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Cleaner Hearths, Better Homes

New Stoves for India
and the Developing World

Douglas F. Barnes • Priti Kumar • Keith Openshaw



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Contents

<i>List of Tables, Figures, and Box</i>	vi
<i>Preface</i>	ix
<i>Acknowledgments</i>	xii
<i>List of Abbreviations</i>	xv
<i>Plate section (between pp. 62 and 63)</i>	
1. Better Stoves and Household Fuel Use	1
2. India's Best Legacy Improved Stove Programs	17
3. Maharashtra: Commercial Approach	24
4. Haryana: Women's Involvement	36
5. Karnataka: Technical Innovations and Institutions	50
6. Gujarat: Rural Development Approach	64
7. Andhra Pradesh: Interagency Coordination	78
8. West Bengal: Nongovernmental Organizations	95
9. A New Path for Better Stoves	114
<i>Glossary</i>	143
<i>Annexure: Research Methodology</i>	145
<i>Bibliography</i>	157
<i>Index</i>	166

Tables, Figures, and Box

TABLES

1.1	Particulate Concentration Exposure (24-hour average) of Cooks and Non-cooks across Fuel Types, Andhra Pradesh, 2001	7
1.2	Biomass Collection Time in Rural Bangladesh	10
1.3	Fuel Types and Women's Time Allocation, Rural India, 1996	12
1.4	Stove Use and Women's Time Spent Cooking and Collecting Fuel, Rural India, 1996	12
2.1	Typical Data Collection Instrument, 2001	21
2.2	Summary Attributes for Assessing Best Stove Programs	22
3.1	Improved Stoves Installed in Maharashtra, 1995–2000	25
3.2	Improved Stove Models Distributed in Maharashtra, 2002	26
3.3	User Complaints Regarding Improved Stoves	28
3.4	Frequency of Chimney Cleaning by District, 2000–1	28
3.5	Subsidy Structure of Improved Stoves in Maharashtra	29
4.1	Improved Stove Models Distributed in Haryana, 1994–2002	38
4.2	Perceived Benefits from Improved Stoves, 2000–1	40
4.3	User Complaints Regarding Improved Stoves, 2000–1	41
4.4	Training Courses Conducted by the Technical Backup Unit, 1999–2000	44
5.1	Timeline of Events in Karnataka, 1980–99	52
5.2	Improved Stove Models Distributed in Karnataka, 2000–1	53
5.3	Targets Met under the National Program in Karnataka, 1994–9	53

5.4	Characteristics of Household Users in the Study Area, 2000–1	54
5.5	Perceived Benefits from Improved Stoves, 2000–1	55
5.6	User Complaints Regarding the Improved Stoves, 2000–1	56
5.7	User Modifications to Improved Stoves, 2000–1	56
5.8	Subsidy Structure of the National Program in Karnataka, 2002	57
6.1	Improved Stove Models Distributed in Gujarat, 2000–1	66
6.2	Perceived Benefits from Improved Stoves, 2000–1	67
6.3	User Complaints Regarding the Mamta Model, 2000–1	67
6.4	Frequency of Chimney Cleaning by District, 2000–1	68
6.5	Subsidized Prices for Various Models by NGOs, 2000–1	70
7.1	Improved Stove Models Distributed in Andhra Pradesh since 1994	80
7.2	Perceived Benefits from Improved Stoves, 2000–1	81
7.3	User Complaints Regarding Improved Stoves, 2000–1	82
7.4	Frequency of Chimney Cleaning by Users, 2000–1	82
7.5	Subsidy Structure of the National Program in Andhra Pradesh, 2000–1	85
7.6	Timeline of Events of the Technical Backup Unit, 1990–2000	87
7.7	Training Courses Conducted by the Technical Backup Unit	89
8.1	Improved Stove Models Distributed in West Bengal, 1994–2002	97
8.2	Perceived Benefits from Improved Stoves, 2000–1	98
8.3	Frequency of Chimney Cleaning, 2000–1	99
8.4	Common Types of User Modifications, 2000–1	100
8.5	Key Features of Popular Improved Stove Models	101
8.6	Pricing Guidelines for Fixed One-pot Stoves in West Bengal, 2000–1	103
9.1	Key Attributes of India’s Best Improved Stove Programs	116

FIGURES

1.1	Particulate Matter Concentrations in Kitchen and Living Areas of Households Using Solid Fuels, India, 2005	8
3.1	Map of Maharashtra, Highlighting Case Study Districts	25
3.2	Perceived Benefits from Improved Stoves, 2000–1	27
3.3	Implementation Structure in Maharashtra	32
4.1	Map of Haryana, Highlighting Case Study Districts	37
4.2	Implementation Structure in Haryana	46

5.1	Map of Karnataka, Highlighting Case Study Districts	51
5.2	Initial Delivery Structure in Karnataka	58
5.3	District-level Implementation in Karnataka, Late 1990s–2002	59
6.1	Map of Gujarat, Highlighting Case Study Districts	65
6.2	Implementation Structure in Gujarat	73
7.1	Map of Andhra Pradesh, Highlighting Case Study District	79
7.2	Implementation Structure in Andhra Pradesh	90
8.1	Map of West Bengal, Highlighting Case Study Districts	96
8.2	Implementation Structure in West Bengal	106
Box		
6.1	Sociocultural Practices and Stove Design	69

Preface

For people in developed countries, burning fuelwood in an open hearth evokes nostalgia and romance. But in developing countries, the harsh reality is that several billion people, mainly women and children, face long hours collecting fuelwood, which is burned inefficiently in traditional biomass stoves. The smoke emitted into their homes exposes them to pollution levels 10–20 times higher than the maximum standards considered safe in developed countries. And the problem is not out of the ordinary. The majority of people in developing countries at present cannot afford the transition to modern fuels. Today, close to one half of the world's people still depend on biomass energy to meet their cooking and heating needs.

To be sure, the term 'hearth' in developed countries connotes feelings of warmth and closeness of families. In fact, many people in developed countries still use firewood for ambience and to heat their living rooms or even entire homes, sometimes in state-of-the-art, high-efficiency stoves. In the developed world, wood-burning stoves and fireplaces are tested and approved by various agencies responsible for ensuring that appliances meet strict safety standards. Even before the twentieth-century transition from coal-burning and biomass stoves to gas and electricity, public agencies in developed countries often insisted on major retrofits for original cooking and heating systems to meet fire and pollution codes. The implication for developing countries is that, even without making a complete transition to electricity, kerosene, or Liquefied Petroleum Gas (LPG) or other various types of cooking gases, there are intermediate options for eliminating human drudgery and indoor air pollution.

Cleaner Hearths, Better Homes: New Stoves for India and the Developing World has a twofold goal: describing India's best legacy improved biomass stove programs and recommending ways in which the international community

can promote stoves that are commercially viable, convenient for users, and more energy efficient. By implication, there also would be a reduction of indoor air pollution to more reasonable levels than is common today. To date, the effectiveness of many of the world's stove programs has been hindered by their small scale. Even India's best case examples faced serious challenges. But hard-learned lessons from these cases, combined with varied experience from stove programs around the world, can well serve the international development community's efforts to address the energy problems faced by the poorest populations on our planet.

This book should be of interest to policymakers and scientists across a broad spectrum of disciplines—from health, environment, and economics to sociology, anthropology, and physics. Indeed, the hands of many specialists are required to ensure successful stove programs, which call for social marketing, stove engineering, development of standards, promotion of private and commercial enterprises, and appropriate subsidy schemes. That the book's authors represent diverse disciplines—sociology, physics, and forest economics—underscores the range of perspectives needed to tackle the issues involved in the commercial promotion of improved stoves.

The impetus for writing this book started at the end of a World Bank project on the health implications of indoor air pollution, which coincided with the Government of India's (GoI) cancellation of its 20-year program on improved stoves. The government's decision came as no surprise, given the program's mixed results. They echoed those of other stove programs around the world, which similarly suffered from the many fits and starts of donor interest. There was no lack of evidence in India or, indeed, from around the world, to support skeptics of improved stoves. But diminishing government interest was incongruous with the urgent need to address the health and welfare concerns of people dependent on biomass energy for their livelihoods and subsistence, as well as growing environmental concerns associated with greenhouse gas emissions.

One may rightfully ask: What motivated the authors to produce this book on India's improved stoves? In the face of many doubts, we discovered that users in areas where programs enjoyed relative success valued the benefits of the improved stoves. Also, a large group of dedicated people was genuinely committed to facilitating the acceptance of stoves in many areas. To our surprise, many programs previously branded as hopeless had promising, innovative features. These findings motivated us to dig even deeper until we were convinced that it was incumbent on us to review past experiences and translate them into a set of recommendations that could aid the world's several billion people that depend on biomass cooking and heating energy. In short, despite the myriad difficulties involved in finding solutions, the human dimension of the problem was too big to ignore.

Lessons from the six case studies in India and other stove programs around the globe confirm that there are no magic solutions to alleviating indoor air pollution and the other problems associated with cooking on traditional stoves. Even if households adopt improved biomass stoves, without chimneys or other venting devices, family members cannot escape the negative respiratory effects of breathing smoke emitted into their homes. Yet, for many decades, small and intermittent funding in many countries has hampered learning from experience. One stove expert that reviewed this manuscript asked whether we had given stoves a fair chance to succeed, indicating that financing one scrubber on one power plant is probably equivalent to all of the funding provided for stove programs worldwide over decades. This comparison—albeit a bit exaggerated—nevertheless reveals a need for the international development community to prioritize its handling of indoor air pollution and the human and environmental cost of burning biomass in traditional stoves.

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This book is the product of years of household energy research from around the world. The World Bank's Energy Sector Management Assistance Program (ESMAP) has been a leader in this field for many years, providing both encouragement and funding for this and other works. The book would not have been possible without the support of past and present ESMAP management and staff. Jamal Saghir, Ede Ijjasz–Vasquez, Amarquaye Armar, and Dominique Lallement provided valuable support to bring this work to fruition. Also, Kulsum Ahmed provided a variety of encouragement for this project and type of work over the years; she was responsible for a study on improved stoves and indoor air pollution in Guatemala, which is cited in this book.

Most of the background work for the India case studies was conducted by two of India's leading Nongovernmental Organizations (NGOs) involved in energy and environmental research: The Energy and Resources Institute (TERI) and Winrock International India. The two organizations completed this research as part of a World Bank study on indoor air pollution and household energy in India, which was managed by Kseniya Lvovsky. In fact, the chapter on stoves in the World Bank study *India: Household Energy, Indoor Air Pollution and Health* that was managed by her is based on the more detailed results reported in this book. TERI synthesized many of this work's findings in a previously published report entitled *Fire without Smoke*. Edited by Ibrahim Hafeezur Rehman and Preeti Malhotra, the report describes all six of the case studies included in this book. Other TERI staff members, responsible for producing original versions of the case studies of Andhra Pradesh, Karnataka, and West Bengal, are C.K. Jalajakshi, S.N. Srinivas, Debajit Palit, and Nandita Hazarika. From Winrock International India, based in New Delhi, the original case studies of Gujarat, Haryana, and

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The internal and external reviews of this book were responsible for a significant reshaping of the book's introduction and conclusion. Internal World Bank reviews by Marlon Lezama, C. Mark Blackden, Sameer Akbar, Kseniya Lvovsky, and Anjali Acharya were extremely thoughtful and pointed us in the right direction for finalizing the manuscript. Sameer Akbar in particular has been very helpful in updating the work on climate change issues and more recent developments in stoves. Rogerio de Miranda also provided much of the information on Latin America that is part of this book.

The contributions of the external international reviewers were invaluable. All are international experts in the field of indoor air pollution and improved stoves, and their reputations speak for themselves. They include Kirk Smith of the University of California at Berkeley, generally regarded as the founder of the work on indoor air pollution as it relates to health, and Robert van der Plas of MARGE International in The Netherlands, who brings decades of experience in implementing improved stove programs in Africa, Asia, and Latin America and the Caribbean. Eva Rehfuss, formerly of the World Health Organization (WHO), is known for her recent advocacy and excellent publications on the health effects of indoor air pollution. Mitali Sen of the United States Census Bureau contributed to this work through her expertise in gender and energy in India. Veena Joshi of the Swiss Agency for Development and Cooperation has been involved in rural energy and improved stoves within India for most of her career. Finally, the work of Jyoti Parikh, an advocate of clean household energy, strongly influenced the policy recommendations offered in this book. Without these reviewers' insightful comments, this book would not have been possible.

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Abbreviations

ARTI	Appropriate Rural Technology Institute
CIFOR	Center for International Forestry Research
CSIR	Council of Scientific and Industrial Research
ESMAP	Energy Sector Management Assistance Program
FAO	Food and Agriculture Organization
GoI	Government of India
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
IEA	International Energy Agency
IHDS	India Human Development Survey
IIT	Indian Institute of Technology
KENGO	Kenya Energy and Environment Organization
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goal
MNRE	Ministry of New and Renewable Energy
NCAER	National Council of Applied Economic Research
NEDCAP	Non-conventional Energy Development Corporation of Andhra Pradesh Ltd
NGO	Nongovernmental Organizations
NISP	National Improved Stove Program
OECD	Organisation for Economic Co-operation and Development
ORG	Operations Research Group
OTA	Office of Technology Assessment
PM	Particulate Matter
R&D	Research and Development

SEW	Self-employed Worker
TERI	The Energy and Resources Institute
UNDP	United Nations Development Programme
WHO	World Health Organization

1

Better Stoves and Household Fuel Use

From an early age, many rural women across the developing world learn to cook for their families using open-fire stoves in poorly ventilated kitchens. Over the years, they become accustomed to incessant coughing and watering of the eyes, which are symptomatic of overexposure to indoor cooking smoke. Also affected are their young children, who spend many hours a day in or near the indoor cooking area. Rural families typically spend a significant number of hours each week collecting biomass fuels—dried wood lying on the ground, small trees and branches, agricultural residue, and animal dung—from common village lands or farmers' fields. Over time, the collection of biomass fuels can lead to a deteriorated local environment, thereby depleting biomass supplies and requiring family members, especially women, to walk even longer distances to collect cooking fuel. These intertwined problems, first identified several decades ago, were put before the international development community as the 'other energy crisis' (Eckholm 1975). Crisis was probably too strong a word for a health and environmental issue that had gone virtually unnoticed for thousands of years. Such a pattern of household energy use and local fuel collection linked to poor health and local environmental pressure is more akin to a syndrome that, even today, remains invisible to most policymakers.

Breaking this household energy syndrome involves simple solutions, including better ventilation of the indoor kitchen or cooking space and switching to liquid fuels, such as kerosene or LPG. Liquid fuels are used increasingly in urban areas, but have been slow to reach rural populations, including many of the world's poorest people. Of the 3 billion residents who currently depend on solid fuels, it is generally accepted that 2.4 billion will

continue using biomass as their main cooking source for decades to come. While the world's rural poor may one day use liquid fuels or gas for cooking, the more urgent need is to improve on their current household energy use. Many symptoms of this invisible syndrome can be treated effectively with improved stoves using existing biomass fuels.

Better biomass stoves offer the world's poor many potential benefits leading to cleaner hearths and healthier lives. Compared to traditional stove models, better stoves can be engineered to provide superior performance, burning biomass energy more cleanly and efficiently. As a result, indoor pollution from cooking smoke will be reduced, helping to mitigate respiratory and other diseases. In addition, less time will be required for cooking meals and collecting biomass fuels, allowing women and other family members more time for educational and other productive activities. All of these factors combined contribute indirectly to a reduction in poverty (Barnes *et al.* 2011; Saghir 2005; World Bank 1999a).

Today, several different developments are taking place that have prompted a renewed focus on this issues (World Bank 2011). India has initiated a new national program that is currently exploring the new ways to move forward with in a successful way (IIT and TERI 2010). A new Global Alliance for Clean Cookstoves has been formed with a goal to promote the adoption of over 100 million new stoves by 2020. Some of the new financial instruments that promote climate friendly use of energy now include cookstoves as a possible option for participation in their programs. Finally, a new generation of cookstoves has been developed that are manufactured and, thus, there is a wider variety of designs available for purchase or inclusion in various types of development programs. These, and other developments, make this an ideal time to review the experience of India's past programs, recent international experience, and lessons for future programs.

WHAT IS AN IMPROVED STOVE?

Defining an improved stove, generally regarded as a relative concept, depends on several factors: the type of traditional stove considered; the aim of the design improvement; and issues of affordability. Traditional stoves can range from three-stone open fires to substantial brick-and-mortar models and ones with chimneys. In addition, the nature of the improved status has various dimensions. For example, stoves can be designed to improve energy efficiency, remove smoke from the indoor living space, or lessen the drudgery of cooking duties. In the early stages of most improved stove programs, many models were designed so that even the poorest customers could afford them. Valued at about US\$ 5 or less, these stoves represented an improvement over a three-stone open fire; nonetheless, they were rudimentary devices. Today, there is growing sentiment to support a wider variety of more specialized

stoves, which are sometimes more expensive. Given the many stoves used by rural and urban populations in developing countries, improvements can differ markedly by country or region. Thus, *improved stove* had typically been used as an umbrella term encompassing an array of diverse stoves. A brief history of the use of the term improved stove is followed by a more precise definition of stove terms as they are employed in this book.

Early stove programs of the late 1970s and the early 1980s, supported by developing country governments, international donor agencies, and NGOs, commonly assumed that the benefits of the improved stoves were self-evident (Barnes *et al.* 1994). They believed that an initial intervention would lead seamlessly to a self-sustaining program. Most of these programs were designed to enhance energy efficiency; thus, early efforts, which focused on dissemination of more efficient stoves, often remained oblivious to local customs, economic settings, and the availability and prices of local biomass fuels. Because many of these early programs were based on stoves developed in a laboratory setting without extensive field testing, they often overestimated the energy efficiency of the improved stoves and underestimated that of traditional ones. In keeping with the goal of assisting the poorest of the poor, the early improved stoves were built on-site using inexpensive materials so that even the poorest populations could afford them.

Several country examples illustrate the common and unique experiences of relatively successful programs (see the Guatemala example in the plate section). Guatemala was among the first countries in Latin America and the Caribbean to focus on improved stove design, with its development of the Lorena stove in the late 1970s (Ahmed *et al.* 2005). An all-mud stove built entirely on-site by trained artisans, the early Lorena stove failed to significantly outperform traditional models under field conditions. Although the improved stove worked well initially, its poor durability and hence reduced efficiency became evident with daily use. After the initial rise and fall of the Lorena stove, efforts stagnated. But by the mid-1990s, a more durable model appeared on the scene. This stove was promoted through a social fund and it remains popular even today.

China's improved stove program—like most others in the world—focused initially on rapid dissemination, accompanied by low-cost strategies and significant subsidies. Similar to the early Guatemalan experience, inexpensive construction resulted in poor performance. In addition, most models were not designed to handle both energy efficiency and indoor pollution (Sinton *et al.* 2004; Smith *et al.* 1993). In subsequent program phases, the government played a smaller but a more critical role. In the second phase, it reduced subsidies and pushed for commercialization, accompanied by support for development. In the third phase, it shifted emphasis to extension, promotion, and increased standardization of the most popular models.

These efforts were coordinated mainly through the Ministry of Agriculture's rural energy offices, which promoted various rural energy programs. The National Improved Stove Program (NISP), implemented through county rural energy and other agencies, was an enormous success by any standard. The main program focus was energy efficiency and household smoke removal with a chimney. Today, the program is no longer government-financed, but the private sector still produces the stove components and is leading the way by producing more efficient and less polluting models (Smith and Deng 2010). Many of the new biomass cookstoves are manufactured in factories in China and exported to many parts of the world. China's experience provides ample evidence that development of a program for better cookstoves can succeed in light of the fact that over 100 million improved cookstoves are still in use in China today (WHO and UNDP 2009).

In many African countries, including Kenya, early improved stove programs focused on solutions for urban charcoal users. Simpler in design and less expensive than biomass stoves, charcoal stoves became widely used. Development of the Kenyan Jiko stove was especially successful; the initial pilot project and experimentation period led to its widespread adoption (Openshaw 1982, 1986).

For the purposes of this book, the term 'improved stove' refers broadly to any stove disseminated by governments and independently by NGOs, the private sector, and other organizations that significantly improves energy efficiency, reduces indoor pollution, and increases ease of use. This term, originally intended to encompass all these three mentioned benefits, has been somewhat devalued as a result of overselling the benefits of improved stoves internationally. This has not been the case in countries such as China and Nepal, where successful programs have carried a more positive connotation; but even in those countries, definitions have varied by region.

Thus, it is certainly time to base the stove terminology on a more precise standard. To achieve this goal, throughout this book, the term *traditional stove* refers to either open-fire stoves or cookstoves constructed by artisans or household members that are not energy efficient and have poor combustion features. *Improved cookstove* is used in the historical sense for cookstoves installed in 'legacy' programs, usually with a firebox and chimney, but without standards and poor quality control. *Effective improved cookstove*, cheaper but close in performance to advanced biomass cookstoves, is assembled on-site by qualified installers adhering to standards. *Advanced cookstove* refers to the more recent manufactured cookstoves, based on higher levels of technical research; these cookstoves are generally more expensive and are based on higher, but as yet not well-defined, standards that include safety, efficiency, emissions, and durability; among others, they might include wood, charcoal, pellet, and gasifier cookstoves. Since this book concentrates on the history of

improved stoves and lessons for India and other countries, we have generally used the term *improved stove* to describe the state programs and have used the other terms when dealing with more contemporary issues.

THE VALUE OF BETTER STOVES

Entrepreneurs of better stoves have generally avoided serving rural markets. Because the benefits are long term and not part of the cash economy, the intended consumers might not realize the value of an improved stove. Also, because the natural market consists mainly of poor people dependent on biomass for cooking, affordability might be an issue. Thus, the public policy question is whether the benefits of improved stoves are worth the financial intervention that might be necessary to initiate such programs.

Better stoves have several major private and public benefits. First, they reduce the amount of indoor pollution in a home and, therefore, can improve a family's health. Second, they can reduce either the time required to collect biomass fuels or the money spent to purchase them because they require less fuel than traditional stoves. In most rural economies, biomass fuels are collected from the local environment. Therefore, most of the benefits of having better stoves involve reducing the fuel collection time for household members, especially for women. For those who purchase biomass fuels, the benefits involve avoided expenditures due to reductions in fuel use. Third, less fuel collection can reduce pressure on local biomass resources. However, the literature on the relationship between biomass use and deforestation is not conclusive (Arnold *et al.* 2003; Bense 1995; Dewees 1989; Foley 1987; Millington *et al.* 1990; Ravindranath and Hall 1995). Yet, there is abundant evidence to suggest that extensive collection of biomass energy puts significant pressure on local resources (Bowonder, Prasad, and Raghuram 1987; Hyde and Seve 1993; Stevenson 1989).

Links to Human Health

Improved stoves have been linked to improving human health, a prime development goal. Three of the eight Millennium Development Goals (MDGs) are entirely health related: reducing child mortality; improving maternal health; and combating immunodeficiency illnesses such as Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS), malaria, and other diseases (Sachs 2005; UN 2005). According to the WHO, indoor pollution from solid household fuels ranks as the fourth greatest health risk in low-income countries, including India (Smith 2000; Smith *et al.* 2004; WHO 2002, 2006b). Vital epidemiological evidence links biomass combustion, indoor pollution, and human health, especially that of women and children (Ahmed *et al.* 2005; Bruce *et al.* 2002; Ezzati and Kammen 2001a, 2001b; Hughes *et al.* 2001; Parikh and Laxmi 2001; Smith 1998; Smith *et al.* 2000; Warrick and Doig 2004; World Bank 2002b).

Since poor households are the most likely to use biomass energy (Pachauri *et al.* 2004), improved stoves can potentially affect the MDGs directly (Cabraal *et al.* 2005; Modi *et al.* 2005; Rehfuess *et al.* 2006). Many programs around the world have reported that better stoves reduce indoor pollution (Household Energy and Health Project 2006). Such findings should be viewed with caution, however, since improved stoves could be associated with high levels of indoor pollution compared to desired international standards. At the same time, programs that promote well-designed stoves that are widely adopted by households accustomed to unventilated traditional stoves lead to significant reductions in indoor pollution, typically cutting levels by half.

Smoke Exposure

Long-term exposure to smoke has long been considered an environmental health risk. Fine particles, known as Particulate Matter (PM), are of special concern because they lodge deep in the lungs and are a major cause of respiratory illness. General measurements of PM are the most common method for determining exposure levels. PM₁₀ refers to particles with an aerodynamic diameter less than 10 microns (μm), while PM_{2.5} refers to those with an aerodynamic diameter less than 2.5 μm . Health and environmental agencies generally refer to the number of micrograms (μg) per cubic meter (m^3) of air to express acceptable exposure levels for fine particles of varying diameters. The WHO's most recent exposure level standard for PM₁₀ is 20 $\mu\text{g}/\text{m}^3$ of air (annual mean) and 50 $\mu\text{g}/\text{m}^3$ (24-hour mean) (WHO 2001, 2006c). For PM_{2.5}, its standard is 10 $\mu\text{g}/\text{m}^3$ (annual mean) and 25 $\mu\text{g}/\text{m}^3$ (24-hour mean) (WHO 2006c).

