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What Makes People Cook with Improved Biomass Stoves?

A Comparative International Review of Stove Programs

Douglas F. Barnes, Keith Openshaw,
Kirk R. Smith, and Robert van der Plas

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(List continues on the inside back cover)

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Cover photo caption: Woman prepares tô, a sorghum dish, in West African trial of improved cookstove during the mid-1980s.

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Contents

Foreword

Technical advances in energy efficiency are crucial for developing countries, especially for the many countries whose populations depend primarily on biomass fuels such as wood, charcoal, and agricultural residues. Overuse of these fuels depletes resources and degrades local environments, multiplies the time needed to collect fuel, and creates indoor pollution that threatens the well-being of the most vulnerable members of households.

Transition toward widespread use of modern energy sources such as petroleum products and electricity has begun in many developing countries, but the sheer increase in the size of their populations, combined with limitations on resources and investments, means that many people in developing countries will remain dependent for some time on biomass fuels. Hence, the introduction of improved biomass stoves can be of immediate and significant benefit. These relatively simple and cost-efficient technologies can double the energy efficiency of their "traditional" counterparts and reduce indoor pollution as well.

Yet however promising such improved technologies may be, experience at many levels of energy sector restructuring has shown that enduring change cannot be achieved solely by technological means. This comprehensive review of the successes and failures of stove programs provides a case in point: no matter how efficient or cheap the stove, individual households have proved reluctant to adopt it if it is difficult to install and maintain or less convenient and less adaptable to local preferences than its traditional counterpart. On the other hand, households have been most receptive when the dissemination process takes full account of the capacities and needs of local stove producers and consumers. The review thus adds weight to a conclusion we have made repeatedly in our work: technical improvements in efficiency must be complemented by appropriate project design and implementation, perceptibly superior services, and proper institutional support, if they are truly to take root.

The review also shows that the best stove programs yield economic as well as environmental and social benefits. For example, in urban areas, where most people purchase woodfuels, the payback time of an improved stove in fuel savings for consumers is sometimes only a few months; because the stoves last considerably longer, cash flow is improved for people even if they cannot not yet make the transition to modern fuels. Likewise, in rural areas, more efficient stoves can reduce the time spent collecting fuel for cooking, freeing time for child care and income-producing activities. Of course, biomass stove programs are not the only answer to energy efficiency problems in developing countries: benefits of other energy efficiency programs will be treated in later technical papers.

This report summarizes a large-scale evaluation of improved-stove programs funded by the United Nations Development Programme, managed by the Energy Sector Management Assistance Programme (ESMAP), and conducted by East-West Center and ESMAP staff. ESMAP will issue a report accompanied by case studies in the near future.

Richard Stern
Director
Industry and Energy Department

Abstract

Hundreds of millions of people rely on woodfuels for most of their energy needs, despite the problems associated with traditional use of woodfuels—including energy inefficiency, deforestation, increasing use of time for collection of fuel, and deleterious health and environmental effects.

Modern, efficient biomass stoves can alleviate some of these problems by reducing some householders' cash outlays for fuel, diminishing the time others must spend to collect fuel, reducing air pollution, and relieving local pressure on wood resources. Yet despite the apparent benefits of improved stoves and a recent spate of "dissemination" programs, many developing-country households have failed to adopt them.

This study explores the successes and failures of stove programs and suggests how adoption rates can be improved more consistently. Programs have been most effective where householders pay relatively high prices for woodfuels; in such cases, the improved stoves can pay for themselves in fuel savings very rapidly, even though they are usually more expensive to produce and buy than traditional stoves. Overall, improved stoves are most popular when they are easily and locally manufactured and have clear advantages in fuel economy, durability, ease of use, and cleanliness.

Under the right conditions, the social, economic, and environmental benefits of promoting improved stoves are large. Programs must be targeted carefully, however, to situations in which people pay high prices for fuel or walk long distances to collect fuelwood or other biomass materials. Subsidies may aid in the distribution of stoves but may not result in actual stove use. External support from donors and international organizations can be helpful, especially if focused on testing or consumer surveys. Ultimately, however, dissemination programs are most effective when they allow for interaction and feedback between stove designers, producers, and users.

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The authors are listed in alphabetical order; all contributed equally to the report. The project on evaluation of improved stoves, on which most of this report was based, was funded by the United Nations Development Programme (UNDP), managed by the Energy Sector Management Assistance Programme (ESMAP), and contracted to the East-West Center (EWC), Honolulu, Hawaii, where the work was conducted and supervised by Kirk Smith. The ideas presented in the paper are based largely on material from the project at the East-West Center and on the ideas and experiences of the staff of ESMAP. In addition, for their useful comments, the authors wish to thank Anthony Churchill, Robert Saunders, Joseph Gilling, Gunter Schramm, Maurizia Tovo, Willem Floor, and Ernesto Terrado of the World Bank. The authors also thank all those listed in Annex 1, who contributed cookstove program evaluation papers to the project. Finally, we thank our colleagues at the Foundation for Woodstove Dissemination, Nairobi (Stephen Karekezi and Catherine Gathoga); the Association Bois de Feu, Paris (Marie-Jo Demante); and the Center for Mesoamerican Studies on Appropriate Technology (Edgardo Caceres), who assisted in conducting the global survey.

Note that ESMAP, which managed the work, is issuing a report that includes the main text and case studies of India, China, and Sri Lanka.

1

Introduction

About half of the world's population cook with biomass for all or some of their meals (Scurlock and Hall 1989). The general pattern in developing countries is that with increasing income people generally move up the energy ladder from firewood to charcoal or kerosene and then to liquefied petroleum gas (LPG), natural gas, or electricity for cooking (Alam and others 1975; Barnes and Qian 1992; Leach 1986, 1988; Jones 1988; Reddy and Reddy 1983; Natarajan 1985). This upward shift occurs most often in urban areas, because in rural areas, scarce cash income, combined with freely available biomass resources, leads people to continue to rely on biomass for cooking. Indeed, when firewood is scarce in rural areas, residents typically move down the ladder to crop residues and dung (a phenomenon commonly seen in Asia), and occasionally they even turn to grass and roots for cooking energy. Another factor impeding the movement toward more modern fuels, in both rural and urban settings, is declining incomes. In many parts of Africa, the increase in national income has barely—or not even—kept pace with population over the last decade, so some households have had to switch back from modern to biomass fuels. In addition, poor distribution systems for modern fuels, especially in smaller cities and towns, have prevented many families from switching to modern fuels.

Even though some movement up the energy ladder can be expected over the next few decades, hundreds of millions of people clearly will continue to rely on biomass as their main source of energy, mostly for the basic needs of cooking and space heating. This continued reliance poses some significant problems with regard to energy and economic efficiency. Most traditional biomass stoves are very inefficient. In controlled tests they use up to six or seven times more energy than non-biomass-burning stoves (Openshaw 1979). Because poor people often cannot afford or obtain modern stoves and fuels, the development of more efficient, energy-saving, and inexpensive biomass stoves can help alleviate local pressure on wood resources, shorten the walking time required to collect fuel, reduce cash outlays necessary for purchased fuelwood or charcoal, and diminish the pollution released into the environment. Yet although the potential benefits of modern, efficient biomass stoves have been obvious since the first discussions of the "fuelwood crisis," and many programs have been undertaken to make improved biomass stoves available to potential users, the stoves have been disseminated far less widely than expected. Two crucial questions thus arise:

- Why, in the face of all of the benefits, have so many potential beneficiaries of improved stoves decided not to purchase or use the stoves when given the opportunity?
- How can stove programs be better organized and targeted to increase the likelihood of bringing these benefits to more people?

This review is an attempt to answer these questions. The study on which it is based attempts to assess the very diverse and mixed success of the hundreds of stove programs that have been implemented worldwide. Failure of relatively new programs is not unusual, of course, but the biggest mistake can be to keep repeating the errors of past programs. The review thus sought to determine whether common threads could be found among the successful programs and among the failed programs that could guide the design of better programs.

The study consists of a review of experiences in stove dissemination, including case studies in Asia and Africa (see Annexes A and B for listings of evaluation documents and projects surveyed, respectively). The components of the review include a description of the importance of stoves for people in developing countries, an assessment of progress and problems encountered in stove programs, experience from field trips to review programs in many developing countries, a global survey of 137 programs, and four in-depth case studies. This paper is based primarily on 12 reports produced under the project (listed in Annex 1). Some background on the emergence of stove programs may provide a context for a discussion of the findings.

2

The Emergence of Stove Programs

The development of wood-burning stoves is not a recent phenomenon. Within the last one hundred years, wood-burning stoves were adopted by middle- and upper-income families when access to petroleum-based fuels was a problem. Among the industrialized countries, enclosed wood or charcoal stoves were used both to cut down on indoor air pollution and to facilitate cooking. In some developed countries, sheet metal was the material of choice for making stoves for the urban poor; in others, it was brick or clay. These designs were developed largely by trial and error. Woodfuels were relatively cheap during most of the past century, so efficiency was not an important factor. As urban populations increased, however, woodfuel supplies became relatively more distant from the markets, prices increased, and some stove makers began more intensive efforts to improve their models and make them more efficient.

In the industrialized countries, the development of woodstoves transpired without outside assistance or intervention, and private companies still market efficient woodstoves for heating without much intervention. Is intervention in promoting improved stoves in developing countries necessary, then? The answer is yes, because incomes today are much lower than they were in developed countries during the transition from wood to coal and other fuels. Concomitantly, indigenous development of efficient and convenient biomass stoves does not appear to be occurring spontaneously in many developing countries, even when woodfuel prices are high, because the population's generally low income inhibits them from investing in stoves. Yet the motivation for dissemination of improved stoves is much greater from the national perspective of today's developing countries, because the population pressure on the biomass resources base is much higher.

The recent spate of improved stove programs focusing on energy efficiency began in the 1970s after the large rise in oil prices. Before the oil shocks, households in many countries were able to shift up the energy ladder to the modern fuels when biomass fuels became more expensive and difficult to obtain. This occurred in South Korea in the 1960s, for example. But because of the increased prices and supply uncertainties of fossil fuels following the oil shocks, developing-country households became less able to make the shift, and some had to fall back on biomass fuels. Thus, it seems that people may have to rely on biomass fuels longer than was typical in the past.

