

Organizations and Actors in Interventions to Improve Household Fuel Use in Developing Countries

Jonathan E. Sinton, Lawrence Berkeley National Laboratory
Jayant A. Sathaye, Lawrence Berkeley National Laboratory

ABSTRACT

The global burden of air pollution-related disease falls disproportionately on people in developing countries who are exposed to the products of combustion from cooking and heating with biomass and coal inside dwellings. In principle, mitigating the damages to health is relatively simple, e.g., switching to less-polluting fuels, more-efficient stoves, and better ventilation. Yet change is slow because choices of fuels and technologies are influenced by forces such as limited fuel resources, limited income, and other socioeconomic conditions. Various interventions have been tried, especially since the late 1970s. From this experience, it is possible to draw some lessons about how various actors and organizations can participate in interventions to increase the chances of effecting long-term improvements. Based on case studies of India, China, and Kenya, we discuss the actors and organizations involved in improved stoves programs, which are among the most important interventions for improving household heating and cooking in developing countries, and elaborate the roles, interests and contexts of these actors and organizations. We draw on contributions to a multi-country dialogue on household energy and health sponsored by the Shell Foundation in July-August 2001, in which over 130 people in diverse fields participated.

Introduction¹

About half the world's households use biomass and coal for cooking and heating (Holdren, *et al.* 2000). Solid fuels are typically used in simple stoves, often unvented, with high emissions rates of particulates, carbon monoxide, and other health-damaging pollutants. Consequently, many people in developing countries, particularly rural women and children, are exposed to pollution levels many times higher than those experienced in developed countries. The resulting global burden of disease probably exceeds that from global outdoor exposures for particulates and other important pollutants (Smith 1993; Bruce *et al.* 2000).

There have been some efforts to mitigate indoor air pollution in developing countries, and even more aimed at improving energy use. These initiatives, such as the several hundred village- to national-scale programs to promote improved stoves that have been implemented in various countries, only coincidentally addressed indoor air pollution, (Goldemberg 2000; Barnes and Floor 1996). Although many types of improved stoves are available, dissemination has been limited in most countries, partly because cooking practices are deeply intertwined with local traditions and resource availability. Interventions involving health education or uncoordinated donor-funded efforts have often failed because they have ignored end user's attitudes and conditions. Moreover, it has been difficult to persuade policy makers

¹ The introduction is adapted from a background paper prepared by the authors for the Shell Foundation, available at http://www.shellfoundation.org/dialogues/household_energy/resources/.

to mount campaigns against this hazard because the causal link between indoor air pollution and illnesses has not been as well characterized as for other public health issues. Often, government agencies that could take steps to reduce indoor air pollution see the problem as outside their scope of activities, or less important than other pressing issues.

In some countries, programs have succeeded in deploying large numbers of improved stoves, although effects on indoor air pollution and health have yet to be confirmed. In a few countries, policies have facilitated cheaper, easier access to kerosene and LPG for poor communities, allowing a shift away from the use of traditional biomass for cooking. Such modern fuels have been associated with less acute respiratory illness and other diseases than associated with use of traditional solid fuels. A handful of NGO-led community programs have used market-oriented strategies to successfully introduce improved stoves. While attempts have been made to assess the outcomes of improved stoves programs (Barnes *et al.* 1994), a systematic understanding of how interventions can effect lasting change energy use in rural households is lacking (Ezzati and Kammen forthcoming).

These and other related issues were discussed in a multi-country on-line dialogue on household energy and health sponsored by the Shell Foundation in July-August 2001 (Shell Foundation, 2001). Over 130 people from 27 countries participated in the five-week on-line forum, offering perspectives from fields including stove and building design, public policy, energy and development economics, public health, epidemiology, energy analysis, and gender studies. The many viewpoints represented highlighted the need to have a common framework in which to understand the roles actors and organizations play in interventions. Many of the references throughout this paper are to postings from forum participants.