High levels of smoke exposure are common in the household kitchens of developing countries around the world (Smith *et al.* 2004; Zhang and Smith 1996). Two of the mostly highly studied countries are Guatemala and India. Studies in the Guatemalan highlands have shown that households using open-fire stoves have PM_{2.5} exposure levels averaging more than 700 $\mu\text{g}/\text{m}^3$ of air over a 24-hour period. For households with an improved stove (*plancha*) or those that use LPG, exposure levels are 100–200 $\mu\text{g}/\text{m}^3$ (Baris and Ezzati 2007; Bruce *et al.* 1998; McCracken and Smith 1998; McCracken *et al.* 1999). The most recent study, conducted in 2003–5, reconfirms these levels. For the control group (without the improved stove), the average daily exposure to particulates (PM_{2.5}) was more than 250 $\mu\text{g}/\text{m}^3$ of air compared to 100 $\mu\text{g}/\text{m}^3$ for the intervention group (with the improved stove with chimney) (McCracken *et al.* 2007). The exposure level for the intervention group was still twice that considered acceptable by the WHO.

A study on indoor pollution in India shows that daily exposure to smoke depends not only on its concentration in a particular place, but also on the amount of time that family members typically spend in the various household

microenvironments over a 24-hour period (Balakrishnan *et al.* 2002, 2004; World Bank 2002b). The study found exposure patterns across fuel types (especially between households using solid or clean fuels) and family members (especially between female cooks and other family members), which emphasized gender inequalities regarding the health effects among solid-fuel users. Among households that used solid fuels, mean 24-hour average exposure concentrations of PM₃ were highest for mixed-fuel households (573 µg/m³ of air for cooks and 264 µg/m³ of air for non-cooks)—about 3.5 times higher than for households that used clean fuels (81 and 79 µg/m³ of air, respectively) (Table 1.1). Among solid-fuel users, mean 24-hour average exposure concentrations of PM₃ were significantly higher for women cooks than for men and other family members. Thus, regardless of whether less polluting fuels were used, household biomass fuel use resulted in higher exposure levels among household members, especially those who cooked.

TABLE 1.1 Particulate Concentration Exposure (24-hour average) of Cooks and Non-cooks across Fuel Types, Andhra Pradesh, 2001

<i>Fuel Type</i>	<i>Cases (No.)</i>	<i>Arithmetic Mean (µg)</i>	<i>Standard Error of Mean (µg)</i>
Cooks			
Mixed	70	573	65
Wood	232	403	25
Kerosene	8	156	48
Gas	28	81	6
Non-cooks			
Mixed	231	264	16
Wood	640	202	7
Kerosene	18	104	11
Gas	78	79	2

Sources: Balakrishnan *et al.* (2004); World Bank (2002b).

Note: Measurements are for PM₃ (µg/m³ of air).

But exposure levels were high even among household members not responsible for cooking. Among non-cooks in households using solid fuels (wood and mixed fuels), women above 60 years of age experienced the highest exposure levels, followed by other women. In many cases, older women no longer worked outside the home and were relegated to the task of tending fires. Men, who were more likely to have outdoor jobs, had lower exposure levels than did women. But older men had higher exposure levels than younger men, reflecting the greater amount of time they spent indoors.¹

Other studies confirm that fuel type, kitchen configuration, and proximity to the cooking area have a significant impact on exposure to household air pollution (Figure 1.1). In a 2005 survey in India, households cooking with LPG had much lower levels of pollution exposure compared to other fuels and as expected exposure levels are highest in the kitchen. These findings generally confirm the results of the earlier study in Andhra Pradesh.

Effects on Human Health

Exposure to biomass smoke contributes significantly to numerous respiratory illnesses and diseases, including acute respiratory infection, chronic obstructive lung disease, and lung cancer (Straif *et al.* 2006); it is also a factor in pregnancy-related complications (Boy *et al.* 2000; Bruce *et al.* 2002; Ezzati *et al.* 2000; Naeher *et al.* 2007; Smith *et al.* 2004). Among women and children worldwide, indoor pollution accounts for an estimated 1.5 million premature deaths each year (WHO 2006a). In India, the comparable figure is approximately 400 million (WHO 2007; World Bank 2002b). Studies in both India and Nepal reveal that non-smoking women exposed to biomass

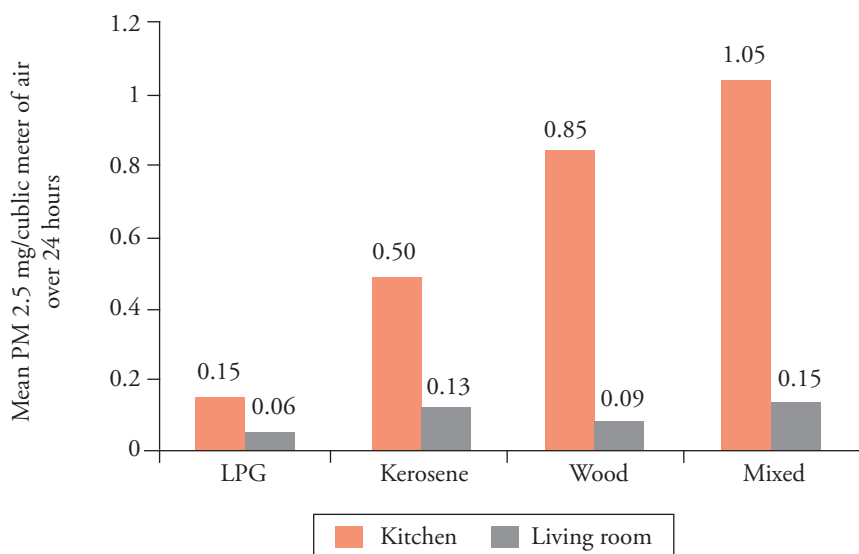


FIGURE 1.1 Particulate Matter Concentrations in Kitchen and Living Areas of Households Using Solid Fuels, India, 2005

Sources: University of Maryland and National Council of Economic Research (2006); Zhang (2009).

Note: Measurements are for PM_{2.5} (mg/m³ of air). The states are Tamil Nadu, West Bengal, Uttarakhand, and Madhya Pradesh. The fuel type is a major fuel. Mixed includes coal, straw, and dung. The sample was approximately 600 households.

smoke have death rates from chronic respiratory disease comparable to those of heavy male smokers (Modi *et al.* 2005).

Children are especially vulnerable since they spend much time indoors close to their mothers who are cooking. Indeed, strong evidence supports the causal linkages between biomass combustion emissions and acute respiratory infection among children (Kammen *et al.* 2002; Parikh *et al.* 2001; Smith *et al.* 2000). A study in Gambia, which examined the health of 500 children below the age of 5, found that girls carried on the backs of mothers who were cooking in smoke-filled huts were six times more likely to develop acute respiratory illness than other children (World Bank 1996). A meta-analysis of all global studies indicates that the risk of acute respiratory infection for children exposed to indoor smoke is 2.3 times higher than for other children.

Household Behavior

Most households are aware that better stoves can remove smoke from their kitchens and other indoor rooms. A 1996 survey of more than 5,000 households from six states in India showed that most villagers agreed that improved stoves were healthier to use than traditional ones because they substantially reduced indoor pollution. Reducing smoke in the vicinity of the cooking area is especially appealing to women, who know the drudgery of keeping cooking vessels and walls free of soot produced by traditional stoves. Thus, one might assume that rural households would be willing to pay more for an improved stove of comparable service level and ease of use that resulted in less eye and throat irritation. But health and avoided death benefits are more difficult to grasp. Technically, the health benefits are the avoided health costs associated with the introduction of cleaner cooking. The avoided death benefits are the loss in productivity due to early mortality caused by air pollution. Although experts are beginning to realize these long-term health consequences of indoor pollution, households generally do not make such connections. Even if the risks are well-known, the vast evidence from the literature on smoking suggests that getting people to change their behavior based solely on long-term health consequences is a difficult task.

Reduced Fuel Collection and Avoided Expenditures

Beyond the health implications, switching to better stoves offers another major private benefit: reducing the time and energy that women must spend collecting and processing ever scarcer supplies of biomass fuels from the local environment. To meet the energy and cooking needs of the household, women must compromise their time spent on other non-monetized work (for example, fetching water), housework (for example, processing food, cleaning house, and caring for children), paid work, and leisure activities, including sleeping (Laxmi *et al.* 2003; World Bank 2004). While this hardship on

women has been noted for decades, the opportunity costs of time spent collecting and processing biomass fuels have received relatively little attention until recently (Hutton and Rehfuess 2006; Köhlin *et al* 2006; WHO 2006b). Growing fuel wood scarcity has led some households to switch to lower-grade biomass fuels, such as crop residues. Because these fuels are burned even more inefficiently than wood, women must spend even more time collecting ever greater quantities of fuel and cooking daily meals.

Evidence from South Asia and Sub-Saharan Africa regarding the unvalued time spent collecting biomass fuels is worth reviewing. In densely populated areas of rural Bangladesh, for example, households spend a high proportion of their cash income on energy. They also spend an average of about 200 hours per year collecting substantial amounts of biomass fuels from local fields and forests. Valued at the average agricultural wage for both men and women, the annual value of this work equals about US\$ 27 (Tk 1,625) per family (Asaduzzaman *et al.* 2008). When added to the energy expenses of the poorest households, expenditures increase to about US\$ 40 (Tk 2,400) per family. Because of the high demand for biomass energy, rural households divide their collection time mainly between fuelwood, cow dung, and tree leaves; crop residue involves little time since it is generally collected as part of farm work (Table 1.2). One also observes seasonal and regional variations.

TABLE 1.2 Biomass Collection Time in Rural Bangladesh
(annual hours per household)

<i>Collection Time Category</i>	<i>Biomass Source</i>			
	<i>Fuelwood</i>	<i>Cow Dung</i>	<i>Tree Leaves</i>	<i>Crop Residue</i>
Income (thousands of Takas)				
< 25	44.4	38.8	112.2	2.1
25–50	74.5	26.0	120.4	1.3
50–75	75.5	13.9	119.9	1.0
75–100	51.2	15.9	106.5	0.8
> 100	31.9	19.7	98.1	0.7
Division				
Chittagong	152.9	20.7	94.9	1.0
Dhaka	28.4	14.9	116.1	0.8
Khulna	32.2	28.8	143.9	1.6
Rajshahi	20.4	34.6	106.3	1.8
All	60.6	24.6	114.3	1.3

Source: Asaduzzaman *et al.* (2008).

For example, in forested areas of Chittagong, household members spend some time collecting fuelwood, but in tree-deficient Rajshahi, more time is spent gathering tree leaves and cow dung. Women devote an average of 150 hours per year collecting biomass, disproportionately more time than do men or children.

India's pattern of rural energy use, though similar to that of Bangladesh, is somewhat less severe. In fact, the relationship between fuel use and time spent collecting fuel and cooking involves some interesting trade-offs. On an average, women who cook with fuelwood spend about 50 minutes collecting fuel, compared to 45 minutes for cooks who use dung and 30 minutes for those who use crop residue. This pattern reflects the reality that crop residue is usually collected and processed on a family's farm, while fuelwood and dung must be collected beyond the immediate household vicinity. The implication is that collecting fuelwood and dung requires more informal labor. But the differences between fuels appear even larger when one recognizes that fuel is not collected every day and most households use a combination of cooking fuels. Fuelwood may be preferred for cooking, in part, because it is easier to use than dung or crop residue, thereby reducing the time required to prepare meals. Cooks who use fuelwood spend about 2.5 hours per day cooking, compared to 2.75 spent by those using dung and 3 hours for those using crop residues. In terms of the total time needed for collecting biomass fuel and preparing meals, fuelwood requires the least amount of time and is the easiest to use. Dung, a slow-burning fuel, often burns at too low a temperature—in the state of Punjab, it is used for boiling milk—whereas straw burns too fast, requiring constant attention.

In rural India, households rarely switch to a single cooking fuel. Comparing the lifestyles of women who use petroleum fuels for cooking with those who use biomass, the former have a small but definite advantage (Table 1.3). The use of LPG stoves significantly reduces the time spent in cooking. This fact is surprising at first, given that women from better-off households tend to spend more time cooking, and LPG users are precisely from such households. But since most LPG users are from the wealthier states of Himachal Pradesh and Punjab, access to amenities may hint at why women spend less time cooking. Similarly, women who use kerosene for cooking are less likely to spend time collecting fuel. The longer time spent in cooking is typical of women's time allocation in better-off households that use these stoves. Switching to kerosene for cooking is more attractive in terms of reducing the hardships and improving the health of rural women. But its use depends on the availability of disposable income, as both the stove and fuel costs are higher than those for traditional stoves and fuels. Although the differences appear small, most rural households in India use multiple cooking fuels, that is, biomass energy along with LPG and kerosene.

TABLE 1.3 Fuel Types and Women's Time Allocation, Rural India, 1996

Activity	Time Spent (mean hours per day)					
	LPG		Kerosene		Biomass	
	Users	Non-users	Users	Non-users	Users	Non-users
Fuel collection	0.5	0.7	0.4	0.7	0.8	0.4
Fetching water	0.7	1.0	0.9	0.9	1.0	0.8
Cooking	2.3	2.8	2.8	2.7	2.7	2.7
Housework	6.3	5.7	5.6	5.8	5.8	5.8
Income	1.4	2.0	1.7	1.9	2.0	1.6
Reading	0.4	0.1	0.2	0.1	0.1	0.3
Watching TV	1.4	0.4	0.7	0.4	0.3	0.9
Leisure	10.5	10.5	10.7	10.4	10.4	10.6
Miscellaneous	0.5	0.7	0.7	0.6	0.7	0.6

Source: World Bank (2004).

Note: Number of cases: LPG, 518 (users) and 4,528 (non-users); kerosene, 757 (users) and 4,226 (non-users); biomass, 3,694 (users) and 1,313 (non-users).

The evidence indicates that rural women in South Asia with access to improved stoves during a time when these programs were in full swing, save a significant amount of time. They spend slightly less time cooking and substantially less time collecting fuel (Table 1.4). Since fuel collection is not necessarily a daily activity, it is probably better to look at the mean time spent collecting fuel for only those who undertake the chore. Among women collecting fuelwood, there is more than a half-hour advantage for those who use improved stoves compared to those who use traditional stoves. Though the time savings is not as great as might be expected, the work of collecting fuel is arduous at best; thus, improved stoves contribute to lessening the amount of drudgery women suffer.

TABLE 1.4 Stove Use and Women's Time Spent Cooking and Collecting Fuel, Rural India, 1996

Stove Type	Time Spent (mean hours per day)					
	All Users			Users Who Collect Fuel		
	No.	Cooking	Fuel Collection	No.	Cooking	Fuel Collection
Traditional	4,654	2.7	0.7	1,433	2.4	2.1
Improved	336	2.6	0.5	129	2.6	1.4

Source: World Bank (2004).

The WHO recently reviewed evidence regarding fuel collection time and biomass energy use among 14 countries in Sub-Saharan Africa (Dutta 2005; WHO 2006b). The number of hours spent collecting biomass energy ranged from a high of 4 hours to a low of 0.33 hours per day. Niger, Burkina Faso, and Ethiopia—countries with the highest levels of biomass scarcity—recorded higher levels of biomass collection time. A partial explanation for this finding might be the various ways in which the questions were asked; nonetheless, the results generally supported the notion that worldwide collection of biomass energy requires a significant amount of time for rural households.

To summarize, the conclusion is that the value of all the unvalued time spent in collecting fuelwood could easily pay for an improved stove that saves fuel and, thus, collection time, along with any expense for purchased biomass. The WHO studies developed economic valuation methods for assessing time savings from fuel collection and cooking, avoided health costs, and environmental benefits (Hutton and Rehfuess 2006; Hutton *et al.* 2006; WHO 2006b). This is a very good study, but one should be cautioned that the value used for the opportunity cost was not the agricultural wage rate; rather it was a higher figure involving more average wage rates. Nevertheless, the results are interesting and for a typical South Asian household, the benefits of switching exclusively to improved stoves or from biomass to LPG amounts to about US\$ 30 (Rs 1,429) per year. This cost compares well to that of an improved stove traditionally disseminated in India—about US\$ 5 (less than Rs 238) per year. Thus, improved biomass stoves and interfuel substitution can significantly benefit rural households, even excluding health and environmental benefits. But because switching to less polluting stoves and fuels may not involve cash expenditures, markets are slow to develop.

Biomass Use and Deforestation

The public benefits offered by improved stoves—a major one of which is reducing pressure on the local environment—are also difficult to quantify. In rural areas of many countries, some local environments have been deteriorating as a result of extensive fuel wood collection. In more sparsely populated areas, the removal of dead wood can benefit the environment. But once local trees become scarce, as is common in many developing countries, people turn to straw and dung for their cooking energy, which may produce even higher levels of indoor pollution. Verifying the direct links between the use of better stoves in a community and connection to local deforestation or loss of soil fertility is difficult.

When Eric Eckholm first focused the attention of the international development community on ‘the other energy crisis’ several decades ago (1975), predictions of Third World biomass shortages were quite common. Fuelwood shortages would mean that women and children could expect to spend many

more hours walking farther distances in search of cooking fuel supplies. At that time, growing populations in developing countries were expected to result in harvesting trees for use as cooking fuels at unsustainable rates, which were predicted to result in significant deforestation problems. But just as the world has recovered from several energy crises, dire predictions that the developing world would run out of biomass energy were overstated. However, the work of Eckholm and others (Agarwal 1986; Arnold 1979; Dunkerley *et al.* 1981; Leach 1987, 1993; Leach and Mearns 1988) contributed significantly by focusing attention on traditional energy use and its associated problems. Indeed, there have been some improvements in the last 25 years, but they have been overshadowed by the continual growth of developing country populations.

Since that time, a significant and growing body of evidence suggests how, when, and why people in developing countries use biomass fuels and the associated problems and opportunities (Alam *et al.* 1985; Allen and Barnes 1985; Barnes *et al.* 2005; Hyde and Amacher 2000; Leach 1986; Myers 1980; Sathaye and Tyler 1991). In many urban areas of developing countries, deforestation has occurred around the urban perimeters (Bowonder, Prasad, and Unni 1987, 1988); interestingly, the price of fuelwood in urban markets can exceed that of petroleum fuels (Barnes 1990; World Bank 1999b, 2009). In densely populated rural areas, fuelwood is often in short supply, causing many residents to switch down the energy ladder to dung and straw. However, it is now recognized that these problems are localized (Köhlin *et al.* 2006; O'Keefe and Munslow 1989), and many areas have biomass surpluses that can be used in new and different ways (OTA 1991).

The availability of biomass energy in rural areas depends on local resource conditions, population densities, and levels of development. In many rural areas, biomass is a plentiful resource—trees grow everywhere. Farmers are producing straw and stalks that can be used for cooking. Consumption of traditional biomass fuels continues to persist in most, if not all, rural areas in developing countries. At the same time, in many other rural areas, residents experience significant shortages of quality biomass fuels. Available statistical evidence shows that in high- and low-income developing countries, rural households depend on biomass fuels—in the form of fuelwood, charcoal, dung, and crop residue—to satisfy 90 percent of their energy needs (IEA 2002, 2006; WHO 2006b).

Despite the wide variation in local resources and population densities, the critical issue is that continuing growth of rural populations is straining local biomass resources. One cannot travel through rural China without seeing trees with their lower branches cut off for cooking fuel. In rural Bangladesh, many residents have turned to using leaves and grass for cooking. In certain areas of India's Deccan Plateau region, where little fuelwood remains, residents have

switched to agricultural residue and dung for cooking. Such examples can be offset by experiences from high-rainfall areas with low population densities, where fuelwood scarcity is not an issue. But such averages are of little consolation to the millions of people who walk even longer distances to meet their basic cooking needs, diminishing the health of their local environments, and themselves in the process.

Household Energy and Climate Change

Recent evidence suggests that the climate-change debate needs to focus more on household energy. In developing countries, households burn about 1.6 billion tons² of biomass are burned every year (WHO and UNDP 2009; and author estimates), amounting to more than 1 billion tons of carbon dioxide emitted into the atmosphere. If the use of biomass fuels in developed countries for all purposes is added to the massive quantities of fuelwood burned in developing countries, the total biomass used for energy is estimated at about 2.3 billion tons (Fernandes *et al.* 2007; IEA 2009; Yevich and Logan 2003; and author estimates). One could argue that a portion of the emitted carbon dioxide is sustainable because the biomass is renewable, but the amount of sustainable growth is open to question.

Biomass energy accounts for about 10 percent of the primary energy consumed globally, about two-thirds of which is used for cooking and heating in developing countries. For millions of rural households in Africa and South Asia, biomass fuels are likely to remain the predominant energy source in the next decades. Most rural households that burn biomass fuels use inefficient stoves or open fires (FAO 2010). Thus, improving cookstove efficiency, including more complete combustion, has enormous potential for energy savings and reduction in greenhouse gas emissions. Estimates of emission reductions from improving the efficiency of traditional cookstoves are uncertain; the underlying data are either unavailable or subject to considerable fluctuation. To date, few studies have addressed the need for better data or the effects of black carbon, which contributes to climate change.

Biomass fuels that are inefficiently burned due to incomplete fuel combustion generally can produce products of incomplete combustion with global warming potential, which linger in the atmosphere for decades (Bond *et al.* 2004; Smith 2000; WHO 2006b). These products of incomplete combustion include such gases as methane and nitrous oxide, and fine particulates in the form of black carbon and organic carbon. Thus, not only are potentially high levels of carbon dioxide emissions being produced in open or semi-open fires, a variety of other global warming emissions are also being produced. In addition, smoke from biomass cooking emits both black carbon, which is largely elemental carbon, and organic carbon, where carbon is combined with other elements, such as oxygen and hydrogen. Both black and organic

carbons are referred are comprised of fine particles suspended in the atmosphere, and they might have a significant impact on the climate (Ramanathan and Carmichael 2008). Black carbon absorbs sunlight and has a significant net warming effect, while organic carbon reflects sunlight back into space and has a cooling effect on the atmosphere.

* * *

The interlinked problems of biomass energy collection, use of traditional biomass stoves, and resulting indoor pollution and its consequences for human health remain invisible to major policymakers in many developing countries. Most fail to factor the time and energy women spend in collecting biomass supplies into the costs of using biomass fuels; therefore, women's expenditure of time and energy is often not equated with value or money. For most women in developing countries, the biomass energy syndrome means a life of poor health burdened with unpaid work and drudgery. In addition, the resulting environmental pressure often leads to degradation of nearby forests and community land.

An effective improved stove program, along with efforts to promote petroleum-based cooking fuels, could help avoid the public health costs associated with the use of unventilated biomass stoves and, thus, offer society an economic benefit. The avoided illnesses and deaths that might be attributed to the use of improved stoves or petroleum cooking fuels may be significant. The costs involved in treating illnesses caused by indoor pollution, which must be borne by public health facilities, may also be significant.

Unfortunately, the lessons of the past 25 years have not taken hold in a commitment to tackle the issue, even as 3 billion people continue to burn biomass and solid fuels in traditional stoves. Although the magnitude of the problem varies by country, opportunities for improvement could be harnessed. To reiterate, the solutions are rather simple. They involve fuel substitution, better ventilated homes, improved local biomass production, and better stoves. Despite the difficulties involved with implementing these simple solutions, their many complementary benefits are worth pursuing. It should be emphasized that this book concentrates on the promotion of better stoves only as one way to deal with the problems surrounding the use of energy in traditional ways. Many of the recommendations offered in this book are derived from the best, innovative approaches to the design, financing, and promotion of stoves found in India and the developing world.

NOTES

1. A study in Bangladesh found that, by increasing the amount of time a child spends outdoors from three to six hours per day, his or her exposure to indoor pollution may be reduced by 50 percent (Dasgupta *et al.* 2004a, 2004b).

2. A ton refers to a metric ton.

2

India's Best Legacy Improved Stove Programs

India is one of the few countries with a sustained commitment to promoting improved stoves. The government mobilized the strength of its bureaucracy, partnered with NGOs, and employed local technical institutes to tackle the problem of inefficient energy use. At the outset of the National Program on Improved Cookstoves, the serious nature of illnesses resulting from indoor air pollution was generally unknown. In its early stages, the national program aimed at improving energy efficiency in India's poorest households; even then, it recommended stoves with chimneys to vent smoke outside the house.

Over the years, the national program evolved to meet new challenges. Technical backup units were financed to deal with technical stove issues, and various forms of implementing agencies were given the task of disseminating improved stoves. Each state had a certain level of autonomy with regard to program management. What emerged was a wide variety of interesting programs, some of which succeeded well in meeting national program goals.

All of this ended in 2002 when the National Program was decentralized to the states effectively ending most national support for improved stove programs in India. Today, the government is setting the stage for the development of a major new program. This hiatus between 2002 and today actually has allowed for a rebirth of ideas and new enthusiasm for a new generation of stove innovations. There has been a rededication to the task of alleviating household air pollution and the burden of fuel collection in the poorest parts of India with the announcement that a large new program is being developed to deal with these issues.

However, as the Spanish philosopher George Santayana once stated, 'Those who cannot remember the past are condemned to repeat it' (1905: 284).