In addition to a desire to rationalize the continuing reliance on biomass fuels, a desire to prevent or mitigate deforestation contributed to the growth of stove programs. A further motivation was that the increasing pressure on biomass resources often results in the burning of crop residues and dung, thus reducing their return to maintain the fertility of the soil (Anderson and Fishwick 1985; Barnes 1990; Digernes 1977; Gorse and Steeds 1987; Hosier and Dowd 1987; Myers 1980; Repetto and Holmes 1983). Although expansion of agricultural lands and poor forestry practices, rather than fuel gathering as such, are more often the leading causes of deforestation, fuel gathering is becoming more difficult for households. Most developing countries now have regions where existing biomass use patterns are unsustainable (Bajracharya 1983). In effect, because it was understood that deforestation problems were often location-specific (i.e., more so than had been assumed), improved cooking end-use efficiency and increased supply programs are seen as viable options for helping to restore local supplies to sustainable levels.

With higher oil prices, increasing deforestation, and talk of an impending "fuelwood crisis," governments, donors, and nongovernmental organizations (NGOs) started to finance and develop stove programs. The principal justification for intervention was that the relatively rapid changes in fossil fuel prices, urbanization, economic conditions, and population densities were such that the natural innovative and entrepreneurial processes for stove development and dissemination were not receiving the proper price signals and other information and resources necessary to keep up with the changes.

Conventional wisdom at the time considered existing traditional, "three stone," biomass stoves to have energy efficiencies of only 5 to 10 percent. Of course, these stoves have other benefits, including space heating, protection from insects, and the flexibility to use a wide variety of fuels in different seasons. Initial efforts seemed to show that fairly simple design changes could create biomass stoves with three to six times the efficiency of the simple traditional stoves. Believing that this seemingly huge efficiency benefit would serve as an adequate incentive for adoption of new stoves, a number of organizations launched stove programs around 1980. These efforts yielded or suggested a mixed array of lessons and further reasons for promoting the adoption of improved stoves.

3

Reasons for Promoting Improved Stove Programs

In addition to supply strategies such as improved tree management and tree planting, two basic demand-side strategies can be applied to the problems of deforestation and fuel affordability mentioned in the previous section. The first is to *take steps to accelerate the natural tendency for households to move up the energy ladder to the modern fuels*. This might be done by making modern fuels more accessible or by subsidizing modern fuels such as kerosene and LPG. Subsidies, however, create other problems by encouraging wasteful use of these fuels elsewhere in the economy. Thus, to work, fuel substitution schemes must be targeted at households that are still using biomass but that would move to modern fuels if they had the proper incentives. Note that this is not simply a matter of making modern fuels cheaper to the consumer than biomass: In many urban situations, kerosene or LPG costs actually are less than daily biomass fuel costs (Alam and others 1985). Here, it is often the larger lump-sum cash investment needed to purchase petroleum-based fuels and stoves that inhibits fuel switching.[1] In such cases, loans or subsidies for appliances and bulk fuel purchases may be an answer.

The second demand-side approach is to introduce improved stove technology *as a new step in the energy ladder between traditional biomass stoves and the modern fuels and appliances*. This approach is appropriate in the many parts of the developing world where modern fuels are not available or will not be affordable in the near future, so that people will have to continue to rely on traditional fuels. If improved biomass stoves were adopted on a large enough scale in such settings, they would reduce the pressure on biomass resources. In addition, a deliberate slowing of the transition to modern fuels may sometimes be warranted. In China, for example, many rural households have been moving up the energy ladder to coal, which, because of the recent opening up of the rural economy, is widely available in many areas that do not have official supplies (ESMAP/Univ. Pennsylvania 1991). This in turn has contributed to severe problems in coal supply, so the

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1. The prices of cooking fuels vary significantly among countries. In some, the price of woodfuels is competitive with modern fuels; in others, it is below the alternatives (see Barnes 1991 for a review of woodfuel pricing issues). The situation is complicated by government policies. For example, in Zambia (ESMAP 1991c), subsidized electricity is cheaper than charcoal for cooking, and in Burkina Faso, where LPG is taxed, wood is cheaper (ESMAP 1986).

Chinese government would like to slow or even reverse the movement of households to coal (Smith and others 1993). The government has included improved biomass stoves as a part of the strategy.

The two classes of benefits that are at the core of most improved stoves programs are their environmental/health and socioeconomic impacts. As indicated, the main justifications given by sponsors for promoting improved stoves have been to alleviate pressure on the natural resource base, to use energy in a cost-effective and efficient way, and to provide a means for the poor to reduce their high expenditures on energy.

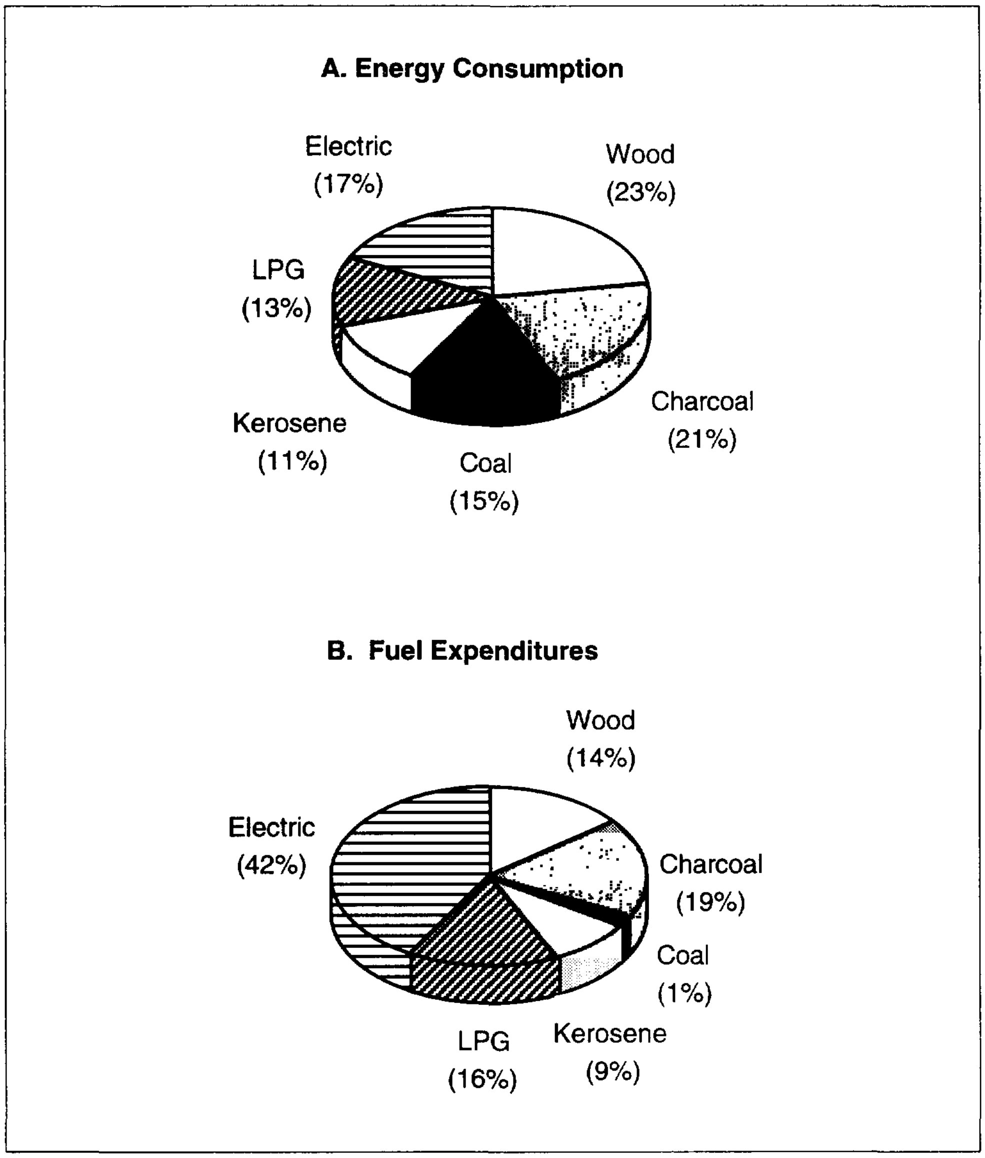
The main beneficiaries of improved stove programs are women and those in the middle- and lower-income levels of society (Eckholm 1983). Recent surveys in urban areas indicate that the lowest 20 percent of the population spend close to 20 percent of their cash income for energy—most of it woodfuel (see Figure 1). More efficient stoves would free some of this cash for other uses and would constitute a substantial benefit for the urban poor. In rural areas, where most people collect rather than purchase fuelwood, the use of more efficient stoves can reduce the time allocated to collection, which can be significant, especially for women (see Box 1). The time saved, in turn, can be freed to earn cash or produce other goods and services.

The economic and environmental impacts of adopting improved stoves also can be quite significant for communities. Where wood is being harvested faster than it is being grown, the use of more efficient stoves to reduce demand for wood to sustainable levels is usually more economically viable than planting new trees, at least initially. It must be cautioned, however, that if wood-fired cooking is made more affordable through improved stove efficiency, people may cook longer than before—for example to boil water more often, as observed in Sri Lanka (Bialy 1991b)—and hence the actual savings of wood may be less than the difference in efficiencies between the traditional and improved stoves. Moreover, benefits of improved stoves are diluted in cases such as Kenya, where some households that were using other fuels switched back to charcoal when efficient stoves were introduced (Jones 1989, p. 42). It should be emphasized, however, that even when the overall savings in wood or charcoal are small, there can be a significant improvement in welfare because people are more productive with the same amount of fuel. Thus, in designing monitoring and evaluation systems for improved stove programs, it may not be enough to look at fuel savings alone.