In this paper, we attempt to develop from an organizational perspective an understanding of interventions on cooking stoves that can reduce indoor air pollution. Stoves programs have been undertaken in many countries (Shell Foundation, 2001), space only allows us to provide context using examples from three countries—India, China, and Kenya—with major improved stoves programs that were initiated to improve public health, reduce use of biomass, or achieve other goals.² We then abstract a typology of actors and organizations involved in such efforts, the environments they face, their sometimes conflicting interests, as well as the roles they play in improved-stove programs.

Case Studies

India

In 1983, India initiated the National Programme on Improved Chulhas (NPIC), a program to provide subsidized improved chulhas, a type of traditional cooking stove, to rural households (Barnes *et al.*, 1994). By 2000, 31.2 million improved biomass stoves had reportedly been installed (Krishna 2001). The Indian government recently decided to discontinue the NPIC, although a few states may continue their programs (Smith 2002).

The NPIC was a highly centralized program administered through offices at the national, regional, state, district, and local (*taluka*) levels (Barnes *et al.*, 1994). Decision-

² Improved stoves are only one measure among the array of technical improvements that can be made to improve indoor environments, and, without parallel improvements, such as installation of flues, may by themselves have little impact. Improved stoves programs, however, are sufficient to illustrate the variety of actors involved in interventions to mitigate indoor air pollution.

making regarding program elements, stove design, financing, and other details were top-down (Krishna 2001). Technical Backup Units (TBUs)—typically universities or research organizations—were identified in each state, with responsibility for ensuring that designs of stoves were appropriate to local needs. Local NGOs were extensively involved, and participated in training and outreach efforts, both to households, and to small enterprises and individuals who were trained in installing and servicing stoves.

Only stoves strictly adhering to government-approved designs were eligible for the subsidy (typically 50%) offered to end users. At least in the earlier stages of the program, the government was effectively a monopsonistic purchaser of the stoves disseminated through the NPIC. Program-evaluation surveys showed that utilization rates of stoves were low, with only about half of households continuing to use them. Surveys showed that users had mixed attitudes. Some users found that the stoves saved fuel and reduced smoke, but others found that the stoves did not save fuel or reduce emissions, did not allow users to cook using traditional methods (such as high-temperature frying), and required greater attention to operate. There appears to be evidence that claims regarding numbers of stoves installed, wood fuel savings, and other program outcomes were exaggerated, perhaps considerably (Krishna 2001). The top-down approach, which in practice excluded participation of end users, who are almost all women, has been blamed for many of these problems. The focus on state targets, for instance, created an incentive for states to deploy as many stoves as possible, without regard for their quality or appropriateness. In later years, earlier deficiencies were rectified to make the NPIC more responsive to local needs. For instance, later variants of the program provided technical support and training directly to villages.

China

China has undertaken many programs aimed at improving the welfare of rural residents, but one was especially aimed at changing stove technology. In the early 1980s, in response to widespread rural biomass fuel shortages, the Chinese government organized a large-scale National Improved Stove Program (NISP)—to provide rural households throughout the country with more-efficient biomass stoves, and later in the program improved coal stoves for cooking and heating (Smith *et al.* 1993). Run through the Ministry of Agriculture (MOA), the NISP supported over 860 of the country's 2,100 counties with about US\$7 million per year. Based in part on existing organizations, a network of administrative, technical, and production offices and enterprises was created. Counties were selected by a bottom-up approach emphasizing availability of administrative, financial, and physical resources, and local desire to participate (Qiu *et al.* 1996). County agencies selected and sometimes developed stove models to adapt and promote, while households paid for materials and installation themselves. Stove testing standards were set, national competitions of stove performance held, and monitoring of program results were carried out.