Thus, in this chapter we will present a history of the improved stoves program in India and later document the best programs in six states.

SCALE-UP TO THE NATIONAL PROGRAM

Before the national program was launched in the early 1980s, stoves were mainly aimed at providing convenience for cooking. As early as the 1950s, India instituted improved stove (*chulha*), biogas, and fuelwood cultivation programs. The Magan *chulha* of 1947 and the Hyderabad Engineering Research Laboratory *chulha* of 1953 focused mainly on reducing cooking drudgery by aiming to remove indoor smoke, thereby reducing health hazards. These early models met with limited success and thus were not distributed widely. The hope for a successful national-level program grew with the 1980 introduction of the popular Nada *chulha* in Haryana, followed several years later by Astra stoves developed in Karnataka. The local women of Nada village helped to develop the Nada stoves, while the Astra stoves were developed by a group of scientists at the Bangalore Centre for Application of Science and Technology to Rural Areas, Indian Institute of Science.

With increased international emphasis on combating deforestation in the 1980s, the primary goal of the improved stoves became greater energy efficiency to reduce environmental pressure. The national program was founded in 1983 as a series of pilot programs with the multiple goals of conserving fuel, reducing smoke emission in the cooking area, and keeping kitchens clean. It also aimed to reduce deforestation (Agarwal 1983, 1986), lessen women's drudgery, reduce cooking time, and improve employment opportunities for the rural poor. It set up technical backup units to develop and test new stove designs and implement training. With the formation of the Ministry of Non-conventional Energy Sources,¹ first as a department in 1982 and then as a full-fledged ministry a decade later, the national program steadily expanded to encompass nearly all states. Even in 1983, there were concerns about the program's sizeable targets and hurried start. Many evaluations were conducted during the early years (ORG 1989; Ramakrishna 1991; TERI 1987); these recognized the national program's importance, but questioned its targeted nature, as well as post-installation maintenance and other implementation issues.

During 1984–2001, more than 34 million improved stoves were produced—more than in any other country in the world, except for China. Intended primarily for rural Indian households, these improved stoves were distributed mainly through the GoI, assisted by large NGOs. To receive approval, improved stoves were required to have a minimum efficiency of 20 percent for fixed mud stoves and 25 percent for portable metal stoves. Under the national program, most improved stoves were built of mud and a few steel components, with a potential life of two years, depending on the

level of maintenance; no specific requirement was made to reduce emissions or vent smoke outside the house. But in October 2000, the Ministry of Non-conventional Energy Sources shifted its policy toward promoting durable cement stoves with chimneys and a minimum lifespan of five years. Reflecting India's diverse cooking needs and customs, the Ministry approved more than 100 improved stove models for distribution beginning in early 2002.

In the 1990s, there was growing recognition that rural people had many other pressing problems beyond the laudable goals of saving energy and growing trees. The wind had gone out of the sails of concerns over biomass energy, and the programs surrounding it began to flounder. A 1996 survey indicated that improved stoves were present in all the villages surveyed and available in village markets (Natarajan 1999); it showed that 60 percent of existing improved stoves were in use in the households. But the survey also showed that improved stoves accounted for less than 7 percent of the total stock of stoves in rural areas and that nearly 60 percent of the surveyed households did not wish to change from their traditional stoves (World Bank 2002a). While a 2002 survey stated that 72 percent of households with improved stoves had operating stoves (World Bank 2002a), these figures failed to account for the limited lifetime of an improved stove; for this reason, many were no longer part of the household inventory of appliances. A recent national survey in India indicated that only 5 percent of rural households had an improved stove (Zhang *et al.* 2006).

At the beginning of this decade, the national program came under significant scrutiny, and the optimism of the early years faded (NCAER 2002; Parikh *et al.* 2001; Pohekara *et al.* 2005; World Bank 2002b). The program faltered owing to overreliance on targets, lack of field monitoring and evaluation, and failure to develop market mechanisms to extend program reach. India was not alone in discovering the difficulty in executing the simple concept of an improved stove program. Internationally, there were failures along with successes; like India, other countries experienced problems as they moved from small pilot efforts into full-fledged national initiatives.

In 2002, the GoI decided to decentralize the national stove program, transferring full implementation authority, together with funding support, to the state level, notwithstanding having spent some US\$ 32 million (Rs 1.5 billion) since inception (Rajvanshi 2003) and having developed, tested, and promoted more than 80 models (Meshram 2001). The government reasoned that sufficient central funds and efforts had been directed toward promoting the national program for nearly two decades. While the Ministry of Non-conventional Energy Sources continued to provide limited technical assistance, the states continued the program using their own resources.

The reasons for the national program's limited success are not entirely clear. One criticism, common to similar government programs, was that it was

driven by targets rather than needs (NCAER 2002). The government used subsidies to encourage stove distribution without paying adequate attention to consumer requirements and after-sales service. Extensive subsidies deterred the development of local markets, which could have been more efficient in manufacturing and servicing improved stoves. Development of markets, targeting areas with greatest need, and other program aspects could have been emphasized more after initial pilot testing (Barnes *et al.* 1994).

In theory, the benefits of improved stoves are high compared to their costs, but in practice, the reality is much different. If only a fraction of the benefits developed under the national program had been perceived by rural households, the program would not have required significant subsidies, and customers would have been willing to purchase the improved stoves at retail cost. But improved stoves must be designed to account for a range of issues. Primarily, they must handle a diversity of cooking services, improve fuel efficiency, and reduce indoor pollution. In addition, they should offer cooking convenience and be attractive in the kitchen. The national program's low adoption rates indicate that many obstacles—including the type and effectiveness of the government subsidies used for promotion—must be resolved before the benefits of improved stoves can be realized.

BEST PRACTICES

Despite these problems, certain states in India succeeded in fulfilling some of the promises of the national program. This book extracts lessons from six case studies, along with lessons from other successful experiences internationally. These cases were not intended to be representative of the national program or the six state programs since the studies were carried out in selected districts. Rather, the aim was to gain an in-depth understanding of the best practices found in India's national program so that future improved stove programs might be better designed.

The method used to select the six states involved a panel of experts comprised of rural energy specialists, rural development experts, NGOs, government professionals, and stove scientists. The main selection criteria were simple. The improved stove program had to reach many households (reflected by a high adoption rate) and be relatively sustainable (reflected by the purchase of a second improved stove or refurbishing of an existing one). In addition to these criteria, the six states were chosen to reflect geographical coverage. Those recognized as having the best improved stove programs were Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, and West Bengal.

Case-study research was comprehensive and relied on a 2001 survey, which included interviews with project officials; surveys of rural energy users; and focus group discussions with users and non-users of traditional and improved

stoves, stove builders, designers, and suppliers (see Annexure). Based on the issues addressed, interview questionnaires were developed for these various groups. Concise checklists were prepared for focus group discussions. Finally, a structured questionnaire was developed for assessing the improved stove user profile. Table 2.1 describes the data collection techniques.

TABLE 2.1 Typical Data Collection Instrument, 2001

<i>Stakeholder Group</i>	<i>Instrument</i>	<i>Target Interviews</i>
Implementing agencies	Interviews and discussions	Interviews and discussions with key staff members
NGOs	Postal and direct interview	Questionnaires mailed to NGOs; some contacted directly
Users	Focus group discussions	2–3 groups (8–10 persons) per village
Non-users	Interviews	7–10 persons per village
Technical backup unit	Discussions and interviews	2–5 people at the unit and in the field
Stove builders (Self-employed Workers [SEWs])	Focus group discussions and interviews	3–8 stove builders
Stove materials and parts suppliers	Questionnaires and interviews	All

Source: See ‘Annexure: Research Methodology’ at the end of the book.

To objectively review each program, a comprehensive set of issues was developed to allow for eventual comparisons across states (Table 2.2).

While regional peculiarities may have contributed to greater success in the six states examined, the states themselves were characterized by unique approaches to effective distribution. Andhra Pradesh featured remarkable interagency coordination and emphasized complete coverage within villages. Gujarat took an integrated rural development approach. In Haryana, women’s self-help groups played a critical role at every stage of design and development. Karnataka emphasized research and development and technical innovations, while Maharashtra took a commercial approach, building on its long history of purchasing stoves. Finally, West Bengal relied on its large network of local NGOs.

* * *

All of India’s state programs shared certain features since, for the most part, they were financed nationally. Even as part of a large national initiative, however, they were allowed the freedom to grow in unique ways. The result was

TABLE 2.2 Summary Attributes for Assessing Best Stove Programs

<i>Program Attribute</i>	<i>Key Questions of Case Studies</i>
Financing and subsidies/pricing	<ul style="list-style-type: none"> • How were subsidies and pricing balanced so that poor households could afford the improved stoves? • What was the relationship of stove pricing to production and marketing costs? • How did the cost of producing inexpensive stoves made of local materials compare with making more expensive ones using higher-quality components or parts?
Market development	<ul style="list-style-type: none"> • Were the markets for the improved stoves identified via surveys or other market assessment techniques?
Improved stove identification and development	<ul style="list-style-type: none"> • What processes were involved in the technical design and development of the improved stoves for sale or distribution?
Customer service/satisfaction	<ul style="list-style-type: none"> • What were the effects of the improved stoves on rural communities? • Were customers satisfied with the before- and after-sales process?
Operations/procedures	<ul style="list-style-type: none"> • What was the allocation of institutional responsibilities? • What types of community-level and artisan training were provided?
Communications/promotion	<ul style="list-style-type: none"> • Was customer outreach conducted? If so, how effective was it? • How was the communication between the executing agency, stove manufacturer, and rural beneficiaries managed?
Local perceptions	<ul style="list-style-type: none"> • Did local people value the improved stoves because they saved energy, were convenient to use, or eliminated indoor pollution? • What were the reasons for adoption or non-adoption?

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

that many prospered while others floundered. But this freedom also meant that the best practices discovered could become available to national and international planners, providing insights into how future national programs in developing countries might better promote improved stoves.

Today, India is venturing on a new and innovative path with the promise of fresh ideas for a better stove program. We started this chapter with the famous quote that those who ignore the past might be condemned to repeat it. We would like to revise this phrase to say that learning from the best and worst features of the past can offer guidance on the way forward towards more successful efforts to promote better stoves and cleaner cooking. Against this brief historical backdrop of India's program, the next six chapters examine the intricate tapestry of implementation across the country's most successful efforts.

NOTE

1. The Ministry of Non-conventional Energy Sources has been renamed the Ministry of New and Renewable Energy.

3

Maharashtra

Commercial Approach

When the national program in Maharashtra began, a potential market for improved stoves was already in place, reflecting rural residents' long history of purchasing traditional stoves. At the initiative of the ARTI, a Pune-based NGO and technical backup unit for the national program, an agenda complementary to the national target program was developed to train traditional potters in the design, construction, promotion, and sale of improved stoves. With modest investments, these entrepreneurs made reasonable profits by selling their stoves through the national program and on the open market. When the program focus turned to durable stoves made of cement and the number of qualified workers decreased, the technical backup unit responded by testing whether baked-mud stoves could be approved as 'durable'. Market demand, combined with an innovative technical backup unit, put Maharashtra at the forefront of marketing improved stoves.

This case study focused on findings from three western districts: Kolhapur, Sangli, and Satara (Figure 3.1). The commercial approach to stove distribution developed in these districts provides important lessons for future initiatives.

BACKGROUND

India's third largest state, Maharashtra is home to 97 million people (GoI 2001). Located in the western peninsular part of the subcontinent, the state is bounded by the Arabian Sea to the west, Gujarat to the northwest, Madhya Pradesh to the north, Andhra Pradesh to the southeast, and Karnataka and Goa to the south (Figure 3.1).

Since the national program was established in 1983–4, Maharashtra has distributed an average of 120,000 improved stoves annually (Table 3.1).

MAHARASHTRA

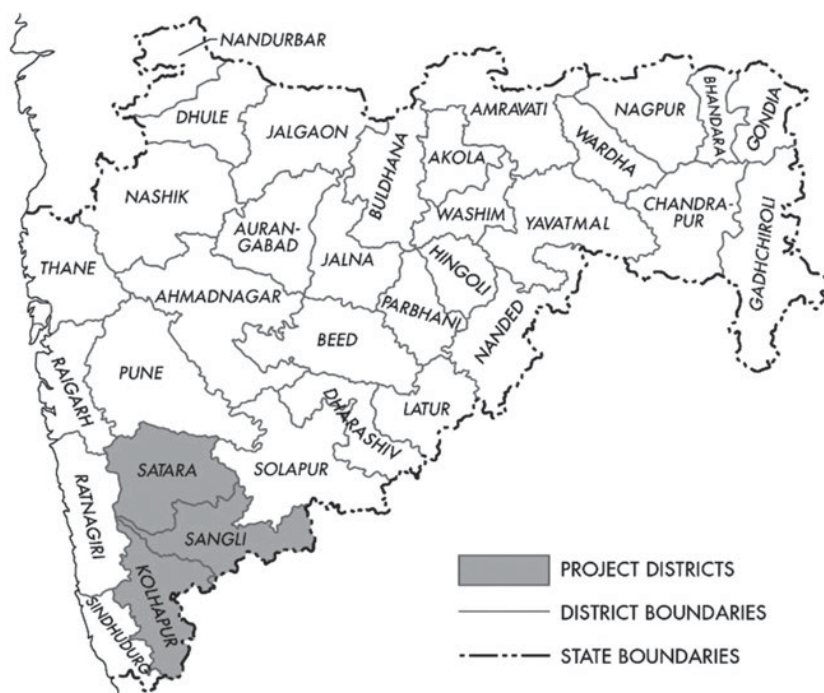


FIGURE 3.1 Map of Maharashtra, Highlighting Case Study Districts

Source: General Services Department Printing, Graphics and Map Design, The World Bank, Washington, D.C., 2011.

Three government agencies have shared responsibility for distribution. The Rural Development and Water Conservation Department has handled 80 percent, while coverage of the remaining 20 percent has been shared by the Maharashtra Energy Development Agency and the Khadi and Village Industries Commission. Through state- and district-level authorities, participation has been garnered from a diversity of rural households, with emphasis given to socioeconomically disadvantaged groups.

TABLE 3.1 Improved Stoves Installed in Maharashtra, 1995–2000

Thousands of Stoves	1995–6	1996–7	1997–8	1998–9	1999–2000
Target	160	140	200	100	140
Achievement	170	184	213	100	109

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Interestingly, improved stoves were not unusual in rural Maharashtra, especially among those who could afford a one-time cost of Rs 180–200 (US\$ 3.8–4.2). Each village cluster had one or two potters that constructed and sold both traditional and improved stoves; as a result, many villagers were aware of the technology and its benefits. While households in backward classes preferred to purchase cheaper traditional stoves, others tended to purchase a combination of energy devices. Improved stoves were used to prepare main dishes, while traditional stoves were used to heat water and prepare cattle feed. If available, LPG was reserved for making tea or cooking for special occasions. Under the national program, 16 percent of the households that owned improved stoves also used traditional stoves and 30 percent used LPG stoves. Economically better-off households, who could afford LPG stoves, were less likely to become beneficiaries.

HOUSEHOLD CHARACTERISTICS AND USER PERCEPTIONS

In Kolhapur, Sangli, and Satara, landless farmers comprised 37 percent of households, 56 percent owned less than 2 hectares, and only 7 percent owned larger tracts. For 85 percent of households, stoves were made of mud; cooking fuel consisted of gathered fuelwood and sugarcane residues or, in their absence, purchased fuelwood or cow dung. Widely varying consumer preferences between districts and even between villages in the same district were reflected by a variety of stove designs (Table 3.2). For example, households in Chikli preferred a front-opening grate, while those in Nagaon preferred a side-opening one; raised stoves (using bricks) were also common in Nagaon.

TABLE 3.2 Improved Stove Models Distributed in Maharashtra, 2002

<i>Model</i>	<i>Description</i>	<i>Thermal Efficiency (%)</i>
Laxmi	Fixed mud two-pot, with chimney	24
Grihalaxmi	Fixed mud single-pot, without chimney	26–8
Parvati	Fixed mud two-pot, without chimney	26–8
Bhagyalaxmi*	Fixed mud two-pot, without chimney	26–8
Priyagni	Portable, metallic single-pot	28–30

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Note: * Developed for users in high-rainfall areas who desired some smoke to eliminate pests.

In Maharashtra, stove users' medium- or high-level satisfaction with the improved stoves resulted, in large part, from the initiative and sustained efforts of the ARTI, the state's technical backup unit, which involved

traditional potters in design and development. Users appreciated this feature, along with the stoves' many benefits, including better health resulting from reduced kitchen smoke. At the same time, some households reported leakage from chimneys and the need for frequent chimney cleaning.

Of the 73 households surveyed, 63 had improved stoves in working condition. Users who would otherwise have had to purchase fuelwood for lack of crop residues were especially appreciative of the fuel-savings feature; this benefit was reported by nearly half of women users, particularly those in Deshing (Kolhapur district) and Nagaon villages (Sangli district) (Figure 3.2).

Most women users also reported faster cooking as a result of being able to use two pots simultaneously and a cleaner cooking environment. In villages where sugarcane root was the primary cooking fuel, users were especially interested in reducing indoor kitchen smoke. In households where the kitchen was the innermost room, users appreciated the improved stove's ability to remove smoke efficiently. Some users perceived the link between reduced smoke from the improved stoves and the health benefits for themselves and their children.

Despite the many perceived benefits, some women users faced such practical problems as chimney leakage, inappropriate pothole size, inconvenient grate design, greater fuel consumption, and the need for frequent chimney cleaning (Table 3.3).

As a result of these perceived problems, about one-fifth of the users modified their stoves. Unlike users in the northern states, women in Maharashtra preferred smaller potholes to accommodate smaller-sized vessels. In some

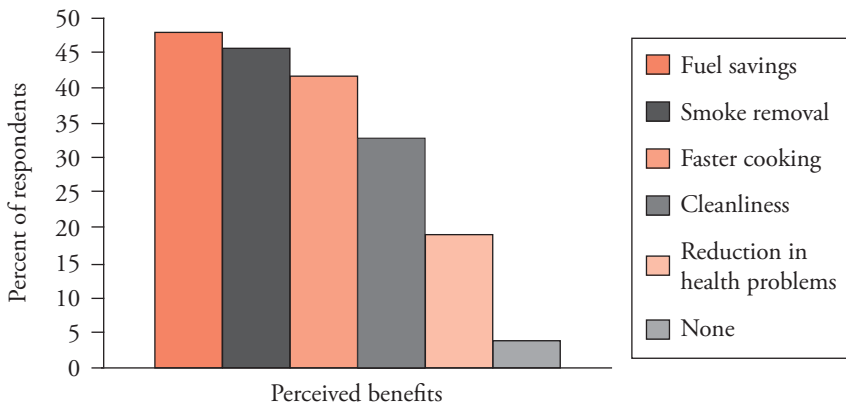


FIGURE 3.2 Perceived Benefits from Improved Stoves, 2000-1

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

TABLE 3.3 User Complaints Regarding Improved Stoves

<i>Perceived Drawback</i>	<i>Households (%)</i>
Leaking chimney	6.8
Too large pothole	5.4
Inconvenient grate	2.7
More fuel needed	2.7
Frequent cleaning required	1.4

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

households, grates were not considered useful because of the difficulty in removing hot ash from underneath it and the lack of space in which to fit large pieces of wood in the firebox. In Murud village (Satara district), most households abandoned their stoves because of chimney leakage during the rainy season resulting from the improper sealing of the gap between the chimney end and the tin roof. In addition, several households cited chimney cleaning as a problem.

About half of the respondents reported that they cleaned the chimneys of their improved stoves at least once a month (Table 3.4). The other half said they cleaned their chimneys once every three months or less often. Many users were unaware that their chimneys required cleaning.

TABLE 3.4 Frequency of Chimney Cleaning by District, 2000–1

<i>Frequency</i>	<i>Households (number)</i>				<i>Households (%)</i>
	<i>Kolhapur</i>	<i>Sangli</i>	<i>Satara</i>	<i>All</i>	
Weekly	0	0	0	0	0
Twice monthly	0	6	6	12	17
Monthly	10	10	2	22	31
Quarterly or less	20	12	0	32	44
Never	1	0	5	6	8

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

An evaluation of consumer preferences indicated that users were not concerned about stoves conforming to technical specifications; rather, their main interests were reducing fuel use, having adequate heat generated in the firebox, and eliminating smoke from the kitchen.¹

SUBSIDIES: AFFORDABILITY VERSUS SUSTAINED DEMAND

The policy of subsidizing improved stoves had both positive and negative effects. Large subsidies ensured distribution in certain parts of the state and increased affordability across a wide range of household categories, but those most heavily subsidized had the poorest maintenance record. Other household categories chose not to purchase the subsidized stoves because of lack of installation space or incomplete information about the national program. Still other groups were not selected as beneficiaries because emphasis was given to backward classes.

According to central government policy, a subsidy of up to one half of the stove cost was given as a direct discount to all national program beneficiaries. For a two-pot mud stove with chimney, the beneficiary contributed about three-fifths of the unit cost (Table 3.5). At the village level, user contributions varied widely across household categories. In some villages, users paid more than four-fifths the unit cost; more than one-third of that amount covered the potter's transport cost. In other cases, where beneficiaries contributed labor and materials, the cost fell to about two-fifths of the unit cost. Households in backward classes, who received an additional subsidy from the village councils (panchayats), paid little or nothing.²

TABLE 3.5 Subsidy Structure of Improved Stoves in Maharashtra

<i>Cost in Rs (US\$)</i>	<i>Fixed Cement Two-pot Laxmi, with Chimney</i>	<i>Fixed Cement Two-pot Parvati, without Chimney</i>	<i>Two-pot Mud Stove with Chimney</i>
Unit	200 (4.2)	180 (3.8)	180 (3.8)
Central subsidy	80 (1.7)	80 (1.7)	40 (0.8)
SEW charge	30 (0.6)	30 (0.6)	30 (0.6)
Beneficiary share	90 (1.9)	70 (1.5)	110 (2.3)

Sources: Technical backup unit and household survey.

Generally, households that benefited from the largest subsidies exhibited the poorest maintenance. By contrast, better-off households that purchased the stoves outside the national program at slightly higher cost had superior maintenance, with some stoves still in operation after eight or nine years. The condition of the improved stoves was dismal among backward classes. Having paid nothing for an easily accessible product, these households did not appreciate its benefits. This shortcoming was compounded by the local administration's failure to conduct awareness-raising activities on the benefits of stove maintenance and how to perform it. Within six months, these poorly maintained stoves fell into disuse.

Because households in backward classes depended on a single energy device—unlike better-off households, which used multiple cooking devices—longer periods of use may have contributed to poorer stove conditions. In addition, households that did not contribute monetarily could not insist on proper installation. For example, in Murud village (Satara district), households were not given cowls to protect the tops of their chimneys, and chimneys that vented via tin roofs were sealed improperly, resulting in leakage. These inadequacies, in turn, caused users to improvise solutions by covering the chimney top with a small tin vessel or plugging the gap between the chimney and tin roof with pieces of cloth. Persistent problems caused most of these users to revert to their traditional stoves. Finally, households interested in installing improved stoves that were overlooked because of the emphasis given to backward classes were reluctant to purchase more expensive, non-subsidized ones in the open market.

ROLE OF TRADITIONAL POTTERS

Unlike all other states, Maharashtra adopted a unique approach to stove development, which was key to the state's success. This included involving traditional potters in design, development, promotion, and sale of stoves. Since the inception of the national program, the ARTI designed a variety of stove models in response to regional requirements. In the 1980s, it focused on constructing stoves without dampers approved by the state government. Subsequently, it designed and distributed the two-pot Laxmi (with chimney) and Bhagyaxmi (without chimney) models. Stoves without chimneys catered to the needs of households in high-rainfall areas, such as the Konkan region, where a certain amount of indoor smoke was required to eliminate pests.

Aware of the need to integrate competent and dedicated stove producers into the national program, the ARTI recruited and trained unemployed youth in constructing improved stoves to conform to the national program's technical specifications. But the majority of these youth viewed stove construction as a casual job rather than a profession, and dropout rates were high.

Realizing that pottery-making was a traditional family occupation, the ARTI initiated training programs exclusively for such potters. Subsequently, it piloted a quasi-commercial approach that promoted improved stove technology as an income-generating activity among traditional potters. Trained potters were linked with the national program and received independent bulk orders (or targets) to install improved stoves in selected villages. Recognizing the potters' lack of entrepreneurial skills with which to establish sound businesses, the ARTI initiated training and certification programs in the mid-1990s, which included the testing of new models and information-sharing on technical design and development. Business training ensured that potters

learned skills in inventory and cost control, tax and labor laws, salesmanship, and advertising. Some potters received financial assistance with which to establish larger businesses.

In response to the above strategies, traditional potters showed considerable initiative in setting up businesses and discovered synergies with the manufacturing and sale of products from their other enterprises. As of 2000, the ARTI had trained 63 potters in entrepreneurship development. Within the state's guidelines, the potters played a significant role in stove development and distribution, from purchasing materials to constructing and installing the improved stoves. Some earned additional profits by selling these stoves on the open market.

Integrating traditional rural potters into the national program triggered a commercial approach to stove distribution. At the same time, a large part of the potters' business was derived from government-set targets, including backward classes, for whom stoves were completely subsidized.