For people who cook indoors with wood in an unventilated or partially ventilated kitchen, the introduction of improved stoves with chimneys or other means to reduce exposure to the health-threatening pollutants found in biomass smoke is a significant benefit. Studies in recent years have associated a number of health problems with smoke exposure (see Box 2). The *World Development Report* has classified indoor air pollution as one of the four most critical global environmental problems (World Bank 1992, p. 2). More research is needed, however, before quantitative estimates can be made of the amount of ill-health that can be reduced by improved stoves. In any case, because of their greater insulation, most improved stoves are less hot to the touch and hence safer for the cooks and their children. A healthier and safer environment—particularly for women and children—

may be one of the most important potential contributions of improved stoves to ameliorating the cramped living conditions of many poor people.

Figure 1. Average Household Energy Consumption and Fuel Expenditures in 45 Cities



Note: The 45 cities are located in countries including Bolivia, Haiti, Yemen, Indonesia, the Philippines, Thailand, Cape Verde, Mauritania, Burkina Faso, Zambia, and China.

Source: ESMAP Household Energy Surveys.

Box 1. Some Benefits of Improved Stoves for Women and their Families

Many of the benefits of stove programs directly affect the lives of women, especially those in the lower and lower middle classes who cook with woodfuels. The cases presented below illustrate some of these benefits for rural and urban areas, respectively.

Rural Nepal

For rural areas, the benefits of improved stoves consist mostly in the saving of time spent collecting fuel. A recent survey on the hill areas of Nepal, for example, estimated that women there spend about 2.5 hours per day collecting fuelwood, fodder, and grass. In high-deforestation areas, the time required to collect a standard headload of wood increased by 1.1 hours per day, and time devoted to agriculture fell by about 1 hour. The burdens fell mostly on women.

The Nepal results represent a severe case, but it is evident that adoption of improved stoves can reduce time spent collecting fuel, lighten the labor burden on women, and free time for productive farming.

Urban Sub-Saharan Africa

Households in urban areas are more likely to purchase biomass fuels. Improved stoves help urban families both save money and cook more conveniently.

- In Niamey, Niger, an improved stove uses about 0.42 kilograms (kg) per person per day, as opposed to the 0.57 kg per person per day consumed by the typical traditional stove used in Niger. Total family savings for a year amount to about 335 kg of wood, valued at 5,360 CFA ($15.3).
- In Rwanda, the savings with improved charcoal stoves are even greater. There, consumption of charcoal dropped to 0.33 kg per person per day from 0.51 kg per person per day. This means that in a year a family could save about 394 kg of charcoal worth 6,310 Rwanda Francs ($84.1).
- In Kenya, average daily charcoal consumption with an improved stove fell to 0.39 kg per person per day from the 0.67 kg per person per day devoured by the traditional stove. This adds up to a total yearly savings of 613 kg per family, with a value of about 1,170 Kenya shillings ($64.7).

Savings on the order of $15 to $84 are substantial for families in countries such as Niger, Rwanda, and Kenya, where average incomes per person are only $300 to $370 per year. In addition to their overall economy of use, the improved stoves are affordable to purchase. They are also attractive, convenient, and less polluting.

Sources: Jones (1989); Kumar and Hotchkiss (1988); ESMAP (1991a, b).

In addition to its localized social and environmental effects, biomass energy use also has implications for greenhouse gas emissions and the consequent chance for global warming. Here, the benefits of improved stoves are several. To begin with, the improved biomass stoves reduce emissions of carbon dioxide to the atmosphere. Moreover, as explained in Box 3, the potential benefits are even greater than indicated by an examination of carbon dioxide emissions alone. Because traditional biomass stoves often have low combustion efficiencies, they can release large amounts of the products of incomplete combustion. Like carbon dioxide, most of these products are also greenhouse gases, but with even higher global warming potentials. Thus, the potential benefit of stoves that increase combustion efficiency is likely to be substantially greater than has been recognized. Finally, combining high-efficiency combustion techniques with sustainable biomass harvesting practices represents one of the most "greenhouse friendly" energy strategies presently available.

Box 2. Health Effects of Biomass Smoke

Biomass fuels such as wood, crop residues, and dung release large amounts of air pollutants when burned in simple household stoves. Hundreds of different substances are involved, including respirable particulates, carbon monoxide, nitrogen oxides, formaldehyde, and other simple and complex hydrocarbons. In many parts of the world, these pollutants accumulate in poorly ventilated homes or enclosed courtyards. The resulting human exposures may exceed recommended World Health Organization levels by factors of 10, 20, or more.

Several recent studies have identified prolonged exposure to biomass smoke as a significant cause of human health problems. Some key findings are presented below.

Acute Respiratory Infections in Children

Studies in developed countries indicate that acute respiratory infections can be caused by urban environmental pollution and indoor tobacco smoke at levels 10 to 30 times less than levels typically found in village homes. It is hardly surprising, then, that after diarrhea, acute respiratory infections are the chief killers of children in developing countries and cause more episodes of illness than any other disease.

Direct studies of the health effects of biomass in developing countries were completed recently in Nepal, Zimbabwe, and The Gambia:

- Investigators in Nepal found a strong relationship between the reported number of hours per day children stayed by the fire and the incidence of moderate and severe acute respiratory infections. The work involved about 240 rural children under 2 years of age who were examined each week for six months.
- In Zimbabwe, 244 children less than 3 years old who were taken to a hospital with acute respiratory problems were compared with 500 young children who were seen at a Well Baby Clinic. Presence of an open wood fire in the home was found to be a significant factor among the hospitalized children.
- A study of 500 children under 5 years of age in The Gambia found that girls who were carried on their mothers' backs as they cooked in smoky huts had a risk of acute respiratory illness 6 times that of other children, a risk substantially higher than that from parental smoking.

At present, these findings are only suggestive, because so many other risk factors are involved.

Chronic Lung Disease and Cancer

Chronic lung disease and cancer, for which tobacco smoking is the major risk factor in developed countries, are known to be outcomes of excessive exposure to air pollution.

- Studies in Papua New Guinea and India show that nonsmoking women who have cooked on biomass stoves for many years exhibit a higher prevalence of chronic lung disease than might be expected or than that found among similar women who have had lower levels of exposure to cooking smoke.
- In rural Nepal, about 15 percent of nonsmoking women had chronic bronchitis—a high rate for nonsmokers.
- A study in Japan found high rates of cancer in women who had previously used wood as a fuel. However, the results are mixed with regard to cancer: women's lung cancer rates in rural areas of developing countries are low.

The risk factors for both diseases are difficult to measure precisely because the exposures that cause the ill health occur years before symptoms appear. More research is thus necessary.

Other Problems and Challenges

In addition to contributing to the respiratory diseases discussed above, exposure to cooking smoke seems to cause or exacerbate eye problems and to harm newborns.

Research is still needed on how much ill health could be reduced by pollution-control measures such as installing improved stove systems.

Sources: Smith (1987, 1991a).

Apart from the benefits described above, improved stoves can have many important social benefits (see Jones 1989, pp. 39-41, for a list). They may save cooking time because of their higher power output and thermal efficiency or because they are easier to light. They may reach desired cooking temperatures more quickly than conventional stoves and maintain them longer, enabling the cook to save time and effort in preparing the meal and tending the fire. An enhanced quality of life may also derive from use of improved stoves. For example, traditional stoves often release smoke and soot that discolor walls and clothing. Improved stoves do so to much less an extent. Improved stoves also often are more attractive and convenient; for example, they may have two burners, a mechanism to control the power output, spare parts for quick repairs, and a handle for carrying. In several countries, improved stoves have become status symbols as well as better cooking devices. Finally, stove programs that encourage the participation of local women have been an effective way to enhance women's social status in general.

Offsetting some of their benefits, improved stoves are sometimes more temperamental than traditional stoves. A common reason for this problem is that stove designers, in their desire to reduce heat loss, provide too small a hole for adding fuel, requiring the cook to spend much time in cutting the wood into small bits that fit in the hole (Openshaw 1982). In addition, some design changes intended to increase heat transfer efficiency by decreasing air flow can actually increase smoke emissions. Conversely, efforts to reduce smoke exposure by introducing chimneys can reduce efficiency. Clearly a balance must be sought among the perceived and real social benefits, which depend both on the stove and on the cooking customs of the people who use it. In some areas, there just may not be a balance between these factors that will permit the production of affordable stoves.

The main justifications for improved stove programs are economic, social, and environmental. The stoves save money and time for householders; help alleviate the environmental problems and economic externalities of overharvesting of trees; and have social and health benefits, especially for women and children. As suggested, each program will face a distinctive set of challenges and benefits, depending on local conditions. Planners thus should strive to anticipate the particular circumstances of each program so that it can be tailored to increase the probability of stove adoption.[2] But if each program is distinctive and none universal, are there yet common elements that provide some general lessons for maximizing the success of a program?

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2. During the period of the study, two other international groups have been engaged in efforts to improve the monitoring and evaluation (M&E) approaches used for improved cookstove programs. The Food and Agriculture Organization (FAO) has sponsored the development of guidelines for M&E (Joseph 1990), which have been reviewed and may be revised. With funding from the German government, the Gesellschaft für Technische Zusammenarbeit (GTZ) and the Intermediate Technology Development Group (ITDG) have undertaken to develop a draft of M&E guidelines (Crewe 1991) and test them within a number of ongoing stove dissemination programs in developing countries (Klingshirn 1991). These guidelines are to be tailored to specific economic, social, and environmental objectives, such that each stove program can choose a mix of objectives to suit their needs. The principal investigator's three projects (ESMAP/EWC/UNDP, FAO, and GTZ/ITDG) have attempted to avoid excessive overlap.

Box 3. Total Global Warming Potential of Biomass Combustion

Carbon dioxide is the principal and best-known greenhouse gas produced by biomass combustion, but it is by no means the only one. Biomass fires also create products of incomplete combustion (PIC) that are even more powerful greenhouse gases per gram of carbon emitted. Among the PICs are methane, carbon monoxide, and higher hydrocarbons.

Traditional biomass stoves, because of their poor combustion efficiencies, may emit more than 10 percent of their carbon as PIC, whereas improved stoves emit mainly carbon dioxide and water vapor. Hence, because PICs on average have higher Global Warming Potentials (GWPs) than carbon dioxide, the total impact of introducing improved stoves can be substantially higher than indicated by an evaluation based on the traditional and improved stoves' comparative emissions of carbon dioxide alone.