By the early 1990s, about 130 million improved stoves had been installed, and the pressure on biomass supplies had eased in most parts of the country, in part due to increased incomes and availability of fossil fuels and electricity. The NISP was wound down, and MOA turned its attention from efforts to put stoves in homes towards support (loans, tax credits, and training) for stove manufacturers and energy service companies that would market, install, and repair stoves (Zhang and Groenendaal 2001). From the mid-1990s onwards, support for the stove industry was replaced with extension services (technical

advice), and certification systems to standardize stoves (Zheng 2002). The development and dissemination of improved stoves is now left to market actors, with some organizational effort expended by MOA's county-level Rural Energy Offices (REOs). Even so, MOA claims that, in 1998, 185 million of China's 236 million rural households had improved biomass or coal stoves (NBS 1999; EBCREY 1999). Many of these households have used more than one generation of improved stoves, as successive improvements have been made to stove models. Feed back from stove users (mainly women) to stove builders (who often are house builders who live in the same villages or townships as their customers) has been important in modifying designs. Nearly one-quarter of stoves are mass produced, allowing greater quality control, and many stoves built in place use mass-produced parts.

In recent years, MOA has turned towards integrated household welfare programs, especially schemes involving biogas (Wang and Chen, 2002). Improved stoves remain an element in a few programs, where biomass cook stoves are integrated into *kangs* (large brick beds heated with flue gases) as part of overall retrofits to houses.

Other agencies also have improved stove programs. The Ministry of Health (MOH) started an program in the mid-1990s to promote "improved kitchens" in poorer regions, including improved stoves, clean water supply, and sanitation projects (Zheng 2002). MOH also has a program to provide improved stoves in areas where fluorosis from burning high-fluoride coals is endemic. The State Development Planning Commission, in response to destructive flooding along the Yangtze River in 1998, initiated the Yangtze River Valley Environmental Protection Project. It aims to reduce soil erosion by reforestation, and includes promotion of improved stoves to reduce demand for fuelwood. These projects appear to have collectively deployed many improved stoves, although survey work is needed to independently confirm official stove penetration statistics, and to understand the impacts on indoor air quality, health, and comfort.³ It is challenging, however, to separate the impacts of stove programs from those of other policies, such as promotion of rural coal markets, that have fundamentally altered rural fuel supplies.

Kenya

Kenya has been a leader among African nations in improved stoves programs. Its major stove programs have received substantial support from foreign donors. As of the early 1990s, slightly over one million improved stoves had been installed in households in eastern and southern Africa, and about three quarters of them were in Kenya (Karekezi and Ranja 1997; Kammen 1995). Unlike the Chinese and Indian programs, programs in Kenya have targeted urban as well as rural homes. The Kenyan Ceramic Jiko (KCJ; an efficient, portable, one-pot charcoal cookstove) program is considered to be among the most successful programs undertaken in Africa.⁴ The KCJ program led to the development of a class of specialized, commercial manufacturers of stove liners, including both mechanized and semi-mechanized producers. Artisans purchase the liners, fabricate stoves using the liners and

³ A project is now underway to assess the results of China's stove programs. The University of California, San Francisco and the University of California, Berkeley are collaborating with Tsinghua University, Renmin University, and the China Centers for Disease Control to survey 15 counties and over 3,000 households in three provinces to assess penetration of improved stoves, fuel use, indoor air quality, and health outcomes, and to understand how programs were implemented. Results are expected in 2003.

⁴ A variety of other programs in Kenya, some run by international NGOs, have introduced improved stoves as part of integrated solutions to rural health problems (Doig 2001), but we will not detail these here.

sheet metal, and market the products directly to end users. End users do not receive subsidies for stove purchases. The program was characterized by a high degree of cooperation between the government (Ministry of Energy), foreign donors, universities (stove designers), and local NGOs (outreach and technical support). The KCJ program helped to build up the Kenya Energy and Environment Organization and the Foundation for Woodstove dissemination, both of which have become regional centers of expertise in designing improved stoves and implementing dissemination programs (Kammen 1995).

Although the program was able to create a market for improved stoves, survival of the market after withdrawal of financial support was a key issue (Karekezi and Ranja 1997). After the initial years of the KCJ program, in which the government and NGOs gave it a high level of attention, lower-quality products began to appear on markets. In response to competition and to improve profits, some liner manufacturers began to reduce the amounts of vermiculite and cement used in liners, reducing their lifespan without reducing cost, and thus their attractiveness compared to traditional stoves. Such a trend indicated a need for long-term intervention or regulation, such as standard-setting or certification, to maintain quality control, but the Bureau of Standards did not have the capability to set and enforce standards.