INSTITUTIONAL STRUCTURE

The state's institutional organization for stove production and delivery reflects the significant levels of human resources invested in the national program. The Rural Development and Water Conservation Department was the primary implementing agency, representing 80 percent of the state's annual target of 120,000 stoves. The Maharashtra Energy Development Agency, the nodal agency of the Ministry of Non-conventional Energy Sources set up to promote renewable energy devices, installed and promoted improved stoves as part of the Integrated Rural Energy Planning Program;³ it represented about 20 percent of the state's annual target. The centrally sponsored Khadi and Village Industries Commission was associated with the national program via its network of NGOs and represented 2 percent of the state's annual target (Figure 3.3).

The Rural Development and Water Conservation Department distributed improved stoves through the three-tier local government machinery. At the district level, the national program was implemented through key coordination bodies (*zilla parishads*). At the block level, it was under the purview of the block development officer and supporting staff. At the village level, teams of government agents (*gram sevaks*) were responsible for motivating households to install improved stoves at subsidized prices and providing after-sales service in collaboration with stove designers and producers.

At the block level, preference was given to areas with high population densities, families below the poverty line, and backward classes. State guidelines required that at least 30 percent of beneficiaries be from backward classes. Houses with biogas plants and LPG were discouraged from buying subsidized stoves. Villages were selected based on stove demand of at least 50 percent

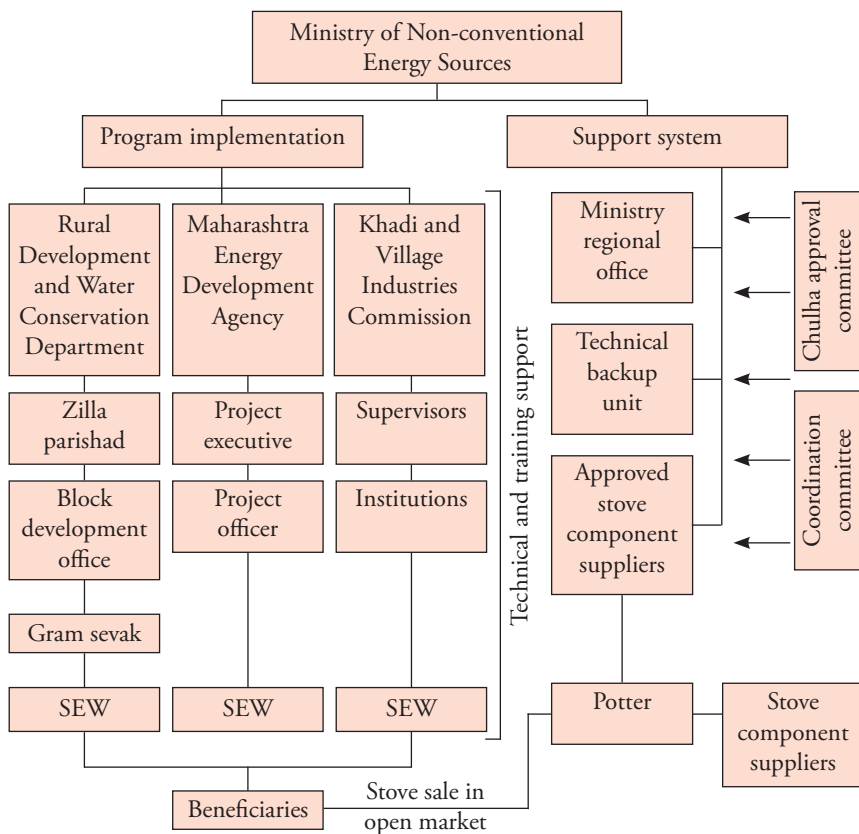


FIGURE 3.3 Implementation Structure in Maharashtra

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

of households. After villages were selected, gram sevaks identified and motivated potential beneficiaries through village assemblies (*gram sabhas*) and user camps.

After collecting beneficiary contributions, the gram sevaks gave the traditional potters or SEWs target numbers of stoves to mass-produce in their shops, depending on their manufacturing capacity. After the completed stove structures were transported to the village, the SEW received the beneficiary's contribution, which was used to buy raw materials. Unlike the Haryana case, where the government procured and supplied all materials, SEWs in Maharashtra procured materials directly from suppliers and recovered the cost from the tehsil project officer at the time of installation.

With direct budgetary support from the central government, the ARTI provided technology and human resource development and training courses

for users, government staff, and SEWs. Promotional and awareness-raising materials included posters, pamphlets, video films, and radio commercials.

The Coordination Committee and the Chulha Approval Committee facilitated interaction among the implementing agencies. Both committees included representatives from the Rural Development and Water Conservation Department, Maharashtra Energy Development Agency, Khadi and Village Industries Commission, Ministry of Non-conventional Energy Sources (Bhopal regional office), ARTI, and NGOs. The Coordination Committee reviewed the previous year's milestones and determined a district-wide training schedule and publicity methods. The Chulha Approval Committee met quarterly to approve new stove designs and manufacturers to supply raw materials and determine the total unit cost with inputs from potters and manufacturers.

IMPLEMENTATION CHALLENGES

The national program faced several production and delivery problems that resulted in poor quality control: inefficient monitoring and after-sales service; insufficient interaction between stove designers, users, and producers; and lack of user awareness and training. Pressure to meet specified government targets led to inefficient monitoring. Despite stringent state guidelines requiring inspection of all improved stoves installed at the block level and 10 percent at the district level, the gram sevak provided monitoring only at the time of construction. The local government did not control the quality of stove construction by traditional potters. For the lack of incentives to provide after-sales service, potters usually failed to check on proper functioning of the installed stoves; as a result, users discarded faulty stoves after a few months or they maintained them poorly.

Although the national program permitted only SEWs trained and certified by the technical backup unit to construct improved stoves, non-certified workers continued to build and install them. For example, in Deshing (Kolhapur district) and Yogewadi (Sangli district), the gram sevaks installed stoves in several households. In many cases, users modified stove sizes and dimensions. And despite a list of approved suppliers, no mechanism was in place to ensure that entrepreneurs and SEWs bought materials from approved vendors.

A second challenge was insufficient interaction between stove designers, users, and producers, which resulted in users' inappropriate design modifications and ultimately their reversion to inefficient traditional stoves. Compared to the technical backup units in other states, the ARTI interacted more frequently with village communities and stove makers. But such interactions required further strengthening through extensive consumer testing of stove models and user-based surveys (for example, evaluation of construction quality, functionality, and user perceptions) to provide stove designers feedback

for developing more user-friendly models (for example, those with easy-to-clean chimneys) that also met engineering standards for smoke removal and energy conservation.

A third challenge was the lack of user awareness and training, particularly with regard to how ad-hoc changes in stove design can affect efficiency. While the ARTI was primarily responsible for training and awareness-raising activities, its funding by the Ministry of Non-conventional Energy Sources was grossly inadequate.⁴

BUILDING ON TRADITION: TOWARD COMMERCIALIZATION

Rural villages in western Maharashtra have a long history of purchasing stoves. The ARTI built on this strength by involving traditional potters in the design, construction, promotion, and sale of improved stoves. The potters were natural partners for the national program since they had an extensive background working with earthen materials used in stove construction. The ARTI compensated for the potters' lack of entrepreneurial skills by providing them extensive technical and business training. As a result, the potters earned reasonable profits by selling stoves within the national program and in the open market. Users, in turn, appreciated that traditional potters constructed the improved stoves. Unfortunately, the targeted nature of the program failed to foster after-sales service competition among the traditional potters. In addition, many households were not motivated to repurchase stoves because they had no choice of models to meet their families' needs and preferences.

However, the discontinuation of distribution in 2002 did not mark the end of the national program in Maharashtra. Various foundations, notably the Shell Foundation, enabled the ARTI to continue as a major promoter of improved stove commercialization (Winrock International 2005). Improved stoves have remained an important component of rural development initiatives related to housing and cleanliness campaigns. The Rural Development and Water Conservation Department, which handled some 80 percent of the state's target under the national program, now distributes improved stoves under two programs: Indira Awas Yojana (a rural housing scheme) and Sant Gadge Baba Swachhata Abhiyan (an awareness-raising hygiene and health movement for rural households). Both these programs are implemented across all 33 districts. At the same time, discontinuation of subsidies has meant higher stove prices and entrepreneurs working harder to generate demand.

In sum, decentralization of the national program to the state level offers Maharashtra an opportunity to develop a new generation of stoves focused on commercialization. Both users and service providers stand to benefit from an enabling environment that promotes the design of more efficient, durable models and provides entrepreneurs incentives to offer households sustained

services resulting in longer-term energy and health benefits. In this new context, subsidies could be directed toward such activities as stove testing and monitoring, user-based surveys, and technical training and education on indoor pollution and stove construction. Finally, the state government could support innovative options to ensure that the poorest users are provided financial assistance.

NOTES

1. Thus, future improved stove programs could stress such factors as biomass shortage and health issues.
2. The panchayats were officially designated to spend at least 15 percent of their development-related funds on the betterment of backward classes.
3. The Integrated Rural Energy Planning Program, implemented at the block level, meets the energy requirements of these administrative units using a combination of renewable energy technologies.
4. Making such activities common across all implementing agencies—and pooling resources across them—might have offered one option for overcoming such a problem.

4

Haryana

Women's Involvement

In 1980, Haryana stirred the hope for a national program with the introduction of the Nada model, an improved stove made by women in Nada village. Developed under a Ford Foundation program, the Nada model was based on women's guidance and feedback at every stage of design, construction, and distribution. Women's participation also resulted in greater awareness among female family members regarding preventive maintenance and repair, which helped to ensure more effective use and longer product life. These initial efforts were transformed into a larger-scale effort that led to establishment of the national program in 1983. By 2000–1, annual distribution of improved stoves totaled 60,000, bringing the cumulative total since program inception to more than 500,000 households—48 percent of the state's rural households. Given the technical innovations that resulted from women's extensive interactions with stove designers, the national program in Haryana offers useful lessons for implementing future stove programs.

This case study focused on densely populated villages in three districts: Fatehabad, Gurgaon, and Panchkula (Figure 4.1). These districts were chosen from among Haryana's 19 districts to reflect greater stove penetration, functionality of improved stoves, and socioeconomic diversity. With the exception of certain villages in Gurgaon, where landless families experienced a scarcity of biomass cooking fuel, most villages had abundant crop residues and dung usable for cooking. Detailed fieldwork was undertaken in each of the villages studied.

BACKGROUND

Haryana is India's 16th largest state, with a population of more than 21 million (GoI 2001). It is situated in the northern part of the country, bordered



FIGURE 4.1 Map of Haryana, Highlighting Case Study Districts

Source: General Services Department Printing, Graphics and Map Design, The World Bank, Washington, D.C., 2011.

by Punjab to the west, Himachal Pradesh to the north, Uttar Pradesh to the east, and Rajasthan to the south (Figure 4.1). Often referred to as the Green Land of India, Haryana is agriculturally rich; 60 percent of its land is fully irrigated, and it leads in wheat and rice production. Because some

67 percent of residents are located in rural areas, the state assigns a relatively high priority to rural development programs. Urban–rural connectivity allows government schemes to reach every village, easing the difficulty of program monitoring.

Construction and distribution of the Nada model, initiated in 1980, was based on the important role that women played at critical stages of stove design and development.¹ Women users appreciated the model's added benefits, and demand quickly grew. It soon became evident that a larger-scale organizational structure was needed for training and monitoring. In 1983, the first year of the national program, 2,400 improved stoves were constructed in two blocks of Palwal and Raipuria districts. By 1986–7, the entire state was covered; between 1998–9 and 2000–1, annual distribution grew from 42,000 to 60,000 (an average of 50,000 households adopted the improved stoves each year). The total number of improved stoves distributed in any given year—equivalent to the state's annual target for that year—was divided equally among districts and within their respective blocks. A typical block target was 500–600 stoves, representing about 10 percent of households. The Department of Women and Child Development implemented the national program in Haryana through its district-, block-, and village-level officers and a network of more than 7,000 village-level women's groups (*mahila mandals*). The Energy Research Centre at Punjab University served as the technical backup unit.

From 1994 to 2002, five main improved stove models were distributed in Haryana (Table 4.1). The Mohini and Akash models were designed to meet the cooking requirements of small and large families, respectively. Newer models, such as the Hara, were used to meet traditional cooking requirements, particularly the simmering of milk.² Traditional Hara stoves were thermally inefficient and extremely polluting, emitting smoke throughout the day. The Mohini Hara and Sohini Hara offered a less polluting way to simmer large quantities of milk for various family sizes.

TABLE 4.1 Improved Stove Models Distributed in Haryana, 1994–2002

<i>Model</i>	<i>Description</i>	<i>Thermal efficiency (%)</i>
Mohini	Fixed mud single-pot, with chimney for small family	24–6
Mohini Hara	Fixed mud single-pot, with chimney for small family	24–6
Jaitan	Fixed mud two-pot, with chimney	26–8
Akash	Fixed two-pot, with chimney for large family	26–8
Sohini Hara	Fixed single-pot, with chimney for large family	26–8

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

HOUSEHOLD CHARACTERISTICS AND USER PERCEPTIONS

The mahila mandals played a key role in motivating village women to adopt the improved stoves. Those that adopted stated that they valued the cleaner environment resulting from smoke removal. Paradoxically, the improved stoves were often kept in outdoor courtyards, while the traditional stoves remained in smoke-filled, indoor kitchens. Survey results revealed that lack of interaction between stove designers and users and gaps in information sharing between the mahila mandals and village communities contributed to a reversion to traditional stoves when the improved ones broke down.

In Haryana, most improved stove users were low-income households engaged in farming activities on their own or others' land. Of the 94 households surveyed, whose improved stoves were made primarily of cement or mud, 52 percent were landless laborers and 25 percent were small farmers who owned less than 2 hectares. About 13 percent were engaged in other services as their primary occupation. The families belonged mainly to Hindu communities (Gujjars, Jats, and Sikhs), backward classes (Harijans and Bajjgars), and a few Muslim communities. Most stove users were illiterate or high-school dropouts, which compared well with the general education level in the region. More than 30 percent of the surveyed households owned bicycles, while a few owned television sets or tractors. Use of improved stoves did not correlate with income levels, as economically better off and landowning families owned LPG stoves; however, LPG was used sparingly (cooking for guests and quick heating).

Of the 94 surveyed households, 58 percent had single-pot stoves, while 42 percent had two-pot stoves. The less expensive, single-pot stoves were used mainly by low-income households. Some better-off households, including those in Rampur Suri and Khangesara villages in Panchkula, used both single- and two-pot stoves.

Two-thirds of the surveyed households used both traditional and improved stoves to adequately meet their household cooking requirements. Traditional stoves were used to prepare food, while improved stoves were used to heat water and prepare cattle feed. Even the economically better-off households that adopted LPG continued to use traditional stoves to aid in food preparation. Typically, the traditional stove (usually without a chimney) was kept indoors, while the improved stove was set in the outdoor courtyard. Household members gave two reasons for keeping the improved stoves outside: they were reluctant to make an indoor roof opening for the chimney and they believed that the traditional stoves could better serve the dual purpose of cooking and heating during the winter season.

Users' overall satisfaction with the improved stoves was reflected in the high percentage (94 percent) of households that reported stoves in working

condition; at the same time, the women who participated in group discussions were mainly those who had working stoves. Furthermore, their stoves were newly constructed. Stoves older than two years were more likely to be dysfunctional.

The most common perceived benefit was smoke reduction; 78 percent of respondents said they valued the improved stoves for a cleaner environment resulting from smoke removal (Table 4.2). Paradoxically, most users reverted to their traditional stoves when the improved stoves broke down. The indoor kitchens, where the traditional stoves were kept, remained smoke filled.

TABLE 4.2 Perceived Benefits from Improved Stoves, 2000–1

<i>Perceived Benefit</i>	<i>Households (number)</i>				<i>Households (%)</i>
	<i>Panchkula</i>	<i>Fatehabad</i>	<i>Gurgaon</i>	<i>All</i>	
Less smoke	18	34	21	73	78
Less soot on vessels and in kitchen	13	10	7	30	32
Fuel savings	0	7	9	16	24
Time savings (faster cooking)	5	3	9	17	18
Fewer health problems (including asthma)	0	4	5	9	10
None mentioned	0	1	7	8	9

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Note: Some respondents reported more than one benefit.

Additional perceived benefits included less soot on cooking vessels and in kitchens (32 percent), fuel savings (24 percent), and faster cooking resulting from the ability to use two pots at the same time (18 percent). For higher-income households (for whom installation of improved stoves was not a necessity) or those residing in areas of plentiful biomass (crop residues and dung), fuel savings was not a major consideration. Conversely, lower-income households in areas of biomass scarcity—such as the Meo community in the Mewat region of Gurgaon—assigned greater importance to such vital priorities as food, over improved stoves.

Despite modifications, 80 percent of users experienced no problems using and maintaining the improved stoves (Table 4.3). In Gurgaon, more than 50 percent of women increased the size of the pothole to accommodate larger vessels to more adequately meet the cooking requirements for larger families. Across all three districts, some 30 percent of respondents either altered the size of the pothole or firebox mouth to better meet their cooking requirements.³ Furthermore, as a regular practice of traditional stove maintenance,

users plastered their stoves with mud, which inadvertently led to altered stove dimensions.

TABLE 4.3 User Complaints Regarding Improved Stoves, 2000–1

<i>Perceived Drawback</i>	<i>Households (number)</i>			<i>All</i>	<i>Households (%)</i>
	<i>Panchkula</i>	<i>Fatehabad</i>	<i>Gurgaon</i>		
Uses more wood	0	2	4	6	8
Takes longer to cook on second pothole	0	4	0	4	4
Pothole is small	1	0	0	1	1
Frequent cleaning required	0	2	0	2	2
Not working	0	1	0	1	1
Smoke comes into room	0	0	1	1	1
Firebox opening is small	2	0	0	2	2
None	26	29	20	75	80

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Note: Some respondents reported more than one problem.

Nearly half of the households surveyed never cleaned their chimneys or were unaware that their chimneys required cleaning. In Panchkula, some chimneys were installed without an opening in the roof because family members, especially men, were unwilling to bore holes in the asbestos roof. This resulted in high levels of indoor pollution. Some respondents, particularly those in Lawas village in Gurgaon, complained that their improved stoves consumed more wood than their traditional ones because of faulty construction. This perceived problem revealed that users lacked the information and services needed for proper stove maintenance. Greater interaction between stove designers and users would have helped to eliminate such problems and ensure more sustained operation.

The reasons why women chose to adopt the improved stoves varied and were not based solely on knowledge of the stoves' benefits. The mahila mandals that motivated the beneficiaries played an important role in facilitating adoption. Indeed, most women stated that they opted for the improved stoves at the request of the head of the mahila mandal operating in their village. In some villages—including Majra in Fatehabad and Lawas in Gurgaon—women believed that the improved stove program would be followed by other government programs, such as cemented kitchens or sanitary latrines, from which they could benefit in the future. These women were disappointed when the follow-on programs failed to occur. Several women,

especially in the Harijan communities, believed that they were required by law to have the improved stoves constructed. Another small group that was aware of the improved stoves' merits had them constructed based on expected benefits. Women who opted not to adopt the improved stoves cited lack of space, unwillingness to bore a hole in the kitchen roof for chimneys, lack of information on the stoves' benefits, and the mahila mandals' preference for households in their groups.

SUBSIDY DEPENDENCE

Subsidies to encourage household adoption of improved stoves accounted for about two-thirds of the Rs 10 million (US\$ 0.2 million) that the Ministry of Non-conventional Energy Sources allocated annually to the state for program implementation. Among poor households, large subsidies played an important role in adoption. For example, users of the single-pot cement stove contributed less than one-fifth of the total stove cost.

Discussions with beneficiaries revealed that, while subsidies made the improved stoves affordable to many poor households, they devalued the importance of the technology. Several households that had used the improved stoves for about two years expressed a longer-term interest in reverting to traditional stoves. They were willing to continue paying for the improved stoves as long as the government provided a matching contribution of at least one half. None wanted to construct an improved stove without subsidies.⁴ Some women expressed a willingness to contribute toward the cost of a more durable stove. Users' attitude matched the perception of village officers, who believed that subsidies were crucial for women who could not afford to contribute even minimally. In a few well-off villages, users were willing to pay more if they were better informed about the improved stoves. This finding highlights the need for greater interaction with potential users to raise awareness about the stoves' benefits.

DEVELOPMENT AND PRODUCTION: WOMEN'S NETWORK

Distribution of improved stoves in Haryana offers positive lessons in implementation. A primary innovative feature was that large numbers of women were motivated to adopt and use the improved stoves entirely through a women's network. In addition, the Energy Research Centre at Punjab University, the state's technical backup unit, played a critical role in the redesign in response to users' changing stove requirements. In 1986, for example, it developed Nada models without dampers, which women found more convenient to use. In 1988, it introduced the baffle, which enabled the second pothole to retain heat. Subsequently, it developed a firebox grate to increase combustion efficiency. Redesign of the traditional tandoor was well received by users.

In response to a feedback survey that found families in Sirsa district using both cement and traditional mud stoves, the Energy Research Centre initiated research in 2001 on cement and high-efficiency pottery stoves. Further inquiry revealed that a mason in Kherpur village and a woman entrepreneur in Chakmal village were manufacturing several cement stoves per day (single-pot traditional models without chimneys) and selling them in nearby villages. A survey conducted in Chakmal showed that women appreciated and regularly used these stoves, most of which had developed cracks. Based on this finding, the Energy Research Centre undertook research to develop improved single- and two-pot stoves using a concrete mix that could withstand high cooking temperatures. After extensive research and development and field testing, new models were developed in Yamunanagar, Ambala, Jagadhari, and several other districts.

Training and Awareness Raising

The Energy Research Centre at Punjab University was responsible for technical training, while the village-level workers and supervisors (*gram sevikas* and *mukhya sevikas*) handled awareness-raising activities, including program orientation and mobilizing women for user-awareness camps. The Energy Research Centre held various courses for a broad range of stakeholder groups: management courses for officials of nodal departments, NGOs, and village-level (panchayat) representatives; training of SEWs in the building of better stoves and entrepreneurial skills;⁵ and teaching consumers about stove use and maintenance. It also held stove-construction certification camps for SEWs and districtwide refresher courses for SEWs and all national program staff, including gram sevikas, mukhya sevikas, and women's circle supervisors. These training camps served as a forum through which the Energy Research Centre could collect feedback from SEWs and staff of the Department of Women and Child Development. An average of five to seven stove-construction training programs, fifteen to twenty refresher courses, and a hundred user-awareness camps were held each year (Table 4.4).

User-awareness camps, conducted in collaboration with the mahila mandal, provided a forum for interaction between stove users and designers. In these camps, usually attended by 20–30 women, complete information on the benefits of the improved stoves and national program was provided through talks, videos, posters, and charts. Because of a personnel shortage, the Energy Research Centre could not always be represented at such camps.

Feedback surveys also played a key role in technology development. These were designed to obtain information from users on the various stove models, quality of the work undertaken by stove producers, and the problems encountered. During 1999–2000, user feedback surveys were conducted in 15 out of Haryana's 19 districts.⁶ Information collected from a random sample

TABLE 4.4 Training Courses Conducted by the Technical Backup Unit, 1999–2000

<i>Course</i>	<i>Annual Target</i> (April 1999–March 2000)	<i>Achievement</i>
Main	6	6
Train the trainers	19	18
User awareness	100	101
Entrepreneurship	2	1
State-level workshop	1	1
Feedback survey	50	51
Publicity material	–	Designed a calendar and a diary

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

of 879 beneficiaries from 51 villages showed that 86 percent of households were using the improved stoves, 7 percent had broken ones, and 7 percent did not use them.

Construction and Service

With regard to stove construction and after-sales service, the national program in Haryana included many positive features. A well-defined implementation strategy included a pre-installation survey, which was effective in determining various family and household characteristics.⁷ Survey questions covered economic status of the family, family size, types of cooking vessels used, and location of the traditional stove. The survey also assessed the feasibility of constructing stoves for all households based on such factors as availability of an appropriate stove site and potential for extending the chimney pipe through the roof [for roofs higher than 1.8 m (the standard length of a chimney pipe), two pipes could be joined together]. In addition, a performance-based system rewarded the best performing mahila mandals. Furthermore, the Department of Women and Child Development organized annual study tours to increase the mahila mandals' exposure to and interest in development work. Finally, the mahila mandals and staff of the Department of Women and Child Development were asked to participate in annual districtwide women's fairs featuring rural development programs, which offered a useful venue for promoting and disseminating information about the national program in Haryana.

Despite these positive features, performance of the SEWs, who constructed the stoves, was only moderately satisfactory. These workers were certified by the technical backup unit and interacted well with women stove users. Once the raw construction materials reached a village, the workers, supervised

by the gram sevika, built the improved stoves. Follow-up support included two household visits within one year of installation to ensure that the stoves functioned for a minimum period of one year. Workers' payment for follow-up visits was linked directly to stove functionality, which helped to ensure reliable after-sales maintenance.