This finding has several tentative but potentially important policy implications. First, the larger-than-anticipated greenhouse gas benefit of changing from a traditional to a clean-burning biomass stove provides an additional incentive for international support of improved stove programs. Second, where fuelwood is not harvested sustainably, a greenhouse benefit can derive from shifting up the energy ladder to kerosene or LPG or from improving the sustainability of fuelwood use. Third, the typical, inefficient charcoal kilns used in developing countries give off substantial emissions of PIC; the total greenhouse impact of the charcoal fuel cycle thus may be much greater than that of a comparable fuelwood cycle. This argues for efforts to improve kiln efficiencies and to encourage fuel switching by charcoal users.

The general impact of these findings is that the GWP of traditional biomass stoves may be larger than has been recognized because of the potential higher PIC emissions. In addition, the incomplete combustion in traditional stoves robs some of the energy contained in the fuel and imposes health problems on the households. Although most of the overall GWP is offset by the fact that much of the fuelwood used in households comes from a renewable resource, the high levels of PICs emitted by traditional stoves still provide strong incentives to introduce stoves with high combustion efficiencies.

*Sources:*Smith (1991b); Floor and van der Plas (1992).

4

General Lessons from Stove Programs

The diversity of stove programs is an outgrowth of the participation of many governments and donors in funding projects or components of other projects (see Annex 2 for a partial list). In effect, stove interventions took many forms, some directed toward rural areas, where biomass is collected, and others toward urban areas, where woodfuel is traded commercially. In addition, programs for stoves that conserve wood and other biomass can be different from those that conserve charcoal.

The early programs assumed that people would adopt the improved stoves quickly and that an initial intervention would lead to a self-sustaining program. Indeed, the work on stoves continually refers to "stove dissemination," which seems to imply that the improved stove need only be distributed to be adopted and that it is intrinsically and obviously superior to the traditional stove just because it has greater energy efficiency. As a consequence of this perhaps naive thinking—oblivious to the influence of custom, setting, and circumstance—many programs failed. (For critical reviews of early efforts, see Agarwal 1983; Foley and Moss 1983; Manibog 1984; Baldwin and others 1985; Gill 1987; and Krugmann 1987.)

The clearest of the lessons learned from early experience is that the chances of success are enhanced when people have an explicit need to save fuel, when the new stoves are a significant improvement over the local traditional stoves, and when stoves can be made readily available by local industries or artisans at affordable prices (see Box 4).

A lesson from the early failures was the fallacy of expecting gains in stove efficiencies that were "proven" in laboratory or other controlled settings. Too many programs started with unrealistic expectations that a successful improved stove should decrease fuel consumption by 75 percent or more. Such claims are still heard sometimes, but it has become clear that stoves used in real households never perform as well as those in controlled test settings. Most people in the stove community now agree that a 50 percent decrease in fuel consumption should be considered a major achievement and that programs should be content with savings of 25 percent or even less.

Profound changes in perception have resulted from examinations of early programs. First, planners are now applying more consistent measures of efficiency.

Second, it is now understood that women in fuel-short areas often are able to achieve efficiencies in their traditional stoves substantially greater than the 6 percent assumed in many analyses. Finally, planners have shed expectations that huge improvements in efficiency alone would make stoves irresistible and that they would need to do little monitoring, sampling, or statistical work to assess programs' efficacy.

Box 4. Possible Reasons for Success or Failure of Stove Programs

Reasons for success	*Reasons for failure*
• Program targets region where traditional fuel and stove are purchased or fuel is hard to collect.	• Program targets region where traditional fuel or stove are not purchased or fuel is easy to collect.
• People cook in environments where smoke causes health problems and is annoying.	• People cook in the open, and smoke is not really a problem.
• Market surveys are undertaken to assess potential market for improved stoves.	• Outside "experts" determine that improved stoves are required.
• Stoves are designed according to consumer preferences, including testing under actual use.	• Stove is designed as a technical package in the laboratory, ignoring customers' preferences.
• Stoves are designed with assistance from local artisans.	• Local artisans are told or even contracted to build stoves according to specifications.
• Local or scrap materials are used in production of the stove, making it relatively inexpensive.	• Imported materials are used in the production of the stove, making it expensive.
• The production of the stove by artisans or manufacturers is not subsidized.	• The production of the stove by artisans or manufacturers is subsidized.
• Stove or critical components are mass produced.	• Critical stove components are custom built.
• Similar to traditional stove.	• Dissimilar to traditional stove.
• The stove is easy to light and accepts different-sized wood.	• The stove is difficult to light and requires the use of small pieces of wood.
• Power output of stove can be adjusted.	• Power output cannot be easily controlled.
• The government assists only in dissemination, technical advice, and quality control.	• The government is involved in production.
• The stove saves fuel, time, and effort.	• The stove does not live up to promised economy or convenience under real cooking conditions.
• Donor or government support extended over at least 5 years and designed to build local institutions and develop local expertise.	• Major achievements expected in less than 3 years, all analysis, planning, and management done by outsiders.
• Monitoring and evaluation criteria and responsibilities chosen during planning stages according to specific goals of project.	• Monitoring and evaluation needs are not planned and budgeted, or criteria are taken uncritically from other projects or not explicitly addressed.
• Consumer payback of 1 to 3 months.	• Consumer payback of more than 1 year.

It would not be easy or fruitful to assign blame for this situation, because it resulted from actions of many different people, all with the best of intentions. Indeed, perhaps the failures were inevitable steps in the progress of stove programs, necessary to entice a sufficient number of people into the field to bring success. In any case, the definition of success itself now has a substantially different color than in the early 1980s. Its quantifiable goals, such as changes in fuel use, are more modest, and its qualitative indicators, such as improvement in convenience, have more legitimacy (see Clark 1985; Caceres and others 1989; and Viklund 1989).

The Stove Market and Consumer Preferences

One specific lesson of importance is that programs have a better chance of succeeding in areas where *people already buy both the fuel and the stove* (see Box 4 and the matrix in Box 8), generally in urban and periurban areas. In many rural areas, fuelwood is not difficult to gather, and there is little pressure to conserve fuel. In some rural areas that have few remaining trees, however—for example, where fuelwood has already been harvested for urban consumption or in arid regions where trees grow back very slowly—rural people may be interested in saving fuel because it is not readily available from the local woodlands. A sure sign of fuelwood shortage is when people, especially women, spend increasing amounts of time collecting fuelwood or have switched to crop residues or dung. The latter two fuels, in addition to being less convenient, efficient, and clean, have better alternative uses as soil conditioners. In short, many programs have failed because the target groups have no shortage of wood or do not perceive shortages and thus see no pressing reason to adopt improved stoves.

Another market or consumer-preference problem involves stove design and production. Some stoves are designed in the laboratory and then manufactured without prior field testing to verify that they actually perform the necessary tasks for persons who prepare meals. In an early stove program in East Africa, for example (Openshaw 1982, 1986), the laboratory-designed stove had a large, insulated collar. This, in turn, required the manufacture of various sizes of stoves to fit the different sizes of pans people used. In addition, the insulation and extended collar made the stove heavy and difficult to move, while the insulation, though a boon to efficient combustion, allowed the inside of the stove to become too hot and to fail rapidly from metal fatigue.

Some programs have had difficulty because they assumed that if a stove is adopted in one part of a country it will be acceptable in other areas despite significant regional differences in cooking habits and needs. A good example of this was a Nepalese stove that was distributed in all areas without being adapted technically to the various environments present in Nepal, although the extension component of the stove programs was good (Pandey 1991). Another problem was that over a nine-year period about 18 different projects undertook stove dissemination; coordination has since improved (Shrestha and others 1991).

People seldom adopt innovations without good reason. Because it is women who most often use stoves, the stoves should be marketed to give them good reason to prefer improved to traditional stoves. In some cases, stoves that are similar to traditional stoves in appearance and function but are more attractive and at least equally easy to use have been adopted quickly by consumers. Similarity is not a universal requirement, of course, but ease of use may be. Improved stoves that have complicated features or require extra work may not get any use at all. This was clearly the case in a program in Kenya, where a custom-made improved woodstove that took about 2 to 3 days to install failed because women had neither the time nor the tools to cut the wood to the small size required by the stove's restricted firebox (Openshaw 1982). In fact, many of the people who did adopt that stove ended by enlarging its firebox, knowingly sacrificing energy efficiency for convenience. On the other hand, a new Kenyan charcoal stove, although a distinct improvement over the traditional model, was similar in function to the existing stove and was quickly adopted (Karekezi and Walubengo 1989).

The price of stoves can be a significant barrier to their adoption. Improved woodfuel stoves are typically about twice as expensive as the local traditional stoves. Although in the long run improved stoves save money, the initial cash outlay required may prevent poorer people from affording the stove. Surveys reveal that in most of Africa, middle-income families have adopted improved stoves far more quickly than poor families (Jones 1989). Governments and donors could assist by subsidizing stoves for poor families, but, generally, subsidizing stoves is risky as a promotion strategy. To be authentically attractive to low-income households and to have the greatest chance of being put to sustained use, improved stoves should have a quick payback period. In urban Rwanda—where the price of charcoal is quite high—the payback period for improved stoves is less than a month (see Box 5), and the stoves have been widely adopted without subsidies. High wood prices or scarce supplies of wood increase the likelihood of stove adoption. For the same reason, the improved stoves should be as durable as the traditional stoves, with replacement parts (such as grates) readily available and inexpensive.

For assessing consumer needs and program viability, surveys, consumer panels, and other techniques should be undertaken to determine the existing patterns of stove use, the factors people consider when purchasing new stoves, the person who makes the decision to purchase a stove, and whether income and fuel savings will provide adequate incentives for stove adoption (Baldwin 1987). The improved stoves should be designed around the utensils used and food dishes typically prepared. Stoves must be field tested to make sure that they are acceptable to the prospective consumers, especially women. They should also be modified or redesigned to meet regional requirements (Stewart and others 1987). In the development stage, the stoves should be monitored to determine how best to meet the needs of those using them. These objectives are only met by enlisting the active participation of the users (Cecelski 1984; Tinker 1985; Agarwal 1986; Sarin 1989). Differences among programs have proved even more important than differences in local conditions in explaining the relative successes of stove dissemination (Fraser 1987).