In the early 1980s, a parallel effort to introduce improved stoves in rural areas was begun (Karekezi and Ranja 1997; Kammen 1995). In the first years of the program, the Ministries of Energy and Agriculture, with foreign funding, supported design of the Maendeleo stove, and then its manufacture and dissemination by the Women and Energy Project. The stoves saved about half of the fuel used by traditional three-stone stoves, were easier to use, reduced cooking time, indoor smoke and heat, and incidence of burns. Pilot dissemination of the fixed version of the Maendeleo stove began in 1986, and by 1992, about 250,000 stoves had been deployed nationwide. To create a sustainable industry, commercial production centers for stove liners (installed by a stove installer or household residents themselves) were fostered, and were provided training in manufacturing processes, business management, and marketing. By the mid-1990s there were 40 such production centers, 33 of which belonged to women's groups (Karekezi and Ranja 1997). The liners were distributed by different organizations that have extension programs to villages. Indeed, one reason given for the success in disseminating improved stoves in Kenya's rural areas is that it made use of these existing network instead of trying to create new distribution channels from scratch.

Actors and Organizations

The three case studies above show that a many actors and organizations are involved in the complex interventions needed to promote changes in even relatively simple technologies. Actors can be divided into end users, governments, outreach organizations, development agencies, foundations and other donors, research organizations, and enterprises.⁵ Each category has various goals and influences that condition its participation in intervention programs. For each actor, an intervention program has to serve important goals (and not interfere with other goals) and fit in with restrictions on their activities. The intent of this typology is to outline in general the goals and roles appropriate to each category of actor or organization. Greater specificity requires reference to specific cases, or greater length than this paper can accommodate in order to attempt comprehensiveness.

⁵ See in particular the discussion in Week 3 of the Household Energy and Health On-line Forum (Shell Foundation 2001).

Households and Individuals

While it may seem obvious that households need to be consulted in the design of new stoves, early improved-stoves programs sought little feedback from end users on the design of stoves that were disseminated. While certainly more efficient than the devices they replaced, new stoves did not serve other important needs of users. Some stoves required constant feeding of small amounts of fuel into the combustion chamber to achieve their greater efficiency, and thus required inconvenient changes in stove operation. Certain designs did not provide the intensity or duration of heat needed for cooking traditional foods, requiring unacceptable changes to cooking practices (Miranda 2001). In India, some improved stoves failed to solve what many cooks considered to be a more important problem than efficiency or smokiness—blackening of pots and kitchen walls (Malhotra 2001). Some improved biomass stove designs in China improved efficiency with a smaller combustion chamber, but were not accepted because the smaller chambers could not accommodate enough fuel to provide the intense heat needed for stir frying.

The introduction of new devices is often hindered because targeted households cannot afford to purchase more-expensive stoves without assistance. A solution that depends on end users to react to the financial savings of using improved stoves may work well in urban areas, but fail in many rural areas where there is only a thinly developed cash economy. To an end user, if a stove is not clearly superior in many different respects to the device it replaces, then it is not an improved stove. Furthermore, since households in different places have widely varying traditions and resource constraints, there is no “one size fits all” solution appropriate for all local conditions. Even in the same location, different groups of end users may face different sets of incentives, requiring stratification of intervention approaches (D’Souza 2001). A dialogue is needed between those who design the stoves and those who use them. As a participant in the Shell Foundation on-line forum summed up:

“As has been found with many stoves programmes, community participation in finding the solution to their problems is essential for developing appropriate interventions and for acceptance by the community. While technical methods of reducing indoor air pollution are well known, it is essential for the community to be fully involved in finding the solution which best suits their needs. [Additionally, through this involvement] the community becomes much more aware of the [indoor air pollution] problem and what they can do themselves to reduce their own exposure.” (Doig 2001.)