The Department of Women and Child Development designed a three-tier monitoring system: district, block, and village. Women's circle supervisors monitored district-level situations. At the block level, the gram sevikas were responsible for monitoring; each month, they were expected to visit 20–5 villages and report back on stove construction and functionality. At the village level, the mahila mandal was responsible for stove quality. When problems arose, staff members of the Department of Women and Child Development requested that the SEWs repair the stoves at no extra charge.

Despite this well-defined implementation strategy, the SEWs sometimes produced faulty stoves. Some respondents complained that the improved stoves consumed greater amounts of wood than their traditional stoves as a result of faulty construction. In households with indoor chimney outlets, the SEWs did not suggest a solution. One possible explanation for their apathy was that they did not consider stove construction a remunerative occupation. At Rs 100 (US\$ 2.1) per day for three-to-four months a year, the earnings were not enough to last an entire year. In Panchkula, where thirty-two SEWs were trained, only sixteen continued working in nine blocks while the remainder dropped out to take other jobs.

In addition, the target-driven nature of the national program prevented the SEWs from becoming independent entrepreneurs capable of scaling up. They played no role in motivating potential stove users or developing an improved stove market. Once trained and given targets to meet, few ventured outside their respective blocks.⁸ Indeed, none surveyed improved stoves constructed for users not identified by staff of the Department of Women and Child Development.

SIMPLIFIED INSTITUTIONAL STRUCTURE

Haryana had a well-defined institutional structure and implementation strategy for distributing improved stoves, and successfully met its annual targets (Figure 4.2). Unlike other states that had NGOs or multiple government agencies implementing the national program, Haryana had a single controlling and implementing agency—a positive feature that simplified monitoring and supervision. Furthermore, a vast network of grassroots workers resulted in a broader program reach.

From 1983–4 to 1992–3, the state's Rural Development Department was responsible for the national program, after which responsibility was transferred to the Department of Women and Child Development. It implemented

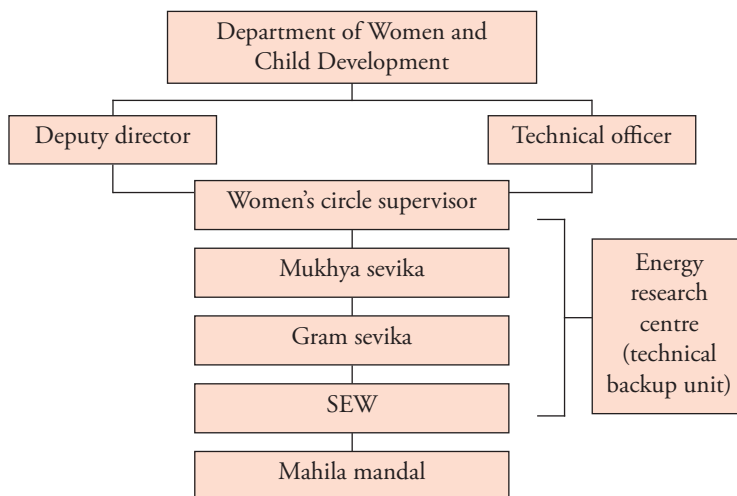


FIGURE 4.2 Implementation Structure in Haryana

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

the program women to women via its network of more than 7,000 mahila mandals. Its official setup included a district-level women's circle supervisor, a block-level mukhya sevika (responsible for 8–10 blocks), and village-level gram sevikas (Figure 4.2). In addition to the national program, staff members were responsible for other women-related development programs. A considerable degree of camaraderie was noted among the women workers.

The mahila mandals served as a link between the villages and the Department of Women and Child Development. Registered under the Societies Registration Act of 1860, a mahila mandal consisting of 20–40 women, worked on a variety of village development programs. In the first year, a mahila mandal received a set-up grant for training and initiating economic activities. Members made monthly contributions, which were collected and deposited in a local bank. Staff of the Department of Women and Child Development facilitated interaction between mahila mandal officers and bank officials so that the mahila mandals could open and operate bank accounts. Mahila mandal officers acted as national-program resource persons and motivators and played a key role in identifying beneficiaries and supervising stove construction in their villages.

The Energy Research Centre at Punjab University, the technical backup unit, was responsible for training, technology development, and obtaining user feedback on various stove models. It was staffed by a director (an honorary position), a senior scientific officer, a technical supervisor, two master craftsmen, and office assistants.

The Directorate of Supplies centrally sourced all raw materials for government programs. The Department of Women and Child Development used a bidding process through which to select potential stove parts suppliers for a two-year term. Three suppliers, two of which were based in Haryana (Mohali and Chandigarh districts), supplied cement pipes to nine districts. Metal fittings were procured from a supplier in Uttar Pradesh (Raibareilly district). Quality-control measures included physical inspection of pipes by the Department of Women and Child Development and inspection of sample stove parts by the Public Works Department laboratory in Rohtak. Once cleared, materials were transported to block offices. Although suppliers sold the national program cement pipes at a per-pipe rate nearly three times less than that of the market, they found it financially viable to join the national program because of the assured market and large volume.

CHALLENGES OF A TARGET-DRIVEN APPROACH

Despite a well-defined implementation strategy, the national program in Haryana experienced various problems that affected program quality and sustainability. The field staff, which worked on a number of development programs simultaneously, could not devote enough time to the national program, resulting in irregular field visits and inadequate interaction with users. For example, for lack of time and because of the distance between villages, the gram sevikas, which were assigned to 40–50 villages each, could visit a given village only once every two or three months. These women workers could not invest enough time and effort to generate latent demand; instead, they requested that selected households adopt the stoves to meet their targets. This shortcoming became apparent when respondents indicated that they adopted the improved stoves at the request of the mahila mandal workers.

While large stove subsidies ensured distribution in certain parts of the state, they did not guarantee sustained demand. In many households, users lacked motivation to repurchase the improved stoves, and many stoves fell into disuse. Thus, in the short term, subsidized stove prices helped the state government meet its targets; but over the longer term, they made the users dependent on the government and unable to appreciate the stoves' benefits. The targeted nature of the program meant that households could not choose stoves from a variety of models; instead, a predetermined model within the national program's guidelines was given to them. Usually, these models did not suit their family needs or cultural practices; as a result, the users modified the stoves. In all of the villages visited, the same model had been installed regardless of family size or other sociocultural requirements. As suggested above, the targeted program also failed to foster competition among SEWs to develop their entrepreneurial skills and establish a viable stove market.

Other challenges included insufficient interaction between stove designers, users, and producers and a lack of user training and awareness-raising activities. While the technical backup unit catered to users' design requirements early on, ongoing improvement was required. More durable models were needed to cater to users' specific requirements. Common problems with the firebox, pothole size, and chimney called for better design and greater interaction between designers and users. Some villagers complained that they were not provided adequate information about the national program. In such villages as Majra (Fatehabad district) and Lawas and Salamba (Gurgaon district), where single-pot stoves had been constructed, women were unaware of the option to purchase two-pot stoves. Finally, users were not trained to understand the inefficiencies caused by ad-hoc changes in stove design.

ROAD TO DISSOLUTION

Haryana was considered a landmark state in initiating the national program. Development of the Nada model in 1980—based on women's involvement at every stage of product design and development—helped women users to accept these stoves, conduct preventive maintenance to ensure longer functional life, and correct minor problems. Implementing the program entirely through a women's network accounted, in part, for the large numbers of households that adopted and used the improved stoves. One of the few states that had a single nodal agency to control and implement the national program, Haryana successfully met its annual targets. At the same time, the targeted nature of the program created various challenges, discussed above, which contributed to the inability to develop a viable market.

Decentralization of the national program in 2002 meant the official termination of Haryana's stand-alone program. Despite the state's budgetary allocation for stoves in 2003, the Department of Women and Child Development believed that sufficient effort had already been made. Departmental staff members involved in the national program were absorbed into other programs. The hiring of SEWs ended; no extra effort was made to promote these workers as improved stove entrepreneurs, even though they numbered about 300 and despite the state's considerable demand for improved cement stoves. The Energy Research Centre at Punjab University ceased to play the role of technical backup unit; its responsibility was narrowed to meeting one-off requests by government departments for installing improved stoves, mainly for demonstration purposes. NGOs with technical expertise in stove construction assumed the implementing agency role, calling on the services of SEWs when needed. In short, the focused multitiered human resource base with hands-on experience in implementing a technical program at the grassroots level dissolved, and the skills nurtured over a period of two decades were abandoned.

The opportunity available in 2002 to continue the improved stove program in Haryana was lost (Winrock International 2005). As of 2005, promoting improved stoves in Haryana is limited to a small component of externally-funded community forestry programs. At this point, reviving the national program could only be achieved through a new impetus from the relevant government ministries—women and health—supported by the media. Without such catalysts, the future of a program in Haryana would appear difficult to sustain.

NOTES

1. The Nada model was a simple modification of the traditional two-pot stove with an attached chimney and two dampers (movable metal or non-metal plates) to regulate air supply to the fire.

2. In Haryana, where there is a milk surplus, the traditional storage method is simmering for many hours a day.

3. Enlarging the firebox mouth for making bread (*roti*) was particularly common among women in the Gujjar community.

4. Reluctance to purchase also resulted from a mismatch between consumer preferences and stove design.

5. With regard to training in cement stove construction, the Energy Research Centre trained SEWs from Haryana and other states where cement stoves were being made (Uttar Pradesh, Bihar, and Jammu and Kashmir).

6. The Ministry of Non-conventional Energy Sources did not issue guidelines on the required number or types of feedback surveys that had to be conducted each year.

7. At the same time, the survey's usefulness and the rigor with which it was conducted were questionable since many households modified their improved stoves after installation.

8. The gram sevikas identified and trained some 300 SEWs (an average of 16 in each block).

5

Karnataka

Technical Innovations and Institutions

The national program in Karnataka enjoyed a long history of support from pioneering technical institutions, along with cooperation among various levels of government, traditional potters, and NGOs. The program benefited from the innovative models developed by the Bangalore Centre for Application of Science and Technology to Rural Areas, which also served as the technical backup unit. The Centre's 1993 design of the Sarale Ole model, a modified version of the Astra Ole, remains the state's most popular model. Comprising all 27 districts, the program also benefited from the involvement of local institutions and motivated government officials, who helped significantly with standardization and quality of stove construction. Between 1988 and 1995, nearly 440,000 improved stoves were installed across the state.

This case study featured two districts: Hassan and Mysore (Figure 5.1). Based on preliminary discussions with district-level officials of the implementing agency, beneficiaries, and officials at the Department of Rural Development and Panchayati Raj, the state nodal agency for the national program, six villages in Hassan and four in Mysore were selected.

BACKGROUND

Situated in southern India, Karnataka covers an area of 1.92 million hectares, most of which lies on the Deccan Plateau (Figure 5.1); about one-fifth of its land area is protected forest. The state is bound by the Arabian Sea to the west, Goa and Maharashtra to the northwest and north, Andhra Pradesh to the east, and Tamil Nadu and Kerala to the south. It stands at the forefront of industrial growth, although agriculture dominates the economy. Its citizenry



FIGURE 5.1 Map of Karnataka, Highlighting Case Study Districts

Source: General Services Department Printing, Graphics and Map Design, The World Bank, Washington, D.C., 2011.

of some 53 million is known for its enterprising spirit and scientific achievements (GoI 2001).

Design and development of the national program in Karnataka began in 1980; several years later, as a result of intensive research conducted by the Karnataka State Council for Science and Technology in Bangalore, in coordination with the Bangalore Centre for Application of Science and Technology to Rural Areas, the first improved stove, Astra Ole, was introduced (Table 5.1).

With the initiation of the national program in 1983–4, formal distribution of improved stoves began. In 1984, the Department of Rural Development and Panchayati Raj was selected as the nodal agency for state-level implementation. Five years later, the National Dairy Development Board milk unions initiated program implementation in the districts of Mysore and Shimoga. In 1989, a technical backup unit was formally established at the Karnataka State Council for Science and Technology to provide program support in research and development, field testing, demonstration, training, and monitoring. Table 5.2 lists some of the models distributed.

During 1994–9, nearly 440,000 improved stoves were installed in Karnataka under the national program (Table 5.3). The Astra Ole model distributed in the initial years had very high efficiency; early feedback surveys indicated that more than half of the distributed stoves were being used in their original form, more than two-fifths had been altered by users,

TABLE 5.1 Timeline of Events in Karnataka, 1980–99

<i>Year</i>	<i>Event</i>
1980	The Karnataka State Council for Science and Technology, in coordination with the Bangalore Centre for Application of Science and Technology to Rural Areas of the Indian Institute of Science, starts work on fuel-efficient stoves for various applications, including domestic cooking.
1981	The national program begins research on the Astra Ole improved stove model.
1984	The Department of Rural Development and Panchayati Raj is selected as the state nodal agency for implementation; the Ministry of Non-conventional Energy Sources provides a central subsidy.
1989	The technical backup unit is established at the Karnataka State Council for Science and Technology.
1993	The technical backup unit at the Karnataka State Council for Science and Technology develops and begins distribution of the Sarale Ole improved stove model.
1994	The Priagni model, the earthenware version of the Swosthee portable metallic stove designed by the Central Power Research Institute, is designed and developed.
1999	A junior engineer in the Mysore panchayat develops a prefabricated mold for constructing the Sarale Ole model. With the involvement of SEWs and NGOs as implementing agencies in Mysore and Hassan, the implementation method changes.

Sources: Department of Rural Development and Panchayati Raj, and Karnataka State Council for Science and Technology.

TABLE 5.2 Improved Stove Models Distributed in Karnataka, 2000–1

<i>Model</i>	<i>Description</i>	<i>Thermal Efficiency (%)</i>
Sarale Ole	Fixed mud single- and two-pot, with chimney	27–9
Sukhad	Fixed two-pot, with chimney and pottery liner	26–8
Mamatha and Abhinava	Fixed two-pot, with and without chimney for large family	24–6
Priagni	Portable, single-pot pottery stove, without chimney	29
Swosthee and Chara Ole	Portable, metallic single-pot, without chimney	29

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

and the rest were in disuse. This model failed to enjoy success in the field because it occupied excessive kitchen space and users disliked the firebox design, which required that firewood be chopped into small pieces and that the firebox be closed while in use. Consequently, the technical backup unit developed several versions that were better suited to the expressed needs of beneficiaries; but these models compromised efficiency. Thus, in 1993, the technical backup unit introduced a simple, modified version of the Astra Ole known as the Sarale Ole. This model was a fixed two-pot stove with provision to feed fuel from the front or side. It quickly gained popularity and became the most widely distributed model in the state. Portable stove models were also developed and distributed, but demand for them was less than for fixed models.

TABLE 5.3 Targets Met under the National Program in Karnataka, 1994–9

<i>Year</i>	<i>Target</i>	<i>Number of Stoves Installed</i>	<i>Achievement (%)</i>
1994–5	175,000	118,282	68
1995–6	150,000	111,295	75
1996–7	85,000	67,588	80
1997–8	88,000	88,953	101
1998–9	40,000	52,668	132
Total	538,000	438,786	82

Source: Department of Rural Development and Panchayati Raj, 1998–9, *Annual Report*, Bangalore.

SURVEY OF HOUSEHOLDS AND USER PERCEPTIONS

In 2000, a user survey and focus group discussions were conducted in Hassan and Mysore to develop a socioeconomic profile of users and to better understand their perceptions about the improved stoves. A total of 129 stove users and 61 non-users were interviewed, and 217 women participated in focus group discussions (Table 5.4).

TABLE 5.4 Characteristics of Household Users in the Study Area, 2000–1

<i>Sample Characteristic</i>	<i>Description</i>
House type	Compact mud, brick with tiles, thatched and asbestos roof
Average family size	Five
Fuel type used	Wood, coconut fronds, cow dung cakes, and crop residues
Typical meal	Ragi balls, ragi and rice roti, and rice
Uses of improved stoves	Cooking main dishes, meat, and making tea and coffee
Utensils	Aluminum and stainless steel

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

A review of stove users showed that, for more than half of the households surveyed, agriculture was the main occupation, and the average number of members in a family was five; more than two-fifths worked as agricultural laborers on other people's land. Most were in low-income groups with small or marginal landholdings; nearly one-fourth were landless. Less than one-tenth owned more than 2 hectares. For most households, the highest educational level attained was high school (10th standard). For about half of households, the main assets were television sets and bicycles. A few well-off ones owned tractors and motorcycles.

All surveyed households owned functional two-pot stoves, namely, the Sarale Ole and the Sukhad models. During the study, a high level of functionality was observed, likely because the stoves were less than two years old, the typical lifespan of a mud stove. Some Sukhad stoves had been cracked, but were still in use. Nearly half of the households surveyed also used other stove types: kerosene (26 percent); traditional (18 percent); LPG (4 percent); and biogas (2 percent). Most households with improved stoves used sugarcane residue or wood to fuel them. Households usually collected fuelwood from their own or revenue lands, while some purchased it [Rs 500–1,000 (US\$ 11–21) per year].

Three-fifths of households with improved stoves used them three to five hours per day to prepare main dishes (ragi balls, rice, and dal), while one-tenth used them one to three hours per day. Some used them either

occasionally (to cook non-vegetarian dishes and food for festivals and guests) or not at all. The practice of using multiple stoves and fuels was common. Women reported that kerosene stoves were used to prepare beverages (coffee or tea), rice, and dishes for large groups. Some respondents indicated that kerosene was rationed and therefore used only for lighting and initial fire lighting. At that time, in the open market, kerosene was priced at Rs 12–15 (US\$ 0.25–0.32) per liter, which was too expensive for everyday cooking. Traditional stoves were used for heating water for bathing and cooking food for large groups, such as hired laborers during harvest season. Some respondents made greater use of their traditional stoves with chimneys than their improved stoves without chimneys, highlighting the perceived importance of smoke removal versus fuel efficiency.¹

Most users were satisfied with the performance of their improved stoves and believed that reduced kitchen smoke had improved their indoor environment and health. Clean kitchen walls and vessels were perceived as major benefits. Respondents who lived in one-room dwellings with a small kitchen area said that, as a result of reduced smoke, their children could now study during cooking hours. Some women mentioned that their palms were cleaner because of less effort required to scrub vessels. Nearly three-fifths reported reduced eye irritation, while others had fewer headaches (Table 5.5).

TABLE 5.5 Perceived Benefits from Improved Stoves, 2000–1

<i>Perceived Benefit</i>	<i>Households (number)</i>			<i>Households (%)</i>
	<i>Hassan</i>	<i>Mysore</i>	<i>Total</i>	
Improved health due to smoke removal	57	62	119	92
Fuel savings	43	52	95	74
Time savings	50	38	88	68
Cleaner kitchen	45	42	87	67
No eye irritation or asthma	44	29	73	57

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Note: Most respondents reported more than one benefit.

Most households reported a half-hour to one-hour reduction in cooking time per day, but some older women believed that cooking on an improved stove took more time. Most women reported fuel savings as a benefit, but not a major one. Another reported benefit was the use of residual heat for drinking and bathing.

About one-fifth of households experienced problems with their improved stoves, including back-smoking resulting from infrequent chimney cleaning, increased fuel consumption, and cracked pottery liners (Table 5.6). About

two-fifths of respondents cleaned their chimneys once a month, while nearly one-fifth never did. Some reported that they smeared cow dung or mud on the stoves once a week, not realizing that this practice would interfere with stove design and efficiency.

TABLE 5.6 User Complaints Regarding the Improved Stoves, 2000–1

<i>Perceived Drawback</i>	<i>Households (number)</i>			<i>Households (%)</i>
	<i>Hassan</i>	<i>Mysore</i>	<i>Total</i>	
Back-smoking	8	2	10	8
Poor construction	1	0	1	1
More fuel consumption	3	2	5	4
Small pothole	1	0	1	1
Cracked pottery liner	3	0	3	2
More time for cooking	0	2	2	1
None	49	58	107	83

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

About one-fifth of household users modified their improved stoves. Common changes included plastering the improved stoves with cement, altering pothole sizes, removing the grate, and attaching a pipe to the chimney so that its height would reach the roof. In some households with thatched roofs, the chimney was removed during the rains to avoid water leakage into the house and was re-attached after the rains (Table 5.7).

TABLE 5.7 User Modifications to Improved Stoves, 2000–1

<i>Modification</i>	<i>Households (number)</i>			<i>Households (%)</i>
	<i>Hassan</i>	<i>Mysore</i>	<i>Total</i>	
None	49	54	103	80
Cement plastering	11	3	14	11
Cowl removed	1	0	1	1
Extra pipe joined	1	0	1	1
Pothole size altered	2	2	3	3
Chimney removed	1	0	1	1
Grate removed	1	4	5	4
Total	65	64	129	100

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Most households with improved stoves said they would refurbish them if new stoves or parts were available. In one village in Mysore, where the improved stoves installed in 1993–4 were no longer functional, most users had retained the chimneys to use with the traditional stoves they had constructed. Few women had tried to build improved stoves on their own. Discussions with villagers indicated that they were willing to pay more for the improved stoves if their durability and performance could be assured. In another village in Mysore, women complained that masons would not do the work unless users bought a chimney set;² those who already had one were not willing to repurchase.

The reasons potential users cited for not adopting the improved stoves included non-affordability, competing household priorities, and lack of space. People living in houses with thatched roofs feared leakage during the rainy season and fires from hot chimneys in the summer. Negative user feedback and male household heads' lack of willingness to purchase also resulted in non-adoption. In Hassan, most non-users that did not belong to self-help groups reported that NGOs that facilitated adoption did not encourage those who were not members of self-help groups. A few households had other stove types, such as LPG and biogas, and, thus, showed little interest in installing improved stoves.

SUBSIDY PATTERN

The national program in Karnataka was funded entirely by the Ministry of Non-conventional Energy Sources until 1993–4, when the state government began contributing a portion of the subsidy. The Ministry provided a central subsidy of 50–70 percent toward stove cost, installation and maintenance fees, and money for capacity building and awareness generation (Table 5.8).³

TABLE 5.8 Subsidy Structure of the National Program in Karnataka, 2002

<i>Unit Cost¹</i>	<i>User Contribution to Stove Cost</i>	<i>User Payment to Mason</i>	<i>User Payment to SEW</i>	<i>Nodal Agency Payment to SEW or NGO</i>
110–60 (2.30–3.40)	35–75 (0.74–1.60)	10–20 (0.21–0.42)	35–60 (0.70–1.30)	93 (2.00) ²

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Note: All figures are in Indian rupees (Rs), with equivalent US dollar amounts in parentheses.

¹ Unit costs for the Sarale Ole and Sukhad Ole construction molds were Rs 130 (US\$ 2.80) and Rs 155 (US\$ 3.30), respectively.

² Of this amount, central and state subsidies were Rs 40 (US\$ 0.80) and Rs 23 (US\$ 0.50), respectively.

The SEWs collected different rates, depending on the distance from the district or block headquarters to the village; thus, user costs varied. Because the SEWs were not entitled to receive any advance, they invested their own money to purchase stove parts (for example, asbestos–cement pipes, cowls, and pottery liners). They also incurred administrative costs related to supervision of installation and paperwork.

Among surveyed households in the backward classes, some reported that improved stoves had been installed free of cost. Some SEWs believed that this approach would lead to later difficulties with regard to users' sense of ownership and ability to collect user contributions. Most users were unaware that the improved stoves were subsidized; those who were aware, did not understand the subsidy pattern.

INSTITUTIONAL ORGANIZATION AND INNOVATION

The national program in Karnataka was implemented through the rural energy division of the Department of Rural Development and Panchayati Raj. It was merged with other state development activities, including rural housing schemes (for example, Ashraya, Indira Awas Yojana, and Swacha Grama Yojana). At the district and block levels, implementation was facilitated by the decentralized government machinery, which included lead district- and block-level functionaries or chief executive officers and village-level self-governance bodies (gram panchayats) (Figure 5.2). For each district, stove distribution targets were conveyed to the respective chief executive officer, who, in turn,

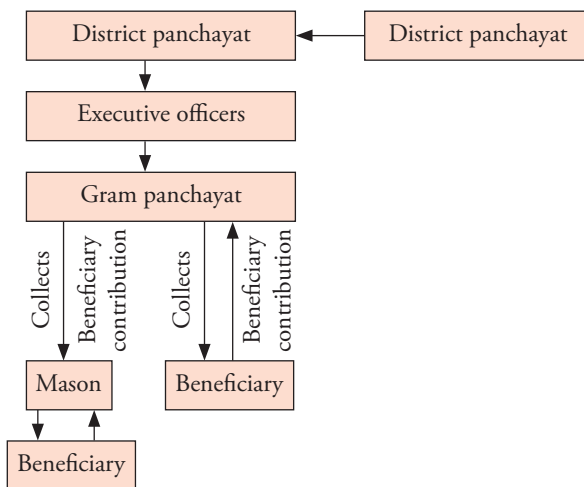


FIGURE 5.2 Initial Delivery Structure in Karnataka

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

sent targets to district blocks. At the block level, the chief executive officers determined the targets for each gram panchayat. At the village level, the gram panchayats identified beneficiaries and had the improved stoves installed by masons or beneficiaries. Subsidies were adjusted accordingly and beneficiary contributions were either collected or adjusted for backward classes using funds earmarked for development activities.