Improved efficiency has been the main goal of many programs, but it is not the only goal. Other improvements may incorporate heat control, a door to modify air inflow, removal of smoke through a chimney, safety features such as insulation to cool outer surfaces, and a more attractive finish. This raises the key question of the processes by which improved stoves are designed, manufactured, and marketed.

Box 5. Financial Benefits of Improved Stoves in Urban Rwanda

Because of extensive use of fuelwood in rural areas, charcoal accounts for only a small percentage of total energy consumption in the country. However, it is the main urban cooking fuel, accounting for 80 to 85 percent of total energy demand. Urban households use charcoal because existing wood resources are distant, and charcoal is perceived to be a more modern fuel. Rwanda's charcoal price is high compared with prices in many other countries in Africa. As a consequence, the potential savings for adopting an improved stove are dramatic. The fuel savings during the first month's use of an improved stove actually pay for the stove. With the incremental investment of about US$2 for improved rather than traditional stoves, a family saves US$113 over 18 months (present value of the investment and savings).

The figures presented below are based on surveys of existing stoves under actual use by families in urban areas in Rwanda. A traditional stove in Rwanda lasts about 9 months, and an improved stove lasts about 18 months, with some maintenance. The cost savings were calculated over an 18-month period, the useful life of one improved stove. Because most urban families in Rwanda use two stoves, the calculations for both the improved and traditional stoves are based on two stoves.

Financial Comparison of Costs of Traditional and Improved Stoves for an Average Urban Family in Rwanda, 1991

Present value of costs over 18-month lifetime of two stoves	*Imbabura (traditional stove)*		*Rondereza (improved stove)*		*Cost savings of the improved stoves*	
	Francs	*US$*	*Francs*	*US$*	*Francs*	*US$*
Cost of two stoves	777	10	891	12	–114	–2
Cost of fuel	25,591	332	16,694	217	8,896	115
Total costs	26,368	342	17,585	229	8,782	113

Note: The discount rate used in the analysis is 12 percent. The dollar figures are somewhat high because a short time after the surveys the currency was devalued from 77 francs to 125 francs per U.S. dollar, and the price of charcoal did not change during this period. In addition, the survey involves average fuel savings between households using either improved or traditional stoves rather than before-and-after testing.

Stove Design and Manufacture

Even though use of biomass energy is nearly as old as the human race and has been the subject of scientific attention for many years, much remains to be learned about biomass combustion. In particular, reliably achieving high fuel efficiency and low emissions with low-cost devices that meet local cooking needs has turned out to be a much more challenging technical goal than originally thought. Despite the relatively small amount of research and development funding that has been available (Chomcharn and Gujral 1991), however, significant progress has been made in understanding the most important technical design principles (see Prasad and others 1985; Baldwin 1987; Stewart and others 1987; Nijaguna and Uppin 1989; and Bussmann 1990).

In the first part of this section, the process of designing the stove is discussed. This is followed by an analysis of the manufacturing process.

Good engineering principles must be matched by effective involvement of local artisans and users if efficient stoves are to be put into widespread use. The stove maker should be involved in the design because efficiency and construction standards conceived in the laboratory may make the stove too complicated to produce profitably. The improved Zambian charcoal stove, for example, was designed originally with a straight sliding door that took eight different pieces of metal to make. A hinged door, albeit with not as good air control, has four metal pieces and is much more practical to assemble (Walubengo 1989; Zambia, Department of Energy 1988). Also, the ash box of the original Zambian stove occupied two-thirds of the stove—a pointless feature given the negligible quantities of ash produced by charcoal combustion. A small ash box built on legs would save a third of the metal. This stove was designed without inputs from the artisans. Now, in anticipation of production, local artisans are modifying the designs.

The fuel savings that can be attained in a laboratory often have little relationship to savings possible under field conditions. A 10 to 20 percent efficiency improvement in controlled settings is likely to turn out to be a negligible improvement when the stoves are used under normal household conditions. Also, some initial efficiency improvements may come from better and more careful cooking practices, often a result of the stove dissemination programs rather than of the stoves themselves. It may take a 30 to 50 percent improvement in controlled settings to be sure of a substantial energy saving in the home. The first "energy-efficient" Lorena-type stoves introduced into Central America, for example, did not save much fuel and were mostly abandoned, although a few were retained because of their convenience and smoke reduction.

Improved stoves have to compete with traditional stoves, which are invariably made of local or scrap material (Baldwin 1987). Clay stoves often use local material, but they sometimes require machines in the manufacturing process. If scrap metal is used, the stove's appearance can be improved by painting. Stove makers in Thailand make the outer metal cladding from misprinted cola can sheets that are imported very cheaply (Openshaw 1979). The improved Gambian stove, however, was made from heavy-gauge imported sheet steel and thus was too expensive for most people to buy.

In designing stoves, it is crucial to consider the needs of the main consumers—women. The different styles of cooking in various countries dictate different stove designs. It is a good idea to introduce an improved stove design into a selected set of households on a trial basis early in the program. Over time, this design can be modified and improved (Hyman 1987), avoiding the problem of, for example, the Kenya stove that required wood to be cut into very small pieces—a task for which the users had neither time nor tools (Jones 1989).

Stoves that are mass-produced by a group of artisans or a small factory will be disseminated far more quickly than custom-built models whose construction and installation may depend on the availability of trained technicians or installers. A metalsmith in an artisanal or factory setting can make many more stoves per day than an on-site stove maker, and a potter working in a mass-production setting can produce batches of 50 to 100 items such as ceramic inserts. Thus, 2 or 3 workers could turn out approximately 2,500 to 5,000 mass-produced stoves each year, whereas 20 to 40 trained installers would be required to produce the same number of custom-made stoves. China's program was slowed initially by such a custom-built approach, although the program is now moving to mass-produced inserts and parts (Smith and others 1993).

Another advantage of centralized production is that it facilitates the quality control necessary to ensure reliable improvements in fuel savings. Quality control is certainly difficult to ensure when householders themselves build the stoves, and it is probably quite uneven even when trained builders/installers perform the work on site, because small variations in the specified dimensions of the stove's interior ceramic or metal parts can cause critical decrements in the stove's efficiency. Recognizing this, administrators of most stove programs (including the two largest, in China and India) are now moving toward centralized, artisanal production for the interior parts of improved stoves (Qiu and others 1990; Ramakrishna 1991a; Tata Energy Research Institute 1987, 1989; Operations Research Group 1989). Installers and householders still can have important roles in building the rest of the stove around the critical parts.

A factor that planners also must consider if they wish dissemination programs to succeed is that the artisans or stove producers must make at least the same profit from an improved stove as they do from a traditional one. If more effort is required to make an improved stove, more profit is required. The profit motive is often critical to a successful stove program, even in China, where many stoves are made in locally organized companies. The benefits of the profit motive can extend to the involvement of artisans in the sale or distribution of the stoves. For example, artisans are already involved in distribution or marketing of stoves in many countries by extending credit to make the purchase of stoves possible or by demonstrating the stoves as a way to sell them. In Tanzania, the stove makers were involved in the sale of stoves, and the program has been quite successful (Kinyanjui 1991). In Botswana, on the other hand, the stove producers were paid by the government on a piecework basis, and the government is now storing many of the stoves that were produced (Openshaw 1986).

The common theme in many successful programs is that the stove makers have been independent entrepreneurs actively participating in the design and even sale of stoves. Although not requiring great subsidies, they generally need technical assistance, both in designing the stoves and in marketing them to local people. A principal role of governments and donor agencies in successful programs thus has been in technical support and assistance in determining where demand is strongest.

The Role of Governments and Donor Agencies

The levels of financial support that stove programs require from governments and donors are generally modest. Programs do, however, require a long-term commitment for project continuity. A global survey of stove programs outside of India and China revealed that the total amount spent on 137 programs was about US$20 million spread over five years (Ramakrishna 1991b). Even the huge Chinese program, with 120 million improved stoves, and the greatly subsidized Indian program, with 8 million improved stoves, have not spent large amounts by most standards. Program costs per stove in use run from less than $2 for the Chinese program to just over $4 per stove in India. This might be compared with the typical cost to utilities of hundreds of dollars per rural household for installing a minimal electrical capacity (100 watts).

From an institutional point of view, the programs that have had the greatest success are those in which the government was not involved in the production or sale of the improved stove. China and India, which have the largest stove programs by far, illustrate this point dramatically (see Box 6). Central planning and reliance on numerous layers of bureaucracy have hindered many programs in India (Ramakrishna 1991a), whereas small inputs for vital technical and management support combined with local stove production in China have brought much success (Smith and others 1993 in press). India, however, has been able to learn from its experience and has been modifying its program accordingly. Such experiences suggest that the objective of any improved stoves program should be the promotion of a self-sustained dissemination of improved stoves, where possible, using existing commercial distribution and retail marketing channels.

Governments and donors can assist in formulating a policy framework that provides incentives to private sector operators to engage in the production, distribution, and sale of improved stoves. The elements of such a policy framework would include criteria for approving stove projects, credit facilities for stove makers, facilitation of availability of raw materials, and promotional support. In Rwanda, the government provides promotional support to stove programs and is preparing a household energy sector policy that will include quality criteria for stoves that may be sold (ESMAP 1991b). Authorities also can monitor the implementation of the policy framework (see Box 7). The monitoring would include fuelwood consumption impact surveys and stove quality control tests.

Governments and donors also can provide stove makers or stove sellers with technical and managerial assistance. This could include support for applied stove research and testing of clay and insulation materials. In China and India, both governments provided stove programs with extensive applied research inputs on stoves and on stove-making materials. A major part of the difficulty in the Nepal program, in contrast, has resulted from the scarcity of resources for technical assistance to the programs (Shrestha and others 1991).

Box 6. A Comparison of Stove Programs in India and China

Between 1982 and 1990, the Chinese National Improved Stoves Program reported the installation of improved stoves in more than 120 million rural households. These are mainly biomass stoves used for cooking, but they included dual-use stoves for cooking and heating in the Northern States, where temperatures are very low during the winter. Perhaps 90 percent of improved stoves installed worldwide were in China. Improved stoves are affordable, and the government contribution is very low compared with some other programs. An improved stove in China costs about 45 yuan ($9), and the government contribution to the program averages about 4.2 yuan per stove ($0.84). Although early programs experienced problems, the benefits of more recent programs in China have been substantial.