This last point highlights the common situation that potential end users are not aware that new devices can help meet goals that are important to them, and may not be aware of what strikes outsiders, for instance, that their indoor environments are heavily polluted. Conversely, stove and program designers must understand which goals are important to particular groups of end users. Benefits such as improved health and greater amounts of free time due to reduced burdens of fuel gathering may not be immediately obvious. In such cases, education and training provided by outreach organizations becomes important. End users themselves are critical to the process of education, since word of mouth is perhaps the most powerful force in determining the reputation of a particular device, especially in rural communities with few media outlets. The “pioneer” users can become agents of change in

promoting new types of stoves (Kulkarni 2001). This phenomenon parallels that found in studies of energy-efficiency programs in the US, where social influences have been found to be particularly successful in inducing conservation (Katzev and Johnson 1987).

Outreach Organizations

Outreach organizations, whether they are NGOs, as in the Indian or Kenyan programs, or government units, as in the Chinese program, form the bridge between end-users and the policy, research, and other communities. These are often the groups that carry out the activities that make it possible for households to change the way they cook and heat by providing education about the benefits of new devices, training in their use and maintenance, and providing ways to make the new stoves more affordable. In addition to performing outreach work themselves, such organizations can identify barriers to implementation and ways to overcome them. They can also arrange for end users to educate each other, for instance, through sponsoring exchange visits from communities that have adopted improved stoves to those that have not. Such exchange visits have been found to be very effective in both Kenya and India (Bates 2001; Malhotra 2001).

Early experience in the Indian program demonstrated that a top-down approach can provide end users with unusable equipment. Outreach organizations have major responsibility for doing the “tailoring” needed to enable a national or regional effort to serve local needs. In China’s stoves program, county-level REOs, with their supporting units in townships and villages, selected stove designs, redesigned them for local conditions, and decided where and how to promote the stoves. REOs were provided not just with resources, but with decision-making authority. Once in place, this system of REOs was available to provide similar services for later programs that also sought to promote improved stoves.

As mediators between end users and the governments and other organizations that plan and fund improved stoves programs, outreach organizations can have an important role in financing change. Multilateral development banks, for instance, are only able to deal in large sums of money, far greater than the small sums that households need to purchase a new stove that a local entrepreneur needs to set up a workshop. Outreach organizations are well placed to take on a large sum of money and break it down into such small increments (Desai 2001). Similarly, they are in a good position to communicate experience gained in other parts of the country and internationally to target communities.

Enterprises

Experience has shown the importance of local enterprises that manufacture stoves and have long-term relationships with customers. Virtually all of the improved stoves programs caused enterprises to emerge or to expand to provide newly designed stoves. The Indian stoves program fostered a class of potters to produce new ceramic stoves (Karve 2001), as the Kenyan program created a similar set of enterprises and individual artisans who manufactured stoves and parts, and as the Chinese program caused manufacturers and artisans to spring up. There is a major difference, however, in the behavior of enterprises depending on the type of stove-dissemination program. The Indian program offered large subsidies for the purchase of specific models, giving manufacturers great incentive to sell only the more-expensive, subsidized stoves, even where they were not appropriate for users

(Bates 2001). As a result, many stoves were sold, but few remained in use for long. In Kenya and China, on the other hand, households footed the bill for stoves. Sensitive to market demand, manufacturers offered devices that end users actually wanted. A recent local variant on the Indian program has succeeded by providing stove makers with training, tools, and molds for making improved stoves, but leaving to artisans the task of marketing and retailing stoves, so that unwanted products are no longer pushed on end users (Karve 2001).

Governments

In many developing countries, national and sub-national governments have found that programs that disseminate improved stoves can serve a variety of the social, economic, and environmental interests that they are charged with protecting. Some improved stove programs have been pursued in order to relieve rural fuel shortages, as in the case of China's program in the 1980s, or to conserve forest resources, as in Kenya. Others have been implemented for public health reasons. Indirect public benefits have arisen from these programs as well, such as employment in new stove manufacturing enterprises.