But the system was not without its disadvantages. These included weak linkages, lack of coordination between various districts and block officers, inadequate monitoring systems to ensure the construction of high-quality stoves, losses and component breakage during transport from manufacturers—sometimes stationed outside districts—to districts and villages, and unmet stove demand resulting from setting targets too low.

Role of Junior Engineers

From 1989, block-level junior engineers were key to introducing stove models and institutional mechanisms for stove delivery. As technical advisors to the national program, they advised the chief executive officers on the types of stoves to be distributed based on their understanding of and experience in the region.⁴ Input of the junior engineers led to initiating innovative implementation methods in the study districts (Figure 5.3). For example, introducing the Sarale Ole mold and involving SEWs in Mysore led to better linkages between stakeholder groups. In Hassan, an initiative to involve such NGOs as the Suma Khadhi Gramudyog Sangha, which linked with local NGOs for improved stove distribution, led to better program implementation.

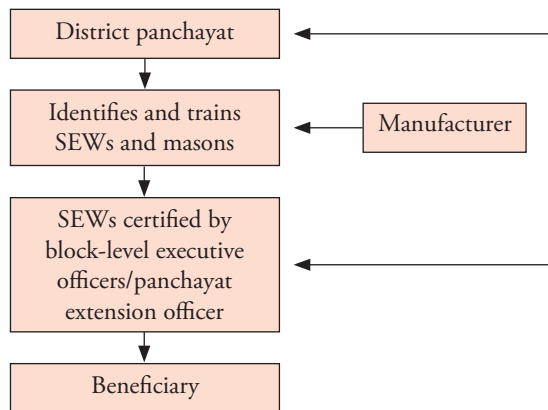


FIGURE 5.3 District-level Implementation in Karnataka, Late 1990s–2002

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Role of Local Institutions

Involving local institutions improved national program implementation in several ways. Because local institutions had established a rapport with local residents, collection of beneficiary contributions was prompt. In areas without local NGOs, SEWs contacted members of the village panchayat, village leaders, and child care (*anganwadi*) givers. With their help, masons identified a few households for whom they constructed improved stoves. They often camped in villages for several weeks at a time to motivate potential users. Involvement of local institutions significantly enhanced community outreach. In Varuna (Mysore), for example, 371 of the village's 400 households—92 percent—installed improved stoves. In 2001, the district commissioner declared Varuna a 'smokeless village'. Efforts of the manager of Kaveri Grameena Bank, a local regional bank, had helped to create women's self-help groups who, in turn, had informed other village women about the advantages of the improved stoves through door-to-door campaigns.

CONSTRUCTION AND TRAINING ISSUES

Local institutions short-listed villages for implementation. SEWs relied on information contained in pre-installation surveys conducted by village motivators. Such surveys included the number of households in a village, houses with stoves, and residents willing to have stoves constructed. Masons working under SEWs linked with NGOs and other local institutions were the main players in stove construction.

Construction of the Sarale Ole model required various component parts, including a chimney pipe, cowl, grate, and pottery liner. Other required materials that were available locally included bricks, sand, and mud. The SEWs paid for the component parts, which they obtained from manufacturers or suppliers in Mysore district and product manufacturers in the district capital of Bangalore. Suppliers covered the cost of in-transit breakage.

On delivery, the village motivators took responsibility for component storage. The breakage cost during loading and unloading was borne by the SEWs. Pottery liners for the Sukhad model were obtained from potters. In 1998–9, participating NGOs procured pottery products from neighboring Andhra Pradesh. The NGOs incurred substantial breakage and transport costs, averaging about one quarter of the cost of one stove. In response to an NGO initiative, three traditional potter families from Andhra Pradesh traveled to Hassan in 2000 to construct pottery liners. But the next year, pottery liners were procured from traditional potters in Hassan. The potters stated that they produced pottery liners 8–9 months per year (August–March); during the off months (April–July), they made pots and worked as agricultural laborers.

Once the materials reached a village, the SEWs sent masons to construct the stoves. The masons camped in a village for several weeks to complete

construction. Discussions with the masons revealed that, although they were capable of constructing ten to fifteen stoves a day, they usually built only five or six because of a lack of designated households, delays caused by village festivals and functions, and social taboos (for example, having to construct in higher-class households before lower-class ones or being allowed to construct in certain households only on auspicious days). Such delays increased the costs incurred by masons and SEWs.

Masons were paid per improved stove they constructed. They built stoves from September to March and worked as agricultural laborers or construction workers during the off months. Beneficiaries provided bricks, mud, and sand and helped in construction tasks (for example, boring a hole in the roof or removing tiles). Given that all materials were ready, a mason could construct an improved stove within one hour. After setting several days, the stove was ready for use.

The technical backup unit conducted various types of training via designated junior engineers in the zilla parishads for SEWs, NGOs, block- and district-level officials, masons, and users. In addition, the National Dairy Development Board organized training for masons, particularly female ones, through various cooperative societies and milk unions.

In its initial phases, the national program had a built-in monitoring system via post-construction visits and random checks by the SEWs and block-level project extension officers. Before claiming the subsidy, SEWs were required to obtain certificates from the village panchayat and block and district levels, which acted as a check on their performance. But interviews with the SEWs revealed that they were unable to visit all villages for lack of time and funds.

Of the 129 user households surveyed, all reported that the SEWs and masons did not return after installation, underscoring the lack of village-level technical assistance. Although the masons explained how to maintain the improved stoves, back-smoking occurred for lack of regular chimney cleaning.

Stakeholder discussions revealed that few users received formal training in improved stove use and maintenance. For example, in 1999–2000, 2,000 improved stoves were constructed in Mysore district, but only five user training programs were conducted. Since the SEWs and masons were the link between the users, technical backup unit, and implementing agencies, more frequent interaction between these stakeholder groups would have helped to identify users' needs and problems.

BUILDING ON LESSONS LEARNED

Several key features accounted for the success of the national program in Karnataka: a high-caliber technical agency that developed innovative stove models based on pioneering research; involvement of local institutions and

motivated government officials, particularly district-level junior engineers; and the improvement and standardization of production quality and construction through introduction and use of prefabricated molds and templates developed by the Karnataka State Council for Science and Technology. In addition, the decision by the Department of Rural Development and Panchayati Raj to change from a target-oriented to a whole-village approach—involving local leaders, SEWs, and NGOs—resulted in the installation of many more improved stoves in particular villages, facilitated better coordination among all stakeholders, and reduced installation costs.

Like other states, the national program in Karnataka was not without its weaknesses. The program could have enjoyed even greater success had it emphasized the phasing out of subsidies; monitoring and after-sales service; quality control and technical training of users and producers; and greater interaction between designers, producers, and users.

Since the withdrawal of central funding in 2002, the distribution of improved stoves in Karnataka has continued under the Swacha Grama Yojana and the World Bank–funded Jal Nirmal Project (Winrock International 2005). Although Swacha Grama Yojana has adequate resources for improved stove distribution, it accords higher priority to promoting biogas technology and LPG, both of which can lead to lower levels of indoor air pollution. The Jal Nirmal Project has increased the chances that beneficiaries will permanently adopt the improved stoves by focusing on awareness generation, creation of household demand, and promoting commercialization via mechanisms and institutions capable of meeting demand (36 agencies in northern Karnataka). Users can choose from a variety of improved stove models, and the mandatory household contribution spans a wide range, making the stoves available to households across economic groups. Key features of the project's stove component—including women in indoor pollution awareness raising and the proposed entrepreneurship training of self-help groups—could offer important lessons in promoting improved stoves in rural areas. In short, Karnataka retains a viable foundation on which future stove programs could be built.

NOTES

1. In one village where the National Dairy Development Board installed improved stoves in 1993, some women had attached chimney pipes from their now dysfunctional improved stoves to their traditional stoves.

2. A chimney set consisted of a cowl, chimney, pottery liner, and grate (for Sarale Ole model), and other components (for Sukhad Ole model).

3. The state nodal agency received half of the Ministry funds at the beginning of the fiscal year and the balance on submitting documents showing that installation targets had been met. The funds released varied by year and were usually based on prior-year performance.

Stoves have existed since the beginning of human history. They have come in various sizes and styles, having been adapted to myriad cultures and food preparation methods. As society has progressed, more sophisticated stove models have been developed. Today's modern kitchen reflects the many types of standardized and specialized cooking devices available, from coffee and tea pots to toasters and gas cooktops.

In developing countries, the pattern of stoves development has ranged from traditional stoves to gas or LPG. Over the last 30 years, various programs have promoted improved stoves as a bridge between traditional and modern ones. The development of better stoves has witnessed several overlapping stages, which are chronicled below.

TRADITIONAL STOVES

Traditional stoves have been around for thousands of years. Users often make the stoves, customizing them to preferred cooking styles. In South Asia, traditional stoves are commonly made of mud, but many households use three-stone, open-fire stoves. It is a common practice in South Asia to use straw, leaves, and dung as cooking fuel. The outdoor stove in Photograph 1 is being fed small twigs. Such fuels require constant attention.

Unless the kitchen is well-ventilated or the stove is located outdoors, cooks are exposed to massive amounts of smoke emissions. Even outdoor stoves may expose cooks to high levels of pollution. Stove efficiency varies widely, depending on use, ranging from 10 to 20 percent.

The indoor stove in Photograph 2 uses small blocks of wood. The black substance visible on the back wall is tar, the product of incomplete combustion. Carbon also covers pots and pans, making them difficult to clean.

First Generation: Custom Built

At the outset, India's National Program on Improved Chulhas focused on producing and disseminating stoves that the poorest households could afford. With the exception of the chimney, these first-generation stoves were made of mud and clay, as illustrated by the Parvati stove (Photograph 3). Indentations

From Traditional to Modern Stoves



PHOTOGRAPH 1 Outdoor Traditional Stove, India

Source: Sonal Desai, Univeristy of Maryland, College Park.



PHOTOGRAPH 2 Indoor Traditional Stove, India

Source: Curt Carnemark/The World Bank.



PHOTOGRAPH 3 Parvati Stove, India

Source: ARTI, India.

in the pot opening helped to channel heat around the pan and prevent smoke from entering the kitchen. From 1980 until about 2002, hundreds of such models were developed. As one might imagine, with repeated heating and cooling, these stoves easily cracked and degraded. The estimated two-year lifespan proved too optimistic; in practice, most stoves failed within a year.

The Lorena stove (Photograph 4), whose name is derived from mud (*lodo*) and sand (*arena*)—the primary materials used to make the stove—was originally developed in Guatemala. This picture, taken in the early 1980s, depicts one of the myriad models developed throughout that decade. Popularity among Latin America’s NGOs, governments, and donor agencies increased. But the use of varying sizes and low-quality construction materials reduced reliability, leading to user dissatisfaction. Today, the Lorena stove is only rarely produced in Latin America.

Second Generation: Manufactured Components

In the 1990s and early 2000s, the trend to make stoves of more durable materials also made them more expensive. In India, the Laxmi (Photograph 5), like the first-generation Parvati, was originally made of mud. But in the last years of the National Program, many stoves were constructed of cement or a mixture of clay and cement,



PHOTOGRAPH 4 Historical Picture of First Lorena Stove, Guatemala

Source: Manuel Tay.

which increased the cost. With the exception of the stove pipe, these models were made from prefabricated molds. But the efficacy of this approach was never proven because, only a few years after adopting it, stove dissemination under the National Program ended.

In Latin America, the *Plancha* (Photograph 6)—so named because of its prominent metal griddle (*plancha*)—was disseminated under Guatemala's social fund program. A more expensive, durable stove lasting 10 or more



PHOTOGRAPH 5 Improved Laxmi Stove, India

Source: ARTI, India.



PHOTOGRAPH 6 Guatemala Government FIS (Social Investment Fund) Stove

Source: Fundacion Solar.

years, the Plancha has a metal top used for roasting corn and preparing tortillas and other staple foods, a shelf for feeding wood, space on top for placing cooking utensils and equipment, and a chimney for venting smoke. For local communities, which had other development options under the social fund program, the Plancha was a popular choice. If a community decided on the stove option, then virtually every household received a Plancha in return for contributions of labor and local materials. The combination of having a durable stove along with many convenient features led to a high degree of popularity and continued stove use.

Third Generation: Manufactured Stoves

Today's third-generation stoves aim to improve quality and lower costs by manufacturing stoves locally and internationally. Thanks to major appliance manufacturers, NGOs, and foundations, a wider variety of manufactured stoves has entered the marketplace in developing countries. In Central America, a rocket powered stove, Justa stove, was first developed by a local NGO named PROLENA/Honduras using masonry materials. The original stove was named for the community leader Doña Justa Nuñez, who really liked the idea of promoting better stoves for the women in her church group. Later, the masonry, which requires significant periods of time for proper drying, was replaced with a metal frame based on the experience of the Ecostove in Nicaragua. This permitted the Justa stove to be produced with a higher level of quality control and

From Traditional to Modern Stoves

in a shorter period of time. This was accomplished with support from groups, such as Trees, Water, and People, Rotary International, and the Aprovecho Research Center. The metal Justa stove is now mass produced by the Honduran Association for Development (AHDESA) (Photograph 7), which permits many more low-income families to benefit from indoor smoke reduction made possible by chimney and the better combustion efficiency of the stove.

Another approach to manufacturing better stoves has been taken by companies such as Envirofit International that make a wide variety of products for worldwide market. Envirofit International produces a line of cookstoves including portable wood (Photograph 8), charcoal, and built-in designs. Their development was a result of a partnership with the Shell Foundation Breathing Spaces program, and requires all of their stoves to meet the industries' most rigorous performance and emissions standards—largely possible through their patent-pending design and materials advances. The company mission is to achieve high sales volume and economies of scale by selling high-quality, low-cost, and durable stoves at a global level. Centralized production has allowed them to meet large initial demand in India and Africa, and they are pursuing localized assembly and production in key markets. The available five-year warranty and approximately 30 percent efficiency levels make them attractive to carbon programs. The pricing for the stoves ranges from \$15 to \$30.

The Ecostove (Photograph 9), which is based on the rocket stove design, was developed by a Nicaraguan NGO called Proleña under the Pro-Tortilla



PHOTOGRAPH 7 Justa Ecostove being manufactured in Honduras by ADHESA

Source: Elisa Derby, Winrock International.



PHOTOGRAPH 8 Envirofit International Manufactured Stove, India

Source: Envirofit International.

program. The stove's innovative combustion chamber design and chimney account for the removal of most smoke from the kitchen. More expensive than first- or second-generation stoves, the Ecostove sells for US\$40–60. But because the stove lasts five or more years, the annual cost is comparable to that of a traditional mud stove. The challenge in these programs is to make the stove affordable through innovative financing to keep the monthly costs low.



PHOTOGRAPH 9 Ecostove, Nicaragua

Source: PROLENA/Nicaragua.

Modern Fuels and Stoves

At the top of the energy ladder for cooking is LPG. Historically, LPG use in India has been restricted to urban areas and high-income households. But because of its convenience and low emissions, LPG is gradually spreading to poorer areas, having reached some 20 percent of rural households. To preserve their low cash income, less wealthy households use LPG sparingly, in combination with biomass fuels. The LPG stove tank is connected by a tube to the stove-top burners (Photograph 10). Depending on the cooking task, the range of stove efficiency is 55–70 percent; even cooking pots and pans remain clean on the bottom. For low income households, the main barriers to LPG use are the connection charges: purchase of stove, tank rental, and required purchase of large quantities of LPG (typically sold in 12–16 kg cylinders).

Widespread adoption of this convenient fuel illustrates that cooks can adapt myriad cooking styles to a fairly universal stove if it is easy to use, can start and stop quickly, and is clean burning. This lesson reinforces the goal of developing woodstoves that are flexible in adapting to many cooking styles.

In Yunnan Province, China, The Nature Conservancy is partnering with Chinese government agencies and the US Environmental Protection Agency to reduce fuelwood demand and address threats to biodiversity and human health by introducing alternative energy technologies in rural homes and schools. The biofuel stove (Photograph 11) in Xidang, a village along the Mekong River Valley, is not a common stove, but illustrates the wide variety of options for clean cooking in the developing world.



PHOTOGRAPH 10 LPG Stove, India

Source: Douglas F. Barnes.



PHOTOGRAPH 11 Biofuel Stove, Mekong River Valley, China

Source: Scott Warren, for The Nature Conservancy.

* * *

Worldwide the various programs to promote new stoves for better energy efficiency and reduced air pollution have shared many features even though there has been little contact between the programs. The earliest ones featured custom-built stoves focused mainly on improving energy efficiency for the poorest households. Many years later, an increasing trend toward manufacturing components or entire stoves emphasized ways in which to reduce indoor air pollution. An overriding concern has been finding affordable ways to promote these innovative stoves to the many people around the world who rely on biomass to meet most or all of their cooking needs.

Many of the challenges in promoting better stoves remain today. Simply stated, it is not easy to design inexpensive stoves that are both affordable by the poor and far superior to their centuries-old cooking devices. Past attempts to resolve these issues no doubt hold the key to developing ways to bridge the vast differences between those using traditional forms of cooking energy and those taking advantage of more modern cooking fuels and appliances. The current trend is toward a greater role for the manufacturing of durable, efficient, and less polluting stoves, and there are many new designs around the world. But the continuing challenge is finding ways to make these new stoves more affordable and suited to the needs of the world's populations who still depend on centuries-old cooking practices.

4. In 1999, a block-level junior engineer in the Mysore district of Karnataka developed an innovative, cost-effective method for distributing the Sarale Ole improved stove model. From a single mold made of 18-gauge MS sheet, 3,000–4,000 improved stoves could be constructed. The cost of one sheet was Rs 900–1,000 (US\$ 19–21), rendering the added cost of a stove negligible. This junior engineer motivated and trained SEWs in how to invest in stove components and construction using the available subsidy. By the following year, the trained SEWs had hired some 22 masons. Using the mold, a mason could build seven to eight stoves per day on average, earning about Rs 175–200 (US\$ 3.7–4.2) per day or Rs 25 (US\$ 0.53) per stove. Owing to the method's popularity, the junior engineer was asked to train masons, other junior engineers, and an executive officer in another district.

6

Gujarat

Rural Development Approach

Successful implementation of the national program in Gujarat can be attributed to an approach that emphasized integrated rural development, decentralization, and targeting those living below the poverty line. By integrating the national program with housing schemes for those living below the poverty line, the state administration was able to harness organizational synergies. By devolving the program to the level of village council (panchayat), it ensured that the program was administered close to its intended beneficiaries and that demand was estimated more accurately. Finally, by targeting families below the poverty line, it ensured that those most likely to have been using inefficient traditional stoves were reached and could, thus, benefit from the program.

This case study focused on four districts: Ahmedabad, Surat, the Dangs, and Bharuch (Figure 6.1). Ahmedabad and Surat represented high-density, national-program areas; the Dangs had a large tribal population living in or near hill and forested areas; and Bharuch had one of the few villages where improved cement stoves were installed and used. In all these four districts, detailed fieldwork was undertaken and focus group discussions and interviews were held with various stakeholder groups. At least two villages were visited in each district, with the exception of Bharuch, where one village was visited.

BACKGROUND

Gujarat, India's seventh largest state and among its most prosperous ones, is home to 50.6 million people (GoI 2001), more than three-fifths of whom reside in rural areas. The country's westernmost state, Gujarat shares its international border with Pakistan to the northwest; the states of Rajasthan and

Madhya Pradesh lie to the northeast and east, respectively, while Maharashtra and the Union Territories of Diu, Daman, Dadra, and Nagar Haveli lie to the south (Figure 6.1). The national program in Gujarat covered all 25 districts; in 2001 alone, 65,000 improved stoves were installed.

The national program in Gujarat was initiated in 1983–4. Three years later, the technical backup unit was established at Maharaja Sayajirao University in Baroda, (presently known as Vadodara). Until 1988, the Forest Department was in charge of program implementation, at which time responsibility was transferred to the Rural Development Department. In 1994, responsibility was devolved to the panchayat level. Currently, it falls within the scope of the panchayats, Rural Development Department, and Rural Housing.

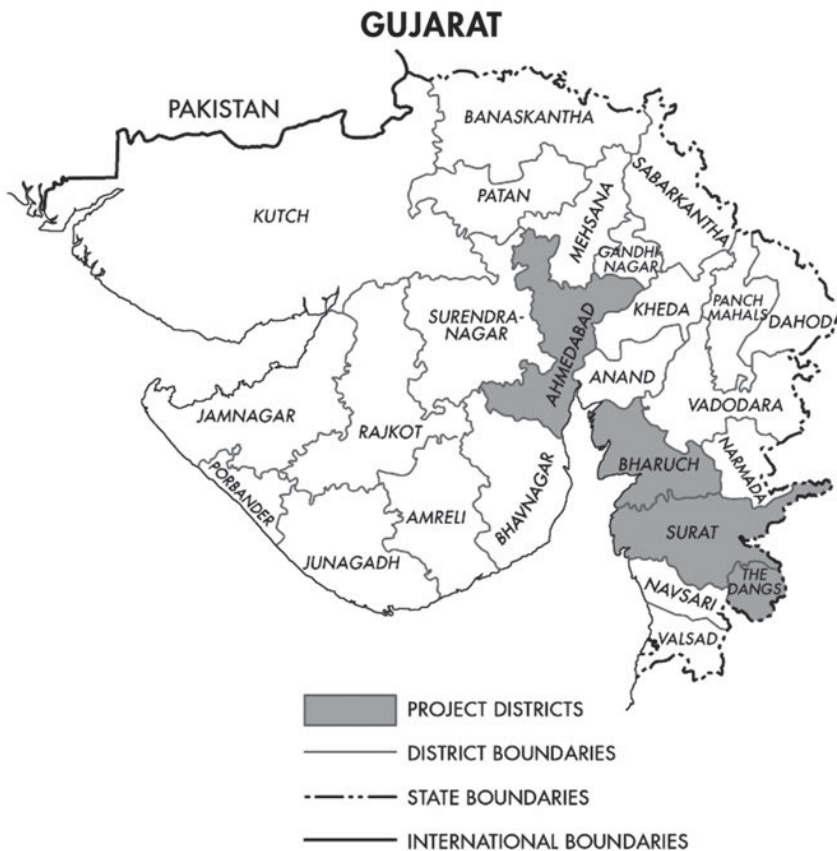


FIGURE 6.1 Map of Gujarat, Highlighting Case Study Districts

Source: General Services Department Printing, Graphics and Map Design, The World Bank, Washington, D.C., 2011.

Other implementing bodies included the Gujarat Energy Development Agency, whose participation in the national program began in 1984–5, and three national-level agencies—the Khadi and Village Industries Commission, National Dairy Development Board, and All India Women’s Conference—which independently allocated portions of their respective national targets to the state.

Improved stoves were distributed under the national program, which focused mainly on families below the poverty line,¹ and the Indira Awas Yojana, a central-government housing scheme. Unlike national program targets, those under the Indira Awas Yojana were not included in state-level targets allocated by the Ministry of Non-conventional Energy Sources. In 2000–1, eight main improved stove models were distributed in Gujarat (Table 6.1). The most popular model was the two-pot Mamta with chimney, followed by the single-pot Sneha without chimney.

TABLE 6.1 Improved Stove Models Distributed in Gujarat, 2000–1

<i>Model</i>	<i>Description</i>
Mamta	Two-pot, with chimney
Supriya	Single-pot, with chimney
Priya	Two-pot, with chimney for large family
Kiran	Single-pot, without chimney for small- or medium-sized family
Sneha	Single-pot, without chimney for medium- or large-sized family
Grihalaxmi	Single-pot, without chimney and with grating at the stove base and bottom
Kamdheni I	Single-pot, with chimney
Kamdheni II	Two-pot, with chimney

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

USER PERCEPTIONS AND PRACTICES

In Gujarat, the improved stove benefits and problems perceived by the targeted household users—most of whom lived below the poverty line—offer insights into these users’ environmental and sociocultural realities. They also suggest how improved stoves might be better designed in the future to meet users’ expectations.

The households surveyed perceived the major benefits of the improved stoves as reduction in or elimination of smoke, fuel savings, and time savings. Other benefits cited included cleaner cooking vessels and kitchens and the ability to cook on two pots at the same time (Table 6.2).

TABLE 6.2 Perceived Benefits from Improved Stoves, 2000–1

<i>Perceived Benefit</i>	<i>Households (number)</i>					<i>Households (%)</i>
	<i>Ahmedabad</i>	<i>Bharuch</i>	<i>Surat</i>	<i>Dangs</i>	<i>All</i>	
Less smoke	28	5	26	9	68	86
Fuel savings	16	6	21	7	50	63
Time savings	14	1	27	4	46	58
Less soot on vessels and in kitchen	26	2	10	3	41	52
Fewer health problems	14	4	13	1	32	41
None mentioned	0	0	2	0	2	3

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

In the four districts surveyed, the importance of fuel savings varied considerably by village. In villages where fuelwood was readily available from the local environment, stove efficiency was a less critical issue than in places where fuelwood collection was labor and time intensive or had to be purchased.

Of the 79 households sampled with regard to the popular two-pot Mamta model with chimney, more than two-thirds reported no problems. However, some users perceived design challenges, including the need for a wider chimney mouth and a larger pothole (Table 6.3).