The Indian program, initiated in 1983, is called the National Programme on Improved Chulhas. So far, about 8 million improved stoves have been disseminated to rural households; the target for this year is 1.8 million. The stoves have a minimum 50 percent government subsidy of about 70 rupees ($4.30) per stove. Although the dissemination levels have been impressive, follow-up surveys suggest that only about half of the improved stoves are still in use. Some reasons for discontinuing their use are that the stoves did not really save energy, did not eliminate smoke, and were incompatible with cooking habits. Other surveys found that adopters felt that their stoves were consuming less energy and producing less smoke. Obviously, these mixed perceptions indicate a diversity of results in implementation.

Several lessons can be learned from the two stove programs. The greater success in China can be attributed to program design and implementation, including the factors shown below.

China	*India*
• The program concentrated efforts on areas of greatest need and selected pilot counties with biomass fuel deficits.	• The program was implemented countrywide, resulting in dispersion of effort and dilution of financial resources.
• Direct contracts between the central government and the county bypassed much bureaucracy. This arrangement generated self-sustaining rural energy companies that manufacture, install, and service stoves and other energy technologies.	• The program administration is cumbersome, moving from the center to six regional offices, state, district, and finally the taluka, where the stove program is just one of many national efforts being implemented locally by the same people.
• Local rural energy offices are in charge of technical training, service, implementation, and monitoring for the programs.	• Monitoring was a weakness in early programs; responsibility fell on local officials who had many other concerns. Corrective actions have been taken recently.
• Recent Chinese improved stoves are not only suitable for fuel savings but are designed for convenience and attractiveness, highlighting the lessons learned from problems in early programs that stressed fuel savings.	• India has made a wide variety of attempts to integrate efficiency and convenience, but all have suffered from the top-down structure of the stove program.
• Stove adopters pay the full cost of materials and labor. The government helps producers through stove construction training, administration, and promotion support.	• Stove adopters pay for about half of the cost of stoves; the government pays the rest. As a consequence, the producer's incentive to construct stoves is oriented toward the government.

Sources: Ramakrishna (1991a), Smith and others (1993).

Box 7. Why Was the Rwanda Stoves Program a Success?

The Rwanda improved stoves project has been successful by almost any measure. Three years after the project started, about 25 percent of households in the capital now use improved stoves. The stoves can be purchased in nearly every market outlet and in many department stores. More than 90 percent of the people who adopted an improved stove say they will buy one again. Householders like the stove for its fuel economy, its longer lifetime, its ease of use, and its cleanliness. Tests in stove adopters' kitchens indicate the fuel savings compared with traditional stoves amounted to about 35 percent. In fact, the people adopting the stove decided to name it *Rondereza,* which means "to save" or "to economize."

The Rondereza stove was initially developed in a laboratory, but its design was later altered in response to user and consumer feedback. At the beginning of the project, several models were tested extensively by households. The Improved Ceramic Jiko, a popular Kenyan stove, was expected to do very well during these initial tests, but it was not preferred by the householders. The model selected was then tested more extensively in a 500-household sample. Many changes were made following suggestions by householders and stove makers, including alteration of the stove's size, quality, color, type/construction of door, and portability. The price negotiated allows an acceptable payback time for households and gives stove makers higher profit margins than on traditional stoves.

Private entrepreneurs were responsible for production, distribution, and retailing of the stoves without any subsidies. However, assistance was provided to selected stove makers for modernizing their facilities. The project initially provided a liaison between these producers and retailers of stoves, but gradually this assistance was phased out. This is why Rondereza stoves are now for sale at all marketplaces and in several shops and supermarkets, and even lower-priced copies of the stove are widespread. The cheaper materials used in the copied stoves reduce their lifetime, but charcoal savings are similar to those obtained with the original model.

The entire project was managed by a very dynamic Rwandese team composed mostly of women, along with short-term outside technical support from expatriates and Rwandese specialists. Government involvement was limited to informing consumers of the economic and environmental benefits resulting from improved stove use for the country as a whole. A systematic publicity campaign was launched to inform charcoal users about the existence of charcoal-saving stoves. In addition, the government provided support for training of stove makers and market surveys regarding consumer satisfaction with the design of the selected stove.

Three main factors were important for the success of the Rwanda program:

- Extensive participation of stove users, producers, and retailers during all phases of the project assured that the stove would be acceptable to the public.
- The high charcoal prices and relatively low cost of stoves were great incentives for households to adopt stoves. The price for the stove struck the right balance between ensuring a short payback period for consumers and allowing private stove makers to make a good profit.
- Government agencies were involved only in technical support, promotion, and advertising, and much of this work was done by a Rwandese team composed mainly of women. The production, distribution, and retailing of the stoves was done by private entrepreneurs without government assistance.

Source: ESMAP (1991b).

In sum, donor or government support may be required to assist in the following areas:

- Surveys and interviews to determine the groups that would find the greatest need for improved stoves
- Designing improved stoves with the collaboration of the artisans and users
- Testing materials for stove makers, especially clay and stove insulation
- Giving advice to stove makers, particularly about budgeting, marketing, and quality control, with the possibility of issuing seals of approval for efficiency
- Providing or facilitating loans to stove makers if necessary
- Promoting stoves through demonstrations, rallies, radio, and TV
- Undertaking field surveys before and after stoves have been introduced to determine energy savings
- Organizing training programs in stove manufacture
- Keeping the stove makers abreast with developments within the country and in other countries and distributing this information freely to all interested parties
- Promoting research to make further improvements of stoves, pots, and pans.

In parallel, advice can be given to producers, transporters, and traders in biomass fuels to improve their productivity.

Perhaps the most important role for governments and donors is in institution building and training. The most important objective of outside assistance should be in creating the institutions and training the people necessary to sustain the stove promotion efforts. All the skills once needed from the outside, including economic analysis, technical research, stove and promotion design, market evaluation, and training should be in place.

In addition, international donors can serve an important role in facilitating information exchange on the technical and managerial aspects of stove programs. A common complaint about past donor assistance, for example, has been that survey and other research done in the context of a particular stove program has never been put into a form that makes it easily available and useful for other programs. This has resulted in the frustrating paradox that senior management of donor organizations feel that they have already funded enough research, but program managers and stove designers feel a strong need for more information. Every donor-assisted program thus should have funding available and staff designated for collecting information in a timely and accessible manner.

The final issue for organizations involves the advantages of NGOs in implementing stove programs compared with those of governments. Stove programs generally involve small amounts of money, and consequently many stove programs have tended to implement small projects through NGOs. The advantages of this approach are that NGOs are not dominated by large bureaucracies, are quick to react to problems, are committed to energy conservation, and are sympathetic to the main woodstove users, including rural women and the urban poor and middle class. However, these very strengths have caused some problems. In Nepal, the involvement of as many as seven different institutions has led to a fragmentation of effort, a problem now being remedied (Shrestha and others 1991). Yet, the NGOs have had many successes in India, where their involvement has generally been focused on small, local programs. In China, the stoves program has functioned well without any involvement of NGOs. Finally, in Kenya, a rural woodstove program became successful in forging close links with an existing government extension agent network of home economists (Klingshirn 1991).

These are a few examples of ways that governments and donors can support stove programs without resorting to massive subsidies of the stoves themselves. Past programs indicate that this support can be at modest levels but that the effort must be sustained over a long period (at least five years and probably more) to reap maximum benefit from the financing. The conclusion is that the form of organization may not be as important as the long-term, integrated commitment of funds rather than the short-term bursts of aid from many different donors that have characterized many programs.

Is There a Role for Subsidies?

Regarding subsidies to stove programs, donors face a dilemma. On the one hand, they want to promote projects that make economic sense and can be operated through private markets. But, on the other, they want to address the needs of the poorest groups that would not otherwise be helped. To use potential for commercialization as the only major criterion for locating stove programs, however, would seem to lead to the rather illogical conclusion that the best projects to fund would be those in areas where self-initiated improved stove development and marketing was just about to occur. The donor then steps in with a bit of up-front funding but basically only slightly accelerates what was about to happen anyway.

Although it is certainly easier to initiate a self-sustaining stove program in areas where people buy stoves and fuels, there are strategies for dealing with other circumstances as well, as Box 8 shows. Indeed, despite the relative difficulty of working in places where people gather fuels and build their own stoves, it could be argued that donors should be concerned mainly with them, because in such areas people will not likely be developing or adapting improved stoves on their own for many years. However, it should be emphasized that treating all areas where fuel is collected as equal is not a wise policy. The type of area in which stove programs are more likely to succeed would be regions in which people spend a considerable amount of time collecting fuel, where they have already moved down the energy ladder to straw and dung, and where they have already begun to show interest in improving traditional stove efficiency. Certainly the challenges and failure rates will be higher in such areas, but the potential human benefits will be greater as well.

The real challenge therefore is to address the many hundreds of millions of households that would not otherwise be able to change their position on the energy ladder for many decades. This would seem inevitably to involve more outside investment than just for the programmatic elements discussed above. It is important, however, to recognize the importance of using the term "investment" and not "subsidy." Donor funds should be well used in such circumstances, even though there may be few transactions in the market place. They should produce benefits at least as great as alternative approaches to the same problems (cost-effectiveness) and, where possible, show net overall benefits.

The real problem with subsidies is perhaps not so much their magnitude as that in so many cases they seem to "sour" stove projects. In almost every case, for example, programs initially offering stoves at no cost have found that use and maintenance rates were unacceptably low. This accounts for the global survey result that shows less than 10 percent of programs now offer full subsidies. People just do not value things that are given to them. Nonetheless, some programs—for example in parts of India—have been able to reach significant numbers of poor people with nearly free stoves, so there is clearly more to be learned about this difficult problem. Part of the problem is just that such groups often have other much more pressing priorities than improved stoves, priorities that might have to be addressed as part of any successful improved stove program. Ways are needed to initiate stove programs that benefit from some of the important lessons that have been learned—for example, the importance of centralized production of critical components—and yet can reach local people who do not have significant cash resources and suffer from having to spend a significant amount of time collecting fuel. Even the most successful stove program, that of China, which has generally relied on user purchase to date, is worried about this problem as it begins to face the task of reaching its poorer and more remote populations.