In some places, it has been found to be both necessary and possible to integrate improved-stoves programs with other interventions to improve public health and alleviate poverty. In small-scale programs in Kenya and Nepal, for instance, folding dissemination of improved stoves into broader-based public health initiatives led to higher adoption rates of the new devices (Barnett 2001; Bates 2001). On a larger scale, China has given up entirely on promoting improved biomass and coal stoves, and government-sponsored programs now only include them as elements of interventions designed to improve the overall well-being of rural households, or to reduce pressure on forest resources. More typically, however, improving indoor air quality is perceived as a worthy goal that cannot compete with other public health or environmental priorities, such as preventing communicable diseases and mitigating ambient air pollution, and is accorded little or no direct attention.

Governments are, of course, not monolithic entities. Typically, different government departments are responsible for the various interests that might be served by an improved-stoves program. In Kenya, both the Ministries of Energy and Agriculture have been involved. China's Ministry of Agriculture oversaw the country's large-scale stove-dissemination program, but the Ministry of Health and the State Development Planning Commission (a comprehensive national planning agency) also have programs that include stoves. Within a country, there may also be smaller programs overseen by subnational governments and NGOs. A lack of coordination between such efforts could lead to duplication and waste of effort, not to mention loss of opportunities for mutual support and strengthening that might be achieved through communication and coordination of efforts. This is an area where national governments could potentially contribute.

A key role for governments is program monitoring. Devolving authority to local decision-makers is necessary for stoves program to be effective for end-users. However, monitoring of results is needed to ensure that resources are not diverted, and that locally mediated programs actually achieve intended goals. Unfortunately, few stoves programs have independently monitored and evaluated. Most reporting on results has been through the same agencies that were responsible for implementation, and which thus have little incentive to report less-than-satisfactory results, as the Indian experience shows.

As allocators of national resources, governments have responsibility for prioritizing expenditures on programs. While governments have been a major funders of improved stoves programs, that spending has been very small compared to other energy, environmental and health programs. Given that household use of solid fuels has major consequences for many issues of national interest, it would seem to be important to clarify those linkages—a job for the research community—to enable policy makers to better order spending priorities.

Perhaps more important than *direct* interventions are *indirect* ways in which governments can promote improved stoves. To ensure long-term success of programs, institutions need to be created that will ensure that end users can maintain stoves and obtain new ones after programs have wound down. Governments have tremendous influence on fuel availability, energy markets, tax policy, access to credit, and other conditions that determine whether there exists the economic and institutional infrastructure needed to sustain markets for improved stoves. Even road-building programs can be of direct benefit; breakage of stove parts during transport has been a major difficulty in India's stoves programs (Karve 2001).

Development Agencies

While bilateral and multilateral development agencies do not always play a significant role in improved-stoves programs (the Chinese and Indian initiatives were domestically driven). In many countries, as in the Kenyan example, these international players can play a key role in enabling governments to act by providing funding and technical assistance. Although often controversial, the role that multilateral development agencies have in promoting institutional changes can influence the development of the institutional “infrastructure” elements noted above needed to sustain dissemination of improved stoves after interventions end. As Barnes and Floor (1996) wrote, “Technical assistance and program lending for rural energy have languished in large measure because the enabling environment and energy policies have not been favorable to otherwise well-intentioned and well-conceived projects.” The now-defunct Asian Regional Wood Energy Development Program sought to help governments integrate planning of wood fuel use into broader energy planning (Heruela 2001). Development organizations can play a crucial role in transferring experience between countries that face many of the same circumstances, increasing the likelihood of transferability of lessons. They can also provide key assistance that enables local commercial networks to provide new stoves to end users, as experience with urban improved-stove programs in Sri Lanka has shown (Touche Ross 1991).

Private Donors

Like development agencies, foundations, charities, and other private donors primarily target funding towards areas that serve their particular missions, and, to a limited extent, are able to influence awareness of issues and setting of policy. On the other hand, foundations have the flexibility to work more freely and directly with NGOs, sub-national governments, and enterprises and can typically operate more quickly. This is a great advantage where opportunities emerge and disappear rapidly, and in areas that are not of priority to national governments. With their control of attention-commanding resources, private donors are also well placed to bring together various groups involved in stoves programs, and to facilitate communication and coordination. Like other organizations, however, private donors have

limited resources, and competition for resources means that not all worthy programs receive attention, particularly if there is no individual to champion a specific cause.