TABLE 6.3 User Complaints Regarding the Mamta Model, 2000–1

<i>Perceived Drawback</i>	<i>Households (number)</i>	<i>Households (%)</i>
Small pothole	5	6
Smoke coming into room	3	4
Low fuel gate	4	5
Broken roof tiles from chimney cleaning	4	5
Narrow chimney mouth	6	8
Inability to cook traditional bread (roti)	4	5
None	62	78

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Note: Some respondents reported more than one problem.

With regard to the single-pot Sneha without a chimney, users perceived that the pothole was too small, the fuel gate too low, and the design unsuitable

for cooking roti; they also complained of the large quantity of smoke it produced. The survey revealed that close to one-third of users had made design modifications, mainly to the pothole diameter; they either changed its size or inserted three nails inside the rim on which to place smaller vessels. In two households, the users had completely dismantled and rebuilt their improved stoves.

In addition to making design and other modifications, such as plastering the improved stoves with mud, users failed to adequately clean the chimneys. In a sample of 67 households across the four districts, two-fifths of respondents admitted that they had never cleaned their chimneys (Table 6.4). At the same time, the survey revealed that close to two-thirds of users had attended training sessions; the other one-third had been instructed by stove masons on fuel preparation, chimney cleaning, and firebox plastering. Thus, failure to maintain chimneys did not result from a lack of training; more likely, it involved the difficulty in cleaning the chimneys. It was found that chimneys with a bend in the pipe, which protruded through the wall, were easier to clean because of access to the bend.

TABLE 6.4 Frequency of Chimney Cleaning by District, 2000–1

Frequency	Households (number)					Households (%)
	Ahmedabad	Bharuch	Surat	Dangs	All	
Weekly	0	2	9	0	11	16
Bi-monthly	8	2	2	0	12	18
Monthly	14	1	0	0	15	22
Quarterly or less	2	0	1	0	3	5
Never	3	1	14	8	26	39

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

More than half of households with functioning improved stoves also used traditional or kerosene stoves. Although they considered the improved stoves useful, the opportunity cost of time spent in cooking meant that more than one stove was needed; this was especially true for poor households that depended entirely on labor wages and where all adults worked (Box 6.1). Typically, the improved stove was used in multiple ways, while the traditional stove was used to heat water or prepare cattle feed. Traditional stoves were preferred for cooking certain foods, such as roti, and were usually installed in courtyards. Most families installed the improved stoves indoors, but one-tenth installed them on verandas.

Users in Gujarat rarely repurchased improved stoves. When asked what they would do when their improved stoves broke, most responded that they would

Box 6.1 Sociocultural Practices and Stove Design

Field visits to the Dangs revealed that the food habits of indigenous (adivasi) communities and the opportunity cost of time spent in cooking required most households to use more than one stove (chulha). In addition, many users were led to make design modifications to meet local fuel requirements.

To prepare leavened millet bread (*nagli rotla*), a staple food, the dough was first roasted in a pan (*tava*) on the improved stove. The pan-roasted dough bread was then transferred to a U-shaped piece of flat iron placed over the adjoining Dangi stove for further cooking. Finally, the bread was placed on embers pulled out from the Dangi stove.

Since all adult household members worked outside the home, the opportunity cost of time spent in cooking was high. Thus, having adjoining improved and traditional stoves helped to ensure that food was cooked quickly. Some households even had side-by-side Sneha models (users often constructed the second one).

Teak, which grows in abundance, was the main fuelwood for cooking. But teak logs were too large to fit into the mouth of the Sneha firebox. Attempting to force large pieces of wood into the firebox chipped away mud at the opening, causing the unsupported top portion to collapse. As a result, many users either enlarged the firebox opening or rebuilt the Sneha models as traditional stoves. Thus, there is a need to train users to cut wood into smaller pieces.

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

revert to using their traditional stoves. Some users of improved mud stoves reconstructed them—usually without adhering to specified dimensions—depending on the condition of the chimney. If the pipe was broken, they simply constructed a traditional stove. New improved stoves were sometimes purchased if the stove mason lived nearby and could be contacted easily. The introduction of cement stoves, to which users responded positively, suggested that the repurchase scenario would likely change.

DIVERGENT VIEWS ON LARGE SUBSIDIES

The improved stoves in Gujarat were heavily subsidized. Most beneficiaries were below the poverty line, which entitled them to both central and state subsidies. Typically, beneficiaries contributed labor and a small amount that most families could afford. For Mamta models with chimneys, the beneficiary contribution was often labor. For other models without chimneys, the state government provided the subsidies. Beneficiary contributions varied by implementing agency or local NGOs, beneficiary income level, and stove type. Many NGOs took no contributions from families below the poverty line, while the Rural Development Department often accepted labor in

lieu of the required cash contribution. Table 6.5 illustrates the variation in beneficiary contributions across the state.

TABLE 6.5 Subsidized Prices for Various Models by NGOs, 2000–1

<i>Improved Stove Model (type)</i>	<i>Unit Cost in Rs (US\$)</i>	<i>User Price in Rs (US\$)</i>
Gramya Kamdar Seva Kendra (Junagadh)		
Unnat (cement)	210 (4.5)	20 (0.42)
Parabat Bhai Ma Kavaira (Porbander)		
Unnat (cement)	220 (4.7)	80 (1.69)
Gujarat Rajya Shramik Vikas Parishad (Ahmedabad)		
Double-pot Mamta (mud)	110 (2.3)	10 (0.21)
Single-pot Mamta (mud)	80 (1.7)	10 (0.21)
Single-pot Sneha (mud)	60 (1.3)	10 (0.21)
Single-pot Kiran (mud)	60 (1.3)	0
Double-pot Priya (mud)	110 (2.3)	10 (0.21)
Mahila Khadi Gramodyog Trust (Dhandhuka)		
Unnat (clay–cement)	80 (1.7)	0
Portable (clay–cement)	80 (1.7)	0

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Perceptions regarding the usefulness of subsidies varied among stakeholder groups. Household users acknowledged certain benefits provided by the improved stoves, but said they were willing to pay only slightly more than they currently did, citing poverty as the reason. Given that most poor rural households in Gujarat constructed their own traditional stoves, it is not surprising that they considered additional stove expenditures, versus income-generating activities, as infeasible. This finding also suggests that household users were unaware of the higher productivity and income generation that the improved stoves could make possible or the linkages between reduced indoor smoke from the improved stoves and better health.

The technical backup unit based at the Maharaja Sayajirao University in Baroda was of the opinion that, if the various shortcomings were eliminated and rural residents believed in the technology, the national program would succeed even without subsidies. Based on demonstrations and interaction with household users on the differences between traditional and improved stoves, it found that the benefits from using improved stoves could be effectively communicated to and understood by potential users. By taking

additional steps to resolve design problems and adapt to women's cooking requirements and cultural habits, it believed that households would be more easily convinced to adopt the improved stoves without subsidies as an incentive.

The Rural Development Department, by contrast, believed that subsidies were critical, especially for families living below the poverty line. But one district development officer suggested that it was possible to phase out subsidies over time without harming the program. Such a phase-out plan would require linking the national program with the various housing schemes of the Department and conducting awareness-raising activities with villagers on the health benefits from using improved stoves. Under the Sardar Patel Awas Yojana, a rural housing scheme supported by the state government, for example, the cost of house construction is Rs 40,000 (US\$ 848). Residents' contribution is limited to labor; thus, they could be asked to contribute a small amount toward the cost of the improved stoves. The district development officer believed that even a family below the poverty line could afford to pay Rs 250 (US\$ 5.3) if properly educated about the health and economic benefits of using improved stoves. Village-level, self-help groups could be used to promote residents' awareness about the harmful effects of using traditional stoves and the comparative advantages of improved ones.

The Gujarat Energy Development Agency officials generally expected that subsidies would be required for all renewable energy and energy efficiency products, regardless of the benefits users enjoyed. By contrast, some representatives of the implementing NGOs believed that the government could not afford to subsidize improved stoves for every rural household in Gujarat. They were of the opinion that better-targeted subsidies would raise awareness about the benefits of improved stoves. With sufficient awareness and successful demonstration projects, the intended customers would be ready to pay for the improved stoves. To achieve this, the NGO representatives advocated that the Ministry of Non-conventional Energy Sources does not require that every household in a particular village be provided with an improved stove before program implementation could begin in the next village. They believed that only about one-tenth of villagers—those that volunteered to participate—should receive subsidized stoves and that the remainder should be encouraged, via demonstrations, to adopt the stoves without any subsidy.

DEVELOPMENT AND PRODUCTION: TRAINING EMPHASIS

The technical backup unit—whose staff included a senior scientific officer, senior research assistant, senior technical assistant, assistant, and two master craftsmen—was responsible for several major development and production activities: design of appropriate improved stove models; stove pricing; and training of personnel involved in national program implementation, stove

masons, and users. In the initial years, the technical backup unit was also involved in stove mason identification and selection. But, as the program progressed, this responsibility was transferred to the implementing agencies.

Based on the feedback it obtained from stove makers and users, the technical backup unit attempted to address a variety of problems, from water seepage through the chimney opening to high fuelwood use. Over the years, it experimented with various types of construction materials, including mud and cement, and pottery liners for improved models with chimneys. As discussed above, of the models approved for implementation, the two-pot Mamta with chimney and the single-pot Sneha without chimney were the most popular (see Table 6.1).

With regard to stove cost, a pricing committee—consisting of the technical backup unit and representatives of the Rural Development Department, Gujarat Energy Development Agency, and other implementing agencies—met when necessary to finalize the unit costs calculated by the technical backup unit for the various stove models.

Training programs were held for personnel involved in national program implementation. Management training was organized to orient agency staff, including NGOs and government officers, to the implementation process; these staff members were provided information on administrative guidelines, motivating potential users to adopt the technology, and the process of identifying and supervising stove masons. Implementation training was organized to promote field testing of the improved stove models. Each year, the technical backup unit adopted five to six demonstration villages where it encouraged residents to construct improved stoves and implement the program on their own. This approach worked because the residents were self-motivated to build stoves. It also acted as a catalyst for surrounding villages to initiate improved stove building. The useful lessons learned through this process were conveyed to implementing agency personnel during management training.

Stove mason training was held at the technical backup unit campus or at centralized district-level locations. Each training program included 20 trainees and was conducted over 10 days. The trainees, usually stove masons identified by the technical backup unit or an NGO, were taught how to construct various approved models. In order to develop a human resource base capable of spreading the technology to other stove masons, a train-the-trainers program was also implemented. During training, the stove masons received a variety of information on the basic functioning and benefits of the improved stoves and their comparative advantages over traditional stoves. This approach ensured that the stove masons would be able to convey the information to users. Through entrepreneurship training, stove masons were encouraged to take up improved stove construction as their livelihood and sell on the open market. The technical backup unit also conducted user edu-

cation training. During these sessions, stove users were informed about the national program and the benefits and maintenance of the improved stoves.

FLEXIBLE ORGANIZATIONAL STRUCTURE

As discussed above, the Rural Development Department was the state nodal agency for the national program. The Gujarat Energy Development Agency was responsible for about two-thirds of the state-level target, with an initial annual target of 2,000 improved stoves, while the Rural Development Department covered about one-third.² Several other agencies—the Khadi and Village Industries Commission, National Dairy Development Board, and All India Women’s Conference—were responsible for smaller targets (Figure 6.2).

The Rural Development Department implemented the national program in Gujarat through a three-tier government system (Panchayati Raj): district, block, and village. At the district level, the district development officer was in charge of development activities. At the block (taluka) level, the taluka development officer was in charge; s/he supervised village-level revenue-collection officials (talatis), oversaw the work of stove masons, allocated targets and

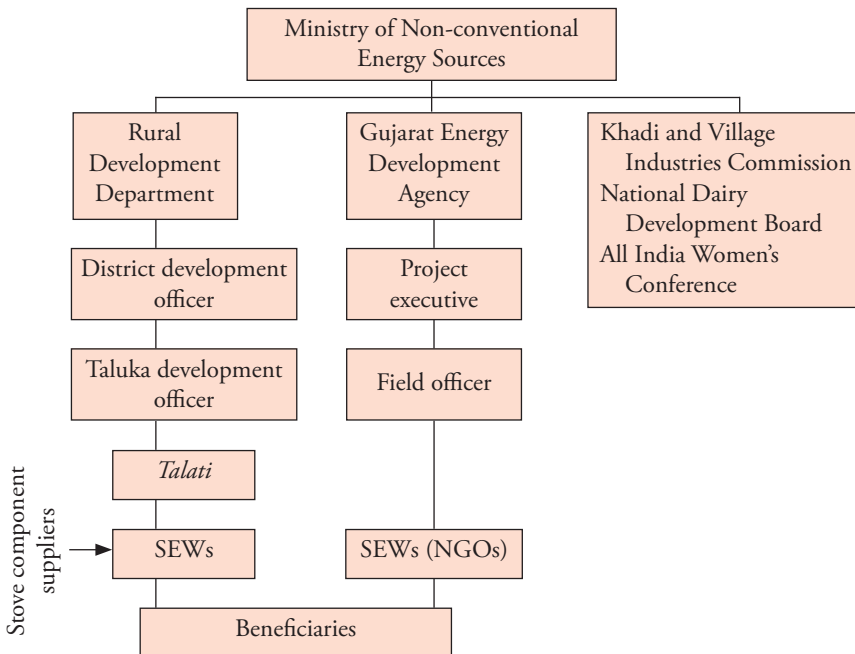


FIGURE 6.2 Implementation Structure in Gujarat

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

forwarded funds to stove masons, and inspected 10 percent of the improved stoves installed in the block; several village extension workers (gram sevikas) were also involved at the block level. At the village level, the talati was responsible for motivating villagers, identifying beneficiaries, estimating demand, supervising construction of improved stoves, and inspecting all stoves after installation. Stove masons—individuals and NGOs identified by the taluka development officer (with the help of the gram sevikas and talatis)—were responsible for procuring raw materials with which to construct the improved stoves.³ Based on village-level estimates by the talatis, the taluka development officers estimated block-level demand, which they forwarded to their respective district development officers; in turn, each district development officer forwarded districtwide demand estimates to the Department, which consolidated them in order to estimate statewide demand.

The Rural Development Department received funds from the Ministry of Non-conventional Energy Sources and the state government. The Ministry gave Rs 110 (US\$ 2.3) per improved cement stove [received in two equal installments (in June and after submission of the utilization certificate)], while the state government gave Rs 145 (US\$ 3.1) per improved cement stove. The Department used the state funds only for families below the poverty line.⁴

In Surat district, the national program was linked to the Sardar Patel Awas Yojana. Integrating the national program with the housing scheme saved the local administration time and resources by enabling it to obtain a predefined set of beneficiaries. The state government adopted a cluster approach for implementing the housing scheme. In each cluster, a local institution was assigned responsibility for implementing the entire program—from hiring an engineer to ensuring that the work, including stove construction, was successfully completed; a section officer was responsible for overseeing construction work. Trained by the technical backup unit in improved stove construction, the section officer trained selected villagers, creating a pool of skilled stove makers. Funds were released in three installments, the final one of which was released on completion and inspection of the structure.⁵

Unlike the Rural Development Department, the Gujarat Energy Development Agency allocated targets to NGOs working throughout the state, thereby extending the program to all districts without increasing its workforce.⁶ Of its 70 employees, only six to seven worked on the national program. The NGOs also contributed to program flexibility by customizing implementation techniques to village requirements. Funding was similar to that described above for the Rural Development Department.

Eligibility criteria required NGOs to have been in existence for at least three years. They were also required to provide details of their work and audited balance sheets for the previous two years. Those NGOs already working with the Rural Development Department on the national program were

ineligible to participate. The Gujarat Energy Development Agency allotted the selected NGOs small targets and closely monitored their performance. Based on performance feedback from field officers, the NGOs were either dropped or allocated higher targets for the next year.

The NGOs preferred to work in villages where they had good rapport with local residents and were reasonably confident of meeting their targets. They often installed improved stoves in villages where they had existing programs; they also selected new villages, sometimes in consultation with the local talatis. To identify program beneficiaries, the NGOs either gathered relevant information (including population, housing, fuelwood situation, and fuel types used) systematically or relied on informal methods [including personal communication with the village headman (sarpanch)].

The stove masons were either full-time NGO employees who had worked with the NGOs on other programs or part-time employees selected from the villages and trained by the technical backup unit. Some NGOs maintained a pool of skilled stove masons in different districts, which they drew on as needed. Part-time stove masons usually held other masonry jobs during the off-season.

Like the Rural Development Department, the Gujarat Energy Development Agency did not play a role in selecting stove construction materials. Rather, the NGOs procured the materials directly from the dealers. Unlike Haryana and Maharashtra, Gujarat had no government-approved dealers.

The NGOs received one half of total funding upfront, which helped to finance construction activities. The other half was released in smaller installments, based on completion reports submitted by the NGOs and inspection reports by field officers of the Gujarat Energy Development Agency. The process of report submission, inspection, and funds disbursement usually took several months.

QUALITY-CONTROL CHALLENGES

The national program in Gujarat faced several major constraints regarding quality control. First, the program lacked standardized stove-construction materials. As mentioned above, Gujarat had no government-approved dealers; neither the Rural Development Department nor the Gujarat Energy Development Agency played a role in approving the materials selected by the respective stone masons and NGOs. Because the NGOs purchased stove accessories from manufacturers located in other states, as well as from within Gujarat, procurement rates could vary considerably. For example, the Agricultural Tools Research Center, a Bardoli-based NGO in Surat district, bought asbestos-cement pipes and cowls in bulk from an agency in Rajasthan at a unit cost of Rs 55 (US\$ 1.2), while most other NGOs paid up to Rs 75 (US\$ 1.6) from in-state dealers. As a result, earnings from

program participation as well as construction costs varied by NGO (see Table 6.5). Second, the Gujarat Energy Development Agency's three field officers were responsible for inspecting all of the improved stoves constructed by the NGOs in Gujarat. In 2001 alone, NGO installations numbered 65,000, far exceeding inspection staffing capacity. Third, NGOs lacked financial performance incentives. Each year, some 20 percent were dropped because of poor performance, reflected in substandard construction and false claims regarding installed stove numbers. The NGOs revealed that despite the significant amounts of time and effort required, implementation incentives were strictly non-financial. These included using the national program as an entry point for expanding operations into new villages, adding the national program to their portfolio of interventions and benefits offered in villages where they were already active, and promoting politically ambitious NGO officials in the villages and region.

An array of other issues played a role in constraining quality control. These included the fiscal arrangements between the implementing agencies. Although the Gujarat Energy Development Agency implemented two-thirds of the state target, it depended on the Rural Development Department for funds. Other issues included Sneha-model design problems, the detrimental relationship between large subsidies and users' failure to maintain the improved stoves, and—despite the technical backup unit's best efforts—failure to initiate entrepreneurial production and maintenance.

SCALED-DOWN SUCCESS

Compared to the other states studied, Gujarat was less successful in developing innovative ways to promote the improved stoves. Even so, the program's rural development approach had several unique features that contributed to positive results. First, using models of both the Rural Development Department and the Gujarat Energy Development Agency permitted greater flexibility of implementation. The Department's three-tier system ensured that accurate demand estimates by local staff were communicated to the top tier; the Agency's ability to use local NGOs permitted swift adaptation of strategies to village realities and enabled the Agency to extend the program throughout the state with minimal use of time and resources. Second, targeting households below the poverty line ensured that the national program benefited those who were most in need and least likely to access LPG, kerosene, or other superior fuel distribution networks. Third, integrating the national program with rural housing schemes for families below the poverty line generated tremendous organizational synergies.

The national program in Gujarat also had its share of shortcomings. Ongoing reliance on large subsidies did not lead to sustainability. The study findings suggest that a reduction or phasing out of subsidies could have

been linked with more effective awareness-raising activities that would have convinced potential users to adopt the improved stoves. In addition, although the NGOs that performed well were rewarded with greater responsibility, the study found that 20 percent failed each year, suggesting a lack of appropriate incentives and possible linkage to low adoption rates.

After the national program withdrew in 2002, Gujarat, like a handful of other states, made significant efforts to continue a scaled-down state program. It targeted marginalized sections of communities, promoting only portable improved stoves at subsidy levels similar to those of the national program.⁷ The Rural Development Department continued to provide beneficiaries improved stoves via rural housing schemes, while the Gujarat Energy Development Agency and its network of NGOs continued to play a significant role in distribution. In the post-2002 phase, the Agency distributed some 40,000 portable improved stoves (Winrock International 2005). All of the stoves procured were from manufacturers outside Gujarat, which diminished the likelihood that users would be able to repurchase. In 2005, the Government of Gujarat discontinued the state program for lack of funding. In turn, the NGOs, which depended directly on government funding, were forced to abandon their efforts.

NOTES

1. All districts maintain lists of those below the poverty line, which are updated every five years. To be considered below the poverty line, a family's monthly consumption expenditure per head must amount to Rs 254 (US\$ 5.4) or less.

2. The Rural Development Department's strong emphasis on meeting targets likely stemmed from the Twenty Point Program (of which the improved stove initiative was a part), which measured the performance of the state administration.

3. Because the stove masons procured their own raw materials for stove construction, the Rural Development Department did not have control over the quality of those used. The taluka development officers were not directly involved in procuring stove construction materials, but were aware of the sources selected.

4. The rationale was that better-off households could afford other energy sources, such as LPG and kerosene. LPG was widely available in rural areas, with 17 private suppliers. By contrast, the study showed that only 3 percent of those who adopted the improved stoves used LPG.

5. A mandatory inspection report revealed whether the improved stoves were constructed in the new houses.

6. In 2001, the Gujarat Energy Development Agency installed more than 65,000 stoves, becoming the primary implementing agency for the national program in Gujarat. Designated as the renewable energy development agency of the Government of Gujarat, it was also involved in distribution of renewable energy technologies.

7. By choosing to promote only portable stoves, the post-2002 state program failed to harness the potential role that scores of stove masons trained under the national program could have contributed.

7

Andhra Pradesh

Interagency Coordination

The national program in Andhra Pradesh enjoyed remarkable coordination between the main implementing agencies—the Non-conventional Energy Development Corporation of Andhra Pradesh and the Khadi and Village Industries Commission—and the technical backup unit at the Regional Engineering College at Warangal. The state adopted a policy requiring the installation of improved stoves in all new houses constructed under the *Indira Awas Yojana* and other state housing schemes. As a result, many beneficiaries received portable improved stoves from housing boards that purchased them directly from the Corporation. Extensive rural outreach was provided through the Corporation’s 22 district branches. The program’s whole-village approach, which emphasized complete coverage within a village, resulted in many more households using improved stoves.

Mahabubnagar was selected as the focal district for this case study (Figure 7.1). The factors responsible for the national program’s success in Mahabubnagar were documented at several levels: individual (stove users), community (SEWs and promoters), and institutional (nodal agencies, NGOs, and technical backup unit).

BACKGROUND

Andhra Pradesh, India’s fifth most populous state, is home to some 76 million people, three-fourths of whom are engaged in agriculture or agriculture-related activities (GoI 2001); located in southern India, the state is bordered by Maharashtra, Chhattisgarh, and Orissa to the north, Bay of Bengal to the east, Tamil Nadu to the south, and Karnataka to the west (see Figure 7.1).



FIGURE 7.1 Map of Andhra Pradesh, Highlighting Case Study District

Source: General Services Department Printing, Graphics and Map Design, The World Bank, Washington, D.C., 2011.

The national program covered all of the state's 22 districts; from 1995 to 2000 alone, some 1.4 million improved stoves were installed.¹

In 1983, the national program was initiated in Andhra Pradesh; that same year, the Non-conventional Energy Development Corporation was established as the nodal agency for program implementation. Six years later, the Khadi and Village Industries Commission, a GoI organization, joined the program as its second nodal agency. The Corporation operated in all twenty-two districts, while the Commission operated in eight. Of the 1.4 million improved stoves distributed during 1995–2000, the Corporation accounted for 89 percent of installations and the Commission for 11 percent. In addition to these main distribution agencies, the State Council of Science and Technology distributed a small number of improved stoves under the

Integrated Rural Energy Planning Program, a centrally sponsored scheme of the Ministry of Non-conventional Energy Sources.²

In 1990–1, the Regional Engineering College at Warangal was established as the technical backup unit responsible for the design and development of improved stoves responsive to local needs. Before that time, the national program had distributed improved stoves that were not suited to users' needs. These earlier models included the Sahayog, developed by the Indian Institute of Technology at Delhi, and the Sukhad, developed by the Rajasthan technical backup unit.³ Since 1994, five principal improved stoves have been distributed (Table 7.1).

TABLE 7.1 Improved Stove Models Distributed in Andhra Pradesh since 1994

<i>Model</i>	<i>Description</i>	<i>Thermal Efficiency (%)</i>
Sukhad	Fixed brick and mud two-pot, with pottery liner and chimney	24
Concrete Sukhad	Fixed concrete two-pot, with chimney	26
Gayathri Junior	Fixed brick two-pot, with chimney	28
Gayathri	Fixed cement two-pot, with chimney for large family	26–8
Gramalakshmi	Fixed mud two-pot, with pottery liner and without chimney	20

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Other key players were SEWs and chulha development agencies, groups of entrepreneurs who invested in stove construction materials, hired masons, identified beneficiaries, and stove installers. Each of Andhra Pradesh's 22 districts had 5 to 10 chulha development agencies. With regard to the training of the SEWs, the Non-conventional Energy Development Corporation offered its own training, while the Khadi and Village Industries Commission relied on the technical backup unit.