Finally, it should be recognized that taxes or subsidies to fuels that compete with biomass fuels also may have a significant impact on the success of stove programs. There is recent evidence that people are quite willing to switch to modern or transition fuels such as kerosene or coal, especially if they are subsidized and made readily available to consumers. The desirability of subsidies or taxes for alternative fuels is a somewhat complicated issue, that has been examined more in detail in another context (see Barnes 1993).

To conclude, although the goal of any stove program must be to reach self-sustainability eventually, there is a need to continue the search for ways to reach areas in which sustainability may be many decades off as well as those where it is just around the corner. In both cases, however, stove programs are obliged to plot a course that leads to eventual self-reliance (Jones 1989). Indeed, as the global survey revealed, some programs have even seen "the extent to which people buy their second improved stove," as the most practical definition of sustainability (Ramakrishna 1991b). Indeed, that purchase would seem unlikely to be greatly influenced by factors other than the householders' frank judgment of the stove's relative costs and benefits.

Box 8. Matrix of Conditions Favorable and Unfavorable for Adoption of Improved Cookstoves and Recommended Program Strategies

	Unfavorable	***Favorable***
	Source of fuel	
Source of stove	*Fuel gathered*	*Fuel purchased*
Constructed by family ***Unfavorable***	**Most unfavorable** (unless fuel deficit is perceived) *Strategy* • Subsidies for stove purchase may be necessary • Long-term effort and extended external involvement is necessary • Favorable short-term results should not be expected	**Somewhat favorable** *Strategy* • Offer incentives or partial subsidies • Fuel price should reflect full value of biomass resources • Assess potential for fuel substitution
Purchased ***Favorable***	**Somewhat favorable** *Strategy* • Encourage conservation of biofuels through education about environmental benefits • Determine alternative uses of biofuels resources	**Most favorable** *Strategy* • Commercialization of improved stove should be possible • No subsidies should be considered for stoves or fuels • Assess potential for fuel substitution

Source: Data originally from Kirk R. Smith and Jamuna Ramakrishna, "Improved Cookstove Programs: Where Are We Now?" ESMAP Draft Report, Washington, D.C.

5

Summary and Conclusions

The estimate of current worldwide trade in woodfuel is about $7 billion, and about two million people are employed full time in woodfuel production and marketing (for a discussion of the value of traditional fuel production, see Peskin and others 1991). Although people will probably switch to cooking with modern fuels in the very long term, many hundreds of millions will be using biomass stoves for decades. It seems inevitable that an increasing amount of biomass fuel will be bought and burned in purchased stoves.

It is also clear that not all of the many millions who burn biomass can or should be reached with improved stove programs. Some are better encouraged to move up the energy ladder. Others may not be subjected to fuel shortages or high indoor smoke levels that would justify the expense of a new stove. To decide whether an improved stove program is a good idea in a particular area, one must return to the two main questions posed in the introduction: First, are the potential economic, social, and environmental benefits sufficient to be worth pursuing? Second, given the problems encountered in the past, is it likely that viable strategies for adoption can be implemented in this area?

This review of economic, social, and environmental factors affecting improved stoves has shown that the potential benefits of stove programs are considerable. This is so even though fuel savings are less than once thought, because of the other benefits that come as well. For example, even leaving aside the large direct benefits of fuel savings, rough estimates of the economic value of the environmental and health benefits of improved stoves typically show potential savings for each stove of about $25 to $100 per year, a payback to society of only a few months for most stove programs of any duration, even at modest acceptance and use rates.

Given the problems encountered in many stove programs, the second question is much more difficult to answer. Stove programs have pursued a variety of different goals and in some cases have been implemented in regions that may not be well suited for promoting stoves and among populations that may have little interest in the stoves. In short, some programs have not shown an understanding of the distinctive role of the improved stove in the energy transition: *The improved biomass stove should be considered a new stepping stone between the traditional biomass stoves used by rural and urban poor* *families and the modern fuels and appliances mainly used by urban, better-off households.* At present, the market niche for such stoves is substantial, and the potential for and benefits of adoption of improved stoves are commensurately large.

In answering the second question it also may be helpful to put stove programs in perspective. Most of the major investments in stove programs have come from the countries concerned and without much involvement of donors. For example, in the two largest programs, in India and China, essentially all the investments have been generated internally. In Thailand, improved stoves development started in the private sector; this is true of other countries in Asia as well. The participation of donors in stove programs has been modest, with funding spread over a large number of small programs. Because of the fragmentation of efforts, planners have not been able to learn from mistakes. A review of many project documents indicates a tendency to "reinvent the wheel." This is partly because of the many different institutional settings and country contexts, but it also stems from a lack of cooperation and communication among programs.

Failure of new and innovative programs is not unusual when they are in their beginning stages, but programs whose problems become persistent and irremediable obviously should be terminated. This is not the case for most stove programs, however. Moreover, among the failures, some consistent themes are emerging that have informed and helped ongoing efforts to evolve. That is, what often started as a purely engineering approach to improved stoves now is evolving into the combination of engineering, production, and marketing that is common to most successful product development cycles.

In sum, most successful programs have shared the following characteristics:

- The programs have focused efforts on a group of users that would most likely benefit from and consequently adopt improved stove. This group generally, but not always, involves those who purchase biomass fuels or have difficulty in collecting their fuels. The people who first adopt improved biomass stoves are usually not the very poorest groups in society but rather are those who have limited cash income and spend a substantial portion of it on cooking fuel.
- In the most successful stove programs, the stove itself is not heavily subsidized. This ensures that the program can be self-sustaining without extensive government support and that people are willing to pay for the benefits of the improved stove compared with the traditional stove.
- The best programs incorporate significant interactions between those who design, produce, and use the stoves. This interaction can come in several different forms, including formal surveys, focus groups to identify problems and prospects for a particular stove design, and actual household testing of stove designs.
- Programs that rely on mass production of the stoves or stove parts seem to be more successful than programs that custom build stoves.
- External support for programs should be limited to factors that support the development, production, and distribution of stoves, and subsidies for the stoves themselves should be zero or minimal. The support does not have to be large, but it

must be sustained and can include support for stove design, laboratory testing, consumer surveys, quality control, training, information access, publicity campaigns, and perhaps credit.

- Stoves that are not valued very highly by the consumers simply will not be purchased. The onus is thus on the stove producers and designers to assess and meet the needs of consumers for efficient and useful stoves.
- Finally, stove programs that receive short bursts of funding are less likely to succeed than those that are given a longer time to develop.

From an institutional perspective, stove programs have been successfully implemented by a wide range of agencies. Given the various conditions within individual countries, it is hard to argue that one form of project or program organization is better than another. Although governments tend to be bureaucratic and cumbersome, several have managed highly successful programs. In contrast, NGO-run programs may be more flexible, more committed, and closer to the users than programs run by governments, yet they may suffer from short-term bursts of money and support and have little long-term direction. The lesson here is that programs can be successfully implemented in a variety of institutional settings if they are both sustainable and carefully attuned to local conditions.

The modern improved stove can be considered an important bridge technology for the millions of people who have access to low-cost, readily available biomass from local woodlands and who are not able to afford the more expensive modern fuels, along with their necessary equipment and appliances. The checkered history of stove programs is fairly predictable, given their diversity and the diversity of conditions under which they have been implemented; the limited, intermittent levels of donor support for most projects; and the wide range of institutions implementing them. Many programs actually began as afterthoughts to larger, more conventional energy or forestry projects. Given these problems, it is essential for stove programs to identify the groups that can benefit most from improved stoves and to determine whether it is feasible technologically to design and produce a stove that is both efficient and acceptable. The target or pilot groups in a program do not necessarily have to involve the people with the most serious need to reduce biomass energy expenditures or time collecting biomass energy, but such people should be included once the program has taken off. The social, economic, and environmental benefits of promoting improved stoves under the suitable circumstances are quite large, and the existing successes demonstrate the usefulness of well-managed programs. Finally, given the problematic role of subsidies, continuing efforts are needed to learn how to address the needs of lower-income groups.

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Annex 1
Evaluations of Improved Cookstoves

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Annex 2
Projects Surveyed for Study

Country	*Project name*	*Begin date*	*End date*	*Cost per year*	*Percent subsidy*
Angola	Introducao de fogareiros melhorados	1/01/90	12/31/92	27,500	
Bangladesh	Fuel Efficient Chulha Energy Saving Project			30,000	17.50
Bangladesh	Fuel Saving Project	7/01/87	6/30/91	140,700	
Brazil	Smoke-Eliminating Woodstoves w/ Ovens	1/01/83			
Burundi	Burundi Community Stove Programme				
Burundi	Ziganya Amakara Implementation: Bujumbura	8/01/86	12/31/90		
Chile	Programma de Investigacion y Desarrollo	1/01/89			
Chile	Estufas de Lena	2/01/80		2,000	
Domin. Rep.	Lorena Stoves	1/01/87		21,670	
Ecuador	NRG Conservation in Rural Areas	3/01/85	6/01/87	17,830	
Ethiopia	Estab. of Electrically Heated Mitad	1/01/80	1/01/95	100,000	50.00
Ethiopia	Estab. of Electrically Heated Geber Mitad	1/01/85	1/01/95	100,000	
Ethiopia	Stove Project No. 1 (Akaki)	6/01/83			
Ethiopia	Addis Ababa REWA Closed-stove Dissemination Centre	4/01/85			
Ethiopia	Cooking Efficiency Programme Planning	10/01/84			
Ethiopia	Cooking Efficiency Improvement and New Fuels Marketing Project (CEINFMP)	12/01/89	3/30/92		
Ethiopia	Dissem. of Improved Charcoal Stove	1/01/87		21,000	
Ethiopia	Dissemination of Improved Wood Stoves	1/01/90		18,000	
Fiji	Pilot Communal Kitchen	1/01/85	8/01/86	7,000	
Fiji	Village Stoves Project	1/01/86		4,000	
Guatemala	National Improved Cookstoves Program			60,000	40.60
Guatemala	Programas de Estufas Mejoradas				
Guatemala	Evaluacion ORNL	12/01/88	12/01/90		
Guatemala	PNUD/DIGEBOS/CEMAT	4/01/89	8/30/90		
Guatemala	Improvement of Housing: Ceramic Stoves	7/01/88	6/30/91	3,500	55.00

