood for 8 hours, 3 times each week.'

Fuel collection – education impacts

- 'Before we had the stove, my two daughters collected wood three days each week.'
- 'My sister and I [aged 14 & 15] miss school 2 or 3 days each week to collect wood. Missing school is a problem. We walk very far and carry 4 or 5 kilos on our backs. Teacher asks us, 'Why don't you come to school?' Missing school to collect firewood hurts our grades.' (Figure 3).
- Before, I collected firewood 7 hours a day, 3 to 4 times a week. I left early to collect firewood and my children stayed home alone. They were absent from school,

Figure 3 Missing school to collect fuel hurts our grades

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because I had to collect firewood. Now I cook food early so the children go to school.'

Benefits of CleanCook stove use

- 'The CleanCook is much faster than the traditional stove.'
- 'Now I rest with the CleanCook Stove, because I do not have to collect wood. And it is faster cooking with the CleanCook Stove.'
- 'It saves me from going very far to get wood, and I no longer have eye irritation. Now I have more time for a social life and my kids.'
- 'From the time saved from not collecting wood with the CleanCook Stove, I take care of my 4 children and family. I have no back pain now.'
- 'Now I do not use wood since I have this stove.'
- 'I had eye irritation and coughing from the wood stove. I don't have eye irritation or coughing with the CleanCook Stove.'
- 'The CleanCook Stove is better than the charcoal; it is quicker and cleaner. Also, the charcoal causes eye irritation.'
- 'I like the stove. It's very good. We need more stoves. The neighbours want stoves. I would like to have another stove. I cook tea, enjera and milk on the stove.' (Figure 4)
- 'Before I used wood for cooking. Look at my ceiling! It is black from the wood. I have no eye irritation and I have no coughing with the CleanCook Stove.'
- 'I had coughing and eye irritation with the charcoal stove. I no longer have those problems, and the CleanCook Stove is safer for my children than the charcoal stove.'

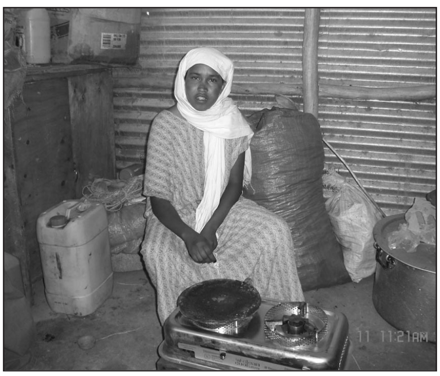

Figure 4 Stove with hotplate for cooking *enjera* a staple food

Assessment

The narratives alone speak of the positive effects of the CleanCook Stove in the Kebrebeyah refugee camp. The twenty study homes that were visited prefer the ethanol-fuelled CC Stove to their other stoves and fuels. Women and girls say they have more time, with the CC Stove, to care for children and attend school; they speak of the risk of rape and being beaten when gathering fuelwood. Their neighbours asked how they too can receive a CC Stove.

The UNHCR Kebrebeyah staff noted that since some of the Somali study households are sharing the stove and cooking for several families on it, they must value the stove. We were told that the Somalis assist each other and only share something if they like it; if they do not like something, they will sell it. Project Gaia's plan for 2006 is to distribute a total of 1000 new stoves to UNHCR's Kebrebeyah camp and to reach all families in 2007. Due to the sensitive issue of discrimination among the different communities, Project Gaia and UNHCR will monitor the distribution of the stoves so that all communities with qualifying households receive the opportunity to participate in the study.

Policy implications/ recommendations

Given the acceptance of the CleanCook Stove by residents and the resulting decrease in fuelwood gathering by those families using the stove, the UNHCR should consider expanding its use to other refugee camps within and outside of Ethiopia, wherever a supply of ethanol is available for purchase. In Kenya, as in Ethiopia, there is an existing domestic ethanol supply with potential for expansion that could be used to fuel the stove in UNHCR camps. The 2006 refugee population in Ethiopia has been estimated at 120,000, while Kenya's is estimated at twice that number.

In Kenya UNHCR purchases and imports fuelwood into several camps. It may eventually have to do this in Ethiopia. 'To try to reduce the number of women being sexually assaulted as they collected firewood outside two major camps in Kenya, UNHCR paid local contractors to haul the wood directly into the sites' (Wilkinson).

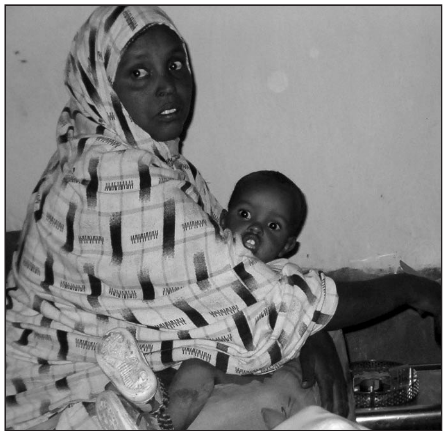

Figure 5 Mother carrying her baby while cooking

Instead of contracting for the purchase of wood, a switch to the ethanol-fuelled stove would decrease or eliminate the need for fuelwood, whether purchased or gathered. This action would:

- Decrease or eliminate accidental injuries, violent confrontation and sexual assaults of women and children.
- Decrease the negative effects or 'fall out' in the community associated with competition for the use of scarce biomass resources.
- Eliminate the likelihood that continued reliance on fuelwood would continue to degrade the environment. Currently, the deforestation in the area is so extreme that the need for firewood of both the locals and refugees is harming the environment and causing conflict.
- Reduce exposure to indoor air pollution. Mothers often cook while carrying their babies (Figure 5). Indoor air pollution is a major cause of pneumonia in children under five years, and of chronic respiratory diseases among women.
- Reduce the administrative and financial burdens on the UNHCR and its partners caused by health and resource conflict problems that come with the use of fuelwood.

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Boiling Point is a technical journal for those working with stoves and household energy. It deals with technical, social, financial and environmental issues and aims to improve the quality of life for poor communities living in the developing world.

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