Universities and Research Organizations

Research organizations have been important not just to identify and define the scope of the problems addressed by improved-stoves programs, but to develop designs of improved stoves, design intervention programs, and carry them out. Indoor air quality in developing countries was not widely recognized as a problem worthy of concern until environmental and health researchers began to investigate its place among causes of ill health worldwide (Smith 1993). Since the 1980s, much work has been done to establish the role of household fuel use in causing ill health, although considerable work remains to be done to persuade many key players of the need for action.

Within countries and internationally, there is a specialized community of stove designers. Technical assistance was institutionalized in the cases described above. India designated Technical Backup Units for its program, China supported stove design organizations nationwide, and Kenya developed new NGOs. These worked with implementing agencies to provide and modify stove designs. Internationally, design organizations such as the Aprovecho Research Center provide assistance to many countries in developing appropriate stove models (Shell Foundation 2001). In addition to providing better devices, those in the research community also provide assistance to governments, development agencies, and NGOs in developing effective dissemination programs.

Conclusions

The preceding case studies and typology of actors and organizations provides a framework for analyzing interventions to improve household energy use for cooking and heating. It enables one to systematically break down any proposed intervention program to determine how it would meet the needs of each class of actors, and what type of involvement would be needed from each. Providing a common framework in which to discuss the merits and faults of a proposed program from multiple viewpoints is especially important, since design of such programs requires input from a wide range of actors who bring with them different organizational and disciplinary perspectives.

Among the most important lessons from experience in previous stoves programs is that excluding any of the sets of actors identified can lead to program failure. A major theme in on-line forum was the need for a “bottom-up” approach to interventions that accounts for the needs of end users in the design of programs and devices. Similarly, programs need to be designed so that the interests of the outreach organizations and enterprises that work face-to-face with end users are aligned with user needs. In places where a cash economy operates, this would mean, for instance, providing local stove manufacturers with the tools needed to build improved stoves and leaving to them the task of selling the product (as in the Kenyan KCJ program), rather than limiting the types of stoves that can be sold to households (as in the early Indian program).

Although we have only briefly considered improved-stoves programs in this paper, the framework could be used to analyze a particular program or set of programs in more detail. It should also be applicable to more-broadly defined efforts to improve health through

modifying energy use in households in developing countries. This is important because it is likely that improved stoves will increasingly be recognized as only one option among a variety of interventions could be promoted to achieve multiple welfare-improvement goals.

Acknowledgements

The authors wish to thank Katy Janda, Maithili Iyer, and two anonymous reviewers for providing valuable comments on this paper, and all the participants in the Shell Foundation's Household Energy and Health on-line forum for sharing their ideas.

References

- Barnes, Douglas F., Keith Openshaw, Kirk R. Smith, and Robert van der Plas. 1994. *What Makes People Cook with Improved Biomass Stoves?: A Comparative International Review of Stove Programs*. World Bank Technical Paper No. 242. Washington DC: World Bank.
- Barnes, Douglas F., and Willem M. Floor. 1996. "Rural Energy in Developing Countries: A Challenge for Economic Development." *Annual Review of Energy and Environment* 21:497-530.
- Barnett, Andrew. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 2001.
- Bates, Elizabeth. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 9 August.
- Bruce, Nigel, Rogelio Perez-Padilla, and Rachel Albalak. 2000. "Indoor Air Pollution in Developing Countries: A Major Environmental and Public Health Challenge." In *Bulletin of the World Health Organization* 78(9):1078-1092.
- Desai, Nikhil. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 2001.
- Doig, Alison. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 25 July.
- D'Souza, Marcella. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 2001.
- Editorial Board of the China Rural Energy Yearbook [EBCREY]. 1999. *Zhongguo Nongcun Nengyuan Nianjian (China Rural Energy Yearbook) 1998-1999*. Beijing, Zhongguo Nongye Chubanshe.