(continued on next page)

Country	*Project name*	*Begin date*	*End date*	*Cost per year*	*Percent subsidy*
Haiti	Rechauds Ameliores	12/01/89	11/01/92		
Haiti	Bonjan Recho: Implementation, Port au Prince	1/01/89	5/01/92		
India	Development Field Testing and Impact of Wood Stoves	1/01/83			60.00
India	Dissemination of cookstove (TARA-Metal) in village	8/01/86	1/01/88		50.00
India	Dissemination of improved cookstoves (NADA-mud) in villages	10/01/86	1/01/89	27,000	75.00
India	Efficient Wood Burning Stove (Priagni Portable)				45.00
India	Development of metallic woodstove	5/01/81			30.00
India	Improved Cook Stove	11/01/83		390,000	55.00
India	National Programme of Improved Chulha				52.00
India	Dissemination of Improved Smokeless Stoves in K.K. District	1/01/85			52.00
India	Dissemination of Improved Cook Stoves, Phase 1	1/01/88	12/01/90	2,400	
India	Development of Cookstoves for Household Use	1/01/86	3/31/91	24,150	55.00
India	Development of Energy Efficient Chulhas (Individual Family and Community Use)	1/01/89	3/01/91	15,900	30.00
India	Kallupatti Chulha			12,500	52.00
India	Pragati Smokeless Chulha	6/01/85	7/01/87	550	40.00
India	Improved stove development for efficient utilization of coal/biomass	3/01/90		39,460	
India	Technical Backup Unit	12/01/84		40,000	45.00
India	Technical Backup Unit, Karnataka	1/01/85		20,000	
India	National Program, Improved Chulhas (NPIC)	4/01/86		4,030	
Indonesia	Sae stoves			10,000	
Kenya	Bura Fuelwood Project	3/01/86	12/01/92	12,000	75.00
Kenya	Rural Stoves, West Kenya	5/01/87	1/01/91		
Kenya	Institutional Fuelwood Savings (IFSP)	1/01/83			
Kenya	Domestic Fuelwood Savings Programme	1/01/81			
Kenya	GTZ/SEP Women and Energy			1,500,000	

Country	*Project name*	*Begin date*	*End date*	*Cost per year*	*Percent subsidy*
Kenya	Urban/ Rural Charcoal and Wood Project				
Kenya	Machakos Renewable Energy Programme			400	
Lebanon	Improved stove design dissemination				
Madagascar	MADA Faritany 2 Implementation	11/01/88	8/30/89		
Madagascar	MADA Faritany 1 Implementation	5/01/89			
Madagascar	MADA HV 101 Implementation: Antananarivo	10/01/88	6/01/89		
Madagascar	MADA Tanika and MADA Mailaka Implementation: Antananarivo	3/01/89			
Malawi	Stoves Programme for Mozambican Refugees (Pilot Phase)	8/01/89	5/30/90	250,000	
Malawi	Stoves Programme for Mozambican Refugees (Expansion Phase)	6/01/90			
Malawi	Malawi Stoves Programme	2/01/87	12/31/94	39,000	
Malawi	Refugees Stove Project	10/01/89		41,300	
Mali	Community Environment, Tominian	4/01/89		311,025	
Mali	Projet Energie Renouvelable	1/01/80	12/31/85	85,710	
Mali	FAMP and Louga: Implementation, Kayes	10/01/87			
Mali	Teliman Implementation: Bamako/ Segou/ Mopti	1/01/88	12/31/92		
Mauritania	Implementation: Nouakchott	8/01/88	12/31/90		
Mexico	Rocket Stove and Oven	1/01/83			2.00
Mozambique	Maputo Coal Stove Project	2/01/86			
Myanmar	Development of Improved Stoves (fuelwood/charcoal)			1,000	30.00
Nepal	Improved Stove Installations in Households	11/01/86	12/01/90	2,300	
Nepal	Improved Stove Dissemination and Exposure Assessment Study, Rural Nepal	11/01/86	3/01/87	5,000	
Nepal	Dissemination of "Tamang" Stoves	5/01/90	4/01/91	500	
Nepal	Stove programme within community forestry project	12/31/81		62,300	
Nepal	Save the Children Stove Project			3,000	15.00

(continued on next page)

Country	*Project name*	*Begin date*	*End date*	*Cost per year*	*Percent subsidy*
Nepal	Andhi Khola Project			766	
Nepal	Domestic Cooking				
Nepal	Improvement of Traditional Stoves for Household Conservation				
Nepal	Shivapuri Watershed Management and Fuelwood Plantations	7/01/85			
Nicaragua	Kitchen and Stove Project, El Limon	3/01/90		71,430	
Nicaragua	Cocinas and Fogones Mejorados	5/01/89	2/01/91	15,300	
Niger	Vulgarization Foyer Ameliore "Albarka"	5/01/90			
Niger	Projet Energie II, Niamey, Niger				
Niger	World Bank/GTZ Stove Project in Niger				
Niger	Projet Foyers Ameliores II	12/01/88		200,000	
Niger	Gazaoua Mai Sauki and Albarka implementation	11/01/82	8/01/91		
Pakistan	Pak-German Fuel Efficient Cooking Technologies	1/01/90		653,300	2.50
Pakistan	Development of Improved Cookstove			25,000	
Pakistan	Domestic Energy Saving (GTZ)	1/01/90			
Pakistan	Pak-German Fuel Efficiency Cooking Technologies	5/01/90		743,000	
Paraguay	Diffusion of Compressed Block Stoves	2/01/87	3/31/91	1,500	
Paraguay	Diffusion of Foblocos in San Pedro	6/01/89		4,000	
Philippines	Silkalan Stove Dissemination	7/01/88	6/01/89	7,846	
Philippines	Establishment of improved stove development and testing lab	1/01/88	12/31/88	1,000	
Rwanda	Rwanda Improved Charcoal Stove				
Rwanda	Rondereza Implementation, Kigali	2/01/88	3/01/91		
Rwanda	3P Ameliores: Implementation, Rwanda	7/01/87	12/31/92		
Rwanda	Metal Improved Stove Implementation: Rwanda	7/01/87	12/31/92		
Rwanda	Pilot project, Kigali, Rwanda	7/01/90	9/30/90		
Senegal	Foyers ameliores				
Senegal	Diffusion de foyers ameliores à Dakar	4/01/90		8,000	
Senegal	Ban ak suuf implementation-Louga	10/01/84	10/01/85		
Senegal	Sakkanal implementation-Louga	7/01/87	6/30/90		

Country	*Project name*	*Begin date*	*End date*	*Cost per year*	*Percent subsidy*
Sierra Leone	Renewable Energy, Njala Univ. (urban)	3/01/84	12/12/89	60,000	
Sierra Leone	Yoni Seed and Claystove (rural)	6/01/87		2,053	
South Pacific	Institute of Rural Development, USP			5,000	
Sri Lanka	Sarvodaya Stove	8/01/79	6/01/82		
Sri Lanka	Improved Cookstoves For Sri Lanka Tea Estates Line Houses	1/01/85			
Sri Lanka	Rural Stoves Programme (NFCP)		12/31/90	95,000	45.00
Sri Lanka	Urban Stove Programme	4/01/87	7/30/89	88,800	
Sri Lanka	Stove Marketing Programme	4/01/91	3/31/96	64,750	
Sudan	Improved Charcoal Stove Marketing	1/01/83	1/01/92	130,000	
Sudan	Kanun El Sirur (KCJ)	6/01/89			
Sudan	Fuelwood Development for Energy in Sudan	1/01/83		116,670	
Tanzania	Dar-Es Salaam Improved Charcoal Stoves	5/01/88	12/01/90	89,200	
Tanzania	UTAFITI Rural Energy	1/01/83	7/01/86		
Tanzania	GTZ/Camartec Stove	11/01/87		400,000	
Tanzania	Morogoro Fuelwood Stove Project, CCT	1/01/85		15,000	
Tanzania	Dodoma Stove Project	1/01/83	12/31/85		
Thailand	KKU/BRI Institutional Linkage	6/01/88	12/01/91	6,000	45.00
Thailand	KKU/BRI Institutional Linkage (Rural users)	6/01/90	12/01/91		40.00
Thailand	Improved Biomass Cooking Stove for Household Use			61,600	
Thailand	Extension of Improved Cooking Stove				
Thailand	Improved Biomass Cooking Stove for Household Use			1,000,000	70.00
Thailand	Accelerated Dissemination Program for Improved Charcoal Stoves	6/01/87	9/30/91		80.00
Thailand	High Efficiency Stove Production				
The Gambia	Household, Commercial, Institutional	11/01/82	9/30/92	200,000	
Togo	Introduction of Improved Charcoal Metal Stoves	3/01/88	9/01/90	74,750	
Uganda	Improved Woodstove	1/01/86		6,000	
Uganda	Improved Charcoal Stove	1/01/87		6,000	

(continued on next page)

Country	*Project name*	*Begin date*	*End date*	*Cost per year*	*Percent subsidy*
Uganda	Usika Stove Project (Ceramic)	1/01/86	12/31/96	33,000	
Uganda	Usika All-Ceramic Stove	2/01/91	12/31/96	5,000	
Zambia	Improved Charcoal Stove Evaluation	1/01/90	12/01/90	20,000	
Zimbabwe	Tsotso Stove	1/01/81			
Zimbabwe	Woodstove Project	1/01/82	1/01/95	5,000	10.00
Zimbabwe	Integrated Domestic Energy Project	4/01/87		35,385	
Zimbabwe	Stove dissemination programme			27,690	
Zimbabwe	Chiweshe Woodstove Project	8/01/90		1,300	10.00

Note: The cost per year for some cases is for the entire project, so the cost for the stoves component may be overstated.

Source: East-West Center Mail Survey, 1990.

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