- Ezzati, Majid, and Daniel M. Kammen. forthcoming. "The Health Impacts of Exposure to Indoor Air Pollution from Solid Fuels in Developing Countries: Knowledge, Gaps, Data Needs, and Policy Options." In *Environmental Health Perspectives*.
- Goldemberg, José. 2000. "Rural Energy in Developing Countries." In *The World Energy Assessment: Energy and the Challenge of Development*. José Goldemberg *et al.*, eds. New York, United National Development Programme: 367-392.
- Heruela, Conrado. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 2001.
- Holdren, John P., Kirk R. Smith, et al. 2000. "Energy, the Environment, and Health." In *The World Energy Assessment: Energy and the Challenge of Sustainability*. José Goldemberg *et al.*, eds. New York, United National Development Programme: 61-110.
- Kammen, Daniel M. 1995. "Chapter 5. From Energy Efficiency to Social Utility: Lessons from Cookstove Design, Dissemination, and Use." In *Energy as an Instrument for Socio-Economic Development* José Goldemberg *et al.* eds. New York: United Nations Development Program. www.undp.org/seed/energy/policy.
- Karekezi, Stephen, and Timothy Ranja. 1997. *Renewable Energy Technologies in Africa*. Nairobi: African Energy Policy Research Network, and London: Zed Books.
- Karve, Priyadarshini. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 2001.
- Katzev, Richard D., and Theodore R. Johnson. 1987. *Promoting Energy Conservation: An Analysis of Behavioral Research*. Boulder and London: Westview Press.
- Krishna, C.V. 2001. Improved Cookstoves: Yet to Be a Success Story. Paper submitted to Shell Foundation, *op. cit.* www.shellfoundation.org/dialogues/household_energy/downloads/CVKrishna.doc.
- Kulkarni, Milind. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 2001.
- National Bureau of Statistics [NBS] (China), Population and Sociological Statistics Department, ed.. 1999. *Zhongguo Renkou Tongji Nianjian (China Population Statistics Yearbook) 1999*. Beijing, Zhongguo Tongji Chubanshe.
- Qiu Daxiong, Gu Shuhua, Peter Catania, and Huang Kun. 1996. "Diffusion of Improved Biomass Stoves in China." In *Energy Policy* **24**(5):463-469.
- Malhotra, Preeti. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 2001.

- Miranda, Rogerio. 2001. Posting to the *Household Energy and Health On-line Forum*. Shell Foundation, *op. cit.* 2001.
- Shell Foundation, Sustainable Energy Programme. 2001. *Household Energy and Health On-line Forum*. www.shellfoundation.org/dialogues/household_energy.
- Smith, Kirk R. 1993. "Fuel Combustion, Air Pollution Exposure, and Health: The Situation in Developing Countries." In *Annual Review of Energy and Environment* **18**: 529-566.
- Smith, Kirk R (Department of Public Health, University of California, Berkeley). 2002. Personal communication. 20 January.
- Smith, Kirk R., Gu Shuhua, Huang Kun, and Qiu Daxiong. 1993. 100 Million Improved Cookstoves in China: How Was It Done? in *World Development* 21:6, pp 941-961.
- Touche Ross Management Consultants. 1991. *Global Climate Change: The Role of Technology Transfer*. Prepared for the UK Department of Trade and Industry and the Overseas Development Administration, London.
- Wang Jiuchen and Chen Yanbin (Division of Renewable Energy, Department of Research, Education, and Rural Environment, Ministry of Agriculture, China). 2002. Personal communication with Jonathan E. Sinton. February 6.
- Zhang Xiliang, and Willem J.H. van Groenendaal. 2001. *The Role of Institutional Support in Energy Technology Diffusion in Rural China*. Paper No. 2001-06. Tilburg, Netherlands: Center for Economic Research, Tilburg University. February.
- Zheng Qishou (Hubei Provincial Rural Energy Office, China). Personal communication with Kirk R. Smith. 21 February.