USER PERCEPTIONS AND PRACTICES

Household surveys and focus group discussions revealed how users perceived the benefits and drawbacks associated with the improved stoves and their attitudes toward purchasing replacements. The results underscore the health benefits offered, as well as weaknesses in post-construction operation-and-maintenance services.

Of the 134 households surveyed, it was perceived that the major benefits of the improved stoves were time savings, fuel savings, reduced eye

irritation, and cleaner kitchens resulting from reduced smoke. Better health alone ranked lowest among the incentives for adopting improved stoves (Table 7.2).

TABLE 7.2 Perceived Benefits from Improved Stoves, 2000–1

<i>Perceived Benefit</i>	<i>Households</i>	
	<i>Number*</i>	<i>%</i>
Time savings	95	71
Fuel savings	80	60
No eye burning	77	58
Cleaner kitchen	63	47
Better health	8	6

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Note: Households could choose more than one benefit.

* Out of 134.

Even though the users surveyed ranked time savings as the primary perceived benefit, they suggested in focus group discussions that the direct time savings were not substantial. These discussions revealed that users heated water or cooked vegetables on the second pot using residual heat, which enabled them to perform two chores simultaneously. This reduced fuel consumption and thus users reported fuel savings as another significant benefit.

The perceived health benefits cited by users included reduced burning and watering of the eyes while cooking and reduced coughing since they no longer had to supply additional air for burning by blowing hard. Few households cited better health as a perceived benefit, suggesting that users might have been unaware that reduced eye irritation and coughing were considered health benefits. Perhaps, over time, users had come to accept eye irritation and coughing as daily facts of life, considering only medical problems that required a visit to the rural doctor as health issues.

Women users said that the kitchen walls were cleaner as a result of reduced smoke. They also mentioned that there was less soot on cooking vessels. Some women living in one-room homes said that the smoke-free environment enabled their children to study indoors while they cooked.

While most of the improved stoves were functional, about half of the households surveyed perceived problems regarding their use. The most frequently cited problems were back-smoking and increased fuel consumption; others included cracked pottery liners and the unsuitability of the stoves for cooking for large families or making traditional bread (roti) (Table 7.3).

TABLE 7.3 User Complaints Regarding Improved Stoves, 2000–1

<i>Perceived Drawback</i>	<i>Households</i>	
	<i>Number</i>	<i>%</i>
None	61	46
Back-smoking	51	38
Increased fuel consumption	16	12
Cracked pottery liners	3	2
Increased cooking time	3	2

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Back-smoking can result from soot formation when chimneys are not cleaned regularly, incorrect use of the second pothole, or faulty stove construction by untrained SEWs. It was found that nearly one-fifth of users failed to clean their chimneys regularly. More than two-thirds of households reported that they cleaned their chimneys at least once a month, but one-sixth never did (Table 7.4). It was also observed that users placed deep round-bottomed pots on the second pothole, which prevented the smoke from passing to the chimney. While only flat-bottomed vessels should have been placed on the second pothole, users were unaware of this recommendation.

TABLE 7.4 Frequency of Chimney Cleaning by Users, 2000–1

<i>Frequency</i>	<i>Households (%)</i>
Never	14
Weekly	17
Bi-monthly	23
Monthly	36
Every two months	6
Quarterly	2
Twice a year	2

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Increased fuel consumption can be caused by faulty stove construction and the resulting stove modifications that households make, as well as feeding more fuelwood than required to make the flame visible (cooks were used to seeing the flames of traditional stoves). Common user modifications included increasing or decreasing the pothole size, removing the grate, and raising the pothole to make the flame more visible.

Another major shortcoming was the lack of information disseminated by trained SEWs and the chulha development agencies on stove operation and maintenance. Without being able to consult such services, users' inappropriate design modifications resulted in reduced stove performance, which undermined some of the benefits offered. Frustrated by not receiving the promised benefits, users reverted to using traditional stoves when the improved ones broke down, thereby undermining the national program's credibility.

The Non-conventional Energy Development Corporation and the Khadi and Village Industries Commission strictly followed the guidelines of the Ministry of Non-conventional Energy Sources, which stated that villages already covered by the national program should not be re-selected. Hence, households in previously selected villages without improved stoves or with broken ones had no further access to the subsidized stoves. In addition, the program's poor supply chain system meant that users could not regularly purchase replacement parts. In short, users had one-time access to the subsidized improved stoves; as a result, their enjoyment of the benefits of greater fuel efficiency and reduced smoke lasted for only about two years, the average life of an improved stove without adequate maintenance and parts replacement.

Nearly three quarters of survey respondents (95 out of 134 households) said that they would repurchase or refurbish their improved stoves. Focus group discussions revealed that users were willing to pay Rs 50–100 (US\$ 1.1–2.1) for improved stoves that were efficient and durable. Because the life of the chimney was five years, users did not need to purchase new stoves, and could have simply replaced individual parts. Pottery liners cost as little as Rs 12 (US\$ 0.30), and construction charges for replacing a worn-out part were as little as Rs 15–20 (US\$ 0.32–0.42). Thus, it would have been possible for users to restore a non-functioning improved stove for just Rs 32 (US\$ 0.68), well below what they were willing to pay.

Focus group discussions indicated that users paid Rs 15 (US\$ 0.32) to cover the stove cost and a gratuity of Rs 5 (US\$ 0.11) to cover installation by the SEW. These discussions also revealed that some SEWs had made false promises to unsuspecting rural users in order to convince them to purchase the improved stoves. Potential users had been told that they would receive cooking vessels and asbestos roofs once the improved stoves were installed. Some users had retained their improved stove receipts, hoping that they would eventually be able to claim their promised cooking vessels and asbestos roofs. Preliminary visits to such districts as Vizianagaram and Anantapur revealed that misinforming potential users in this way was common practice among SEWs. After learning what had happened, these users took a negative view of the national program and were unwilling to repurchase the improved stoves. The discussions also indicated that, while many women were

aware that the national program was a government program, they were unaware of the stove cost and the extent of the subsidy to which they were entitled.

A CHALLENGING SUBSIDY SCHEME

The subsidy structure posed a unique set of interrelated challenges that affected users' willingness to pay, the ability to sustain operation-and-maintenance services, and ultimately user satisfaction; the subsidy structure varied by executing nodal agency. The improved stoves provided by the Non-conventional Energy Development Corporation, which received subsidies from both the central government and district administration, were subsidized as much as 75–90 percent of the total price; by contrast, those provided by the Khadi and Village Industries Commission, which received subsidies only from the central government, were subsidized 40–60 percent. User contributions ranged between 10 percent and 62 percent, depending on the type of stove purchased and the nodal agency involved (Table 7.5).

Such significant differences in beneficiary contributions posed problems for SEWs of the Khadi and Village Industries Commission. For example, users were reluctant to pay Rs 65 (US\$ 1.4) for their Sukhad model if they knew they could purchase the same model for less than one-fourth that amount under the Non-conventional Energy Development Corporation scheme. To avoid this price discrepancy, the Commission decided to operate only in those blocks not covered by the Corporation.

In addition to subsidizing stove cost, the Ministry of Non-conventional Energy Sources provided the Non-conventional Energy Development Corporation and the Khadi and Village Industries Commission funding for training SEWs, potters, and users; awareness-raising activities, such as preparation of brochures and video cassettes; research and development; and support for organizational infrastructure. The amount of annual funding was contingent on yearly achievements and targets. The Ministry released the funds in two installments: half at the beginning of the financial year and half after receiving the nodal agencies' lists of achievements and targets met. Neither the Corporation nor the Commission had complaints regarding the timing of the release of these payments.

In certain districts, the state government also provided subsidies toward the cost of improved stoves under the Drought Prone Area Scheme. This subsidy could only be claimed for villages under the watershed program and village forest-protection committees (Vana Samrakshana Samities).

Initially, the chulha development agencies invested their own funds to implement the national program. They could claim the subsidy only after the respective nodal agency physically verified stove installation. They collected fees from the nodal agencies for the SEWs, who were paid Rs 20 (US\$ 0.42)

TABLE 7.5 Subsidy Structure of the National Program in Andhra Pradesh, 2000–1

<i>Improved Stove Model</i>	<i>Unit Cost in Rs (US\$)</i>	<i>Central Government Subsidy in Rs (US\$)</i>	<i>District Administration Subsidy in Rs (US\$)</i>	<i>User Contribution in Rs (US\$)</i>	<i>User Contribution (%)</i>
Non-conventional Energy Development Corporation of Andhra Pradesh					
Gramalakshmi*	52 (1.1)	20 (0.42)	27 (0.57)	5 (0.11)	10
Sukhad	118 (2.5)	40 (0.84)	63 (1.3)	15 (0.32)	13
Gayathri Junior	172 (3.6)	80 (1.69)	50 (1.1)	15 (0.32) cash + 27 (0.57) sand and brick	9 cash + 16 materials
Khadi and Village Industries Commission					
Sukhad	105 (2.2)	40 (0.84)	–	65 (1.4)	62
Concrete Sukhad	160 (3.4)	80 (1.69)	–	70 (1.5) cash + 10 (0.21) sand and brick	44 cash + 6 materials

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Note: *The Gramalakshmi two-pot stove model has no chimney.

per stove constructed plus food expenses, and the central-government stove subsidy. All of the SEWs interviewed indicated they had secondary occupations, such as agricultural or wage laborer, and were involved in stove construction seven to eight months a year [installation was halted during the monsoon season (June to August)].

The chulha development agencies earned Rs 5–10 (US\$ 0.11–0.21) per improved stove or about Rs 3,000–4,000 (US\$ 63.5–84.7) per month during peak season. With the introduction of more durable models, fewer stoves were constructed and volumes dwindled. The chulha development agencies perceived that their overhead had increased (they were also responsible for transporting cement), but revenue had not. As a result, many left the business; at the time of this study, only six remained in Mahabubnagar.

A critical drawback of the subsidy structure was the insufficient amount that the central government targeted for operation-and-maintenance services. The chulha development agencies preferred not to undertake such work because the services cost them significantly more than the amount offered, owing to high transport costs and the number of required visits.

In Andhra Pradesh, the number of portable stoves distributed was large compared to Karnataka or West Bengal (42 percent versus 1 percent). These portable stoves were distributed under the Indira Awas Yojana and other rural and urban housing schemes of the state government. Under such schemes, it was mandatory for the houses constructed to include improved stoves. The various housing boards purchased the stoves directly from the Non-conventional Energy Development Corporation and distributed them to users. The cost of the stove [Rs 180 (US\$ 3.8)] was deducted from the amount loaned to beneficiaries of the housing scheme. For backward classes, the government provided a subsidy to cover more than one-fourth of the cost. But the higher cost of portable stoves reduced the SEWs' profit margin, and the subsidy scheme had little success via the chulha development agencies.

DEVELOPMENT AND PRODUCTION: INTERAGENCY COMMUNICATION

The technical backup unit at the Regional Engineering College at Warangal was responsible for a broad range of activities, ranging from the design and development of improved stoves; training and technical support to various national program stakeholders, including users, SEWs, potters, and government officials; and the design and development of audio-visual and other publicity materials in the local language. It also conducted surveys and performance evaluations and activities related to research and development and stove testing and certification.

Feedback Responsiveness

Because it interacted often with the nodal agencies, the technical backup unit was regularly updated on user problems. It had a successful track record of introducing improved stove models and modifying existing ones based on user feedback (Table 7.6).

TABLE 7.6 Timeline of Events of the Technical Backup Unit, 1990–2000

<i>Year</i>	<i>Event</i>
1990–1	Established at the Regional Engineering College at Warangal
1990–1	Distributes the Aravali improved stove, catering to larger families (10–12 members)
1990–1	Initiates development of husk-burning improved stove
1991–2	Conducts developmental work on sawdust-burning improved stove
1992–3	Tests the Gramalakshmi model developed by CASTFORD, a Pune based NGO
1993–4	Modifies the Aravali improved stove
1994–5	Develops fixed two-pot Gramalakshmi improved stove model (with grate, ash pit, and pottery liners and without chimney)
1995–6	Develops small-capacity single-pot and portable improved stove models
1997–8	Conducts field evaluation of powdery biomass
1998–9	Performs laboratory experiments to develop large two-pot improved stove models without chimneys catering to larger families (eight adult members)
1999–2000	Develops and distributes fixed two-pot Gayathri and Gayathri Junior improved stove models (with grate, pottery liners, cement plaster, and chimney)

Sources: Annual reports of the technical backup unit and discussions with the Non-conventional Energy Development Corporation of Andhra Pradesh.

Before the technical backup unit was established in 1990–1, the Gramalakshmi improved stove was developed in response to chimney-related complaints regarding the Sukhad model. During these early program years, the Sahayog, Sukhad, and CPRI I and II improved stoves (designed by the Indian Institute of Technology, Rajasthan technical backup unit, and Central Power Research Institute, respectively) were distributed in Andhra Pradesh. In 1991, a feedback survey of 240 improved stoves of the Sukhad model installed during 1989–90 was conducted in two villages (Unikichla and Duggondi) of Warangal district. In response to user feedback, which stated that the second pot size and height of the fuel opening were larger than

required, the technical backup unit modified the second pot size. Similarly, in 1993–4, based on user feedback, it modified the Aravali stove by providing a fire door similar to that of the Sukhad model and adding a suitable grate. Again, in 1994–5, it developed improved stoves without chimneys.

Development of the Gayathri Junior model illustrates the excellent interaction between the implementing agencies. When the technical backup unit first developed the Gayathri model, users found that the stove easily developed cracks. They communicated their complaint to the chulha development agencies, which informed the Non-conventional Energy Development Corporation; in turn, the Corporation conveyed this feedback to the technical backup unit, which made suitable modifications to the stove, thereby introducing the Gayathri Junior model.

The technical backup unit regularly conducted functionality feedback surveys, but these often neglected efficiency and design issues. The technical backup unit remedied this oversight by interacting closely with the Non-conventional Energy Development Corporation and attending to qualitative feedback from the field.

Training

As mentioned above, the Non-conventional Energy Development Corporation identified and trained SEWs and users at the district level and conducted its own training programs, while the Khadi and Village Industries Commission identified the chulha development agencies and SEWs to be sent to the technical backup unit for training. In both cases, the masons hired to construct the improved stoves were required to undergo training (via the Corporation or the technical backup unit). But because of the short time frame within which high targets were expected, the chulha development agencies attempted on-the-job training of untrained masons, which led to faulty stove construction.

The Non-conventional Energy Development Corporation and the technical backup unit also conducted user training that explained the benefits of improved stoves and maintenance procedures. Women were especially encouraged to participate in such training sessions since they were expected to be the primary stove users. In 1999–2000, women represented 58 percent of participants in the technical backup unit's training program for the SEWs.⁴ During these sessions, videos were played explaining the importance of improved stoves; but given the number of districts and blocks in Andhra Pradesh, these were few in number.

The Ministry of Non-conventional Energy Sources set annual training targets and provided funds based on the number and types of sessions that the technical backup unit should conduct (Table 7.7).

TABLE 7.7 Training Courses Conducted by the Technical Backup Unit

<i>Targeted Trainees</i>	<i>Training Focus</i>	<i>Duration (days)</i>
Potential SEWs	Candidates with no previous background were taught how to construct improved stoves; special emphasis was given to construction without the aid of a mold and critical stove dimensions. Successful course completion qualified candidates as SEWs.	10
Trained SEWs	Sessions were organized for trained SEWs that the respective nodal agencies could use to train other potential candidates and stove users.	3
Entrepreneurs	Traditional potters were taught how to manufacture pottery liners for improved stoves.	10
Improved stove users	Organized in villages where improved stoves had already been constructed, women stove users were taught proper maintenance techniques, with the help of models.	1
Managers	District- and state-level officials and NGOs were taught the importance of the national program.	1

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Staff members of the Non-conventional Energy Development Corporation and the technical backup unit frequently attended each other's programs. Staff members of the Corporation were invited to attend the technical backup unit's annual meetings where annual action plans were discussed. Such meetings were instrumental in ensuring that the unit received feedback from the field on performance of the stoves it had designed.

The technical backup unit was also involved in the testing and certification of portable metallic improved stove models, in accordance with the requirement of the Bureau of Indian Standards. Manufacturers were required to obtain certification every two years [the unit charged Rs 1,000 (US\$ 21) for testing].

INSTITUTIONAL STRUCTURE AND ROLES

The Ministry of Non-conventional Energy Sources set annual targets, based on prior-year performance, for the two major nodal agencies for program implementation: The Non-conventional Energy Development Corporation and the Khadi and Village Industries Commission. Targeted users of the improved stoves were rural households; 30 percent of stoves were set aside

for backward classes. The Corporation and the Commission allocated their respective targets among the various chulha development agencies based on prior-year performance and perceived ability to execute targets (Figure 7.2).

Nodal Agency Functions

Incorporated in 1969, the Non-conventional Energy Development Corporation of Andhra Pradesh was the chief nodal agency for implementing all renewable energy programs (including wind, solar, and biogas) of the state and central governments. Its head office was in Hyderabad, with branches in all 22 districts. A district manager headed each branch; while a development officer, assistant development officer, accountant, and several technicians assisted the district manager. The Non-conventional Energy Development

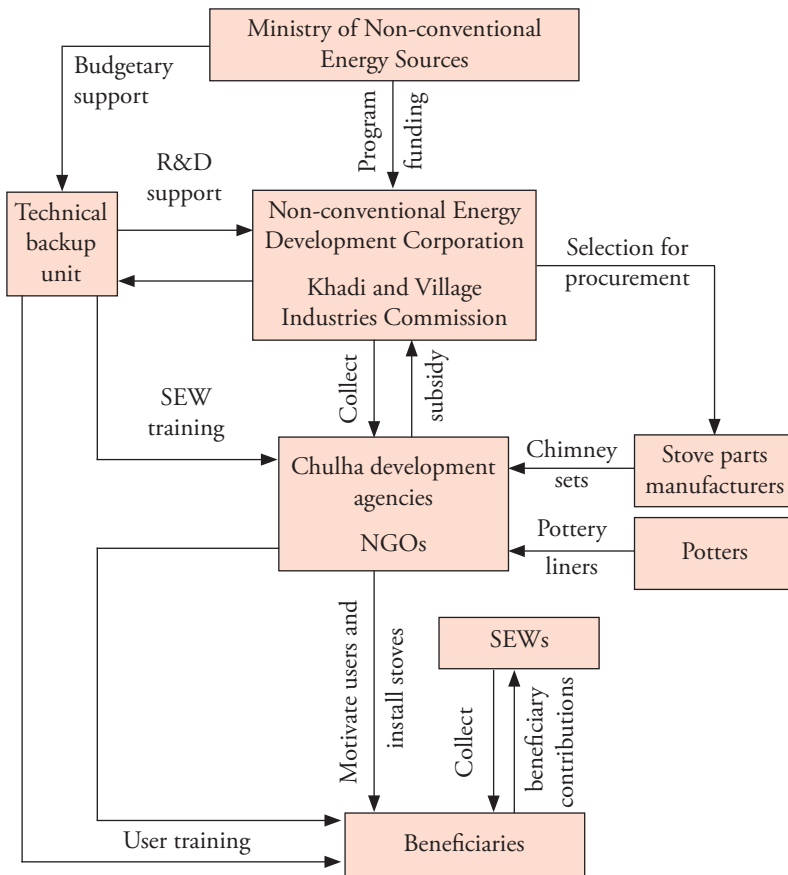


FIGURE 7.2 Implementation Structure in Andhra Pradesh

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Corporation was led by a managing director and had a chairman and board of directors.

The Khadi and Village Industries Commission, a central-government agency under the Ministry of Rural Development, was headquartered in Mumbai. Its main functions were to promote rural and cottage industries development and generate employment opportunities in rural non-farm sectors. The Commission's non-conventional energy cell was responsible for distributing improved stoves and biogas plants across the country. The cell made policy decisions regarding national program implementation and allocated targets to state offices.

The Non-conventional Energy Development Corporation identified specific villages for improved stove distribution, provided the list to the chulha development agencies, and provided its own district-level training for SEWs and users. The Khadi and Village Industries Commission also identified chulha development agencies and SEWs, but relied on the technical backup unit for capacity-building and training activities. The Commission also distributed improved stoves through NGOs. The program was managed by an assistant director and assisted by development officers in charge of the districts, supported by assistant development officers responsible for administrative and technical activities.

Role of Chulha Development Agencies

As discussed above, entrepreneurial SEWs in Andhra Pradesh formed the chulha development agencies, which purchased materials for constructing improved stoves, hired masons for stove construction, identified potential clients, and installed improved stoves. Each district had about 5 to 10 chulha development agencies.

After receiving lists of villages from their respective implementing nodal agencies, the chulha development agencies made preliminary visits to the villages (sometimes accompanied by supervisors from the Non-conventional Energy Development Corporation). They conducted pre-installation surveys to gather information on the number of households, number of houses with reinforced corrugated cement roofs, family size, and number of people willing to install improved stoves. Based on this information [usually collected from the village-council (panchayat) head, local leaders, or secretary of the watershed committee], they estimated the improved stove potential and brought stove construction materials to the villages. When information or estimates were inaccurate, they often had to haul the materials back, incurring additional transport costs.

The chulha development agencies worked with local village leaders to promote improved stoves to potential users. They distributed publicity materials, such as brochures and pamphlets, prepared by the technical backup unit.

Stove builders played a key role as motivators by spreading awareness via word of mouth. Since their revenue depended on number of installations, it was in their interest to raise awareness and convince potential users to install improved stoves. They were required to explain stove features and maintenance techniques, such as cleaning the chimney and preparing the stove. In accordance with the guidelines of the Ministry of Non-conventional Energy Sources, they were required to provide free after-construction service for one year. The stoves were usually constructed in villagers' homes. Other locations, including community and child care (anganwadi) centers and the panchayat office, provided excellent opportunities for generating interest among potential users via product demonstration.

CONSTRUCTION PROCESS AND MODELS

Improved stove construction was a time-intensive process. Users often provided labor and materials to facilitate construction. Such raw materials as bricks and mud were locally available, while chimney and pottery sets had to be obtained from nearby cities. Although there was 100-percent verification of the number of improved stoves installed, the quality of installations was not inspected or considered; for example, there was no quality certification process for chimney sets and cast-iron grates.

The Sukhad model was constructed from locally available bricks and mud supplied by users, while the chimney sets (chimney and cowl) and pottery sets (one pottery liner, two pottery rings, and tunnels) were purchased by the chulha development agencies from manufacturers in Hyderabad and Raichur (Karnataka) (chimneys were made of asbestos and cement). The cost of each chimney set was Rs 60–5 (US\$ 1.27–1.37), including transport. To receive the wholesale rate, a minimum of 300 pipes had to be ordered. Cost varied depending on delivery distance. About 5 percent of sets were usually damaged during transit. Suppliers replaced damaged chimneys, but the chulha development agencies had to bear the cost of sets that were broken or damaged during loading and unloading. The pottery sets were obtained from local pottery-liner manufacturers (potters that had received entrepreneurship training under the technical backup unit's program). Officers of the Non-conventional Energy Development Corporation ensured that the liners were produced according to specified measurements. The cost of each pottery set was Rs 12 (US\$ 0.25). Once stove parts reached the village, workers assumed responsibility for storing them in a safe place. Construction of the Gramalakshmi two-pot model was similar to the Sukhad stove, except there was no chimney set.

The Gayathri model was constructed of cement bought from local manufacturers in Hyderabad. Cost per bag was Rs 140–70 (US\$ 3.0–3.6), depending on brand and quality. The chulha development agencies covered

the cost of transport; it cost Rs 1,200 (US\$ 25) to haul a truckload 60 km and Rs 800 (US\$ 17) to haul 20 km. An expenditure of Rs 200–400 (US\$ 4.24–8.48) was added for loading and unloading cement bags.

The stove required a chimney set, cast-iron grate, and pottery liners. Chimney sets could be obtained from any pipe manufacturer. The only pipe specifications were length (3.05 m) and diameter (7.5 cm). There were no prescribed standards for the cast-iron grate, the cost of which was Rs 12–15 (US\$ 0.25–0.32). Officers of the Non-conventional Energy Development Corporation ensured that pottery liners were produced according to specified measurements.

After the raw materials and stove parts reached the village, SEWs started stove construction in the user's home. Given the time-intensive process, workers usually camped at the village for 15–20 days. Users provided bricks and sand and helped the workers mix the cement and sand and bore a hole in the roof for the chimney. After construction was completed in a village, a field supervisor of the Non-conventional Energy Development Corporation physically verified the installation of each stove. Three months later, the district officer conducted a 10-percent random check, which was repeated six months later.

The Gayathri Junior model was constructed of brick, sand, and cement. While the technical backup unit recommended cement, sand, and rock powder in 1:2:3 ratios, SEWs mixed in rock powder only if locally available. A single stove required 6 kg of cement and needed to set one week before it was considered ready for use. If users were not at home or raw materials could not be obtained, construction was delayed. Village festivals and other celebrations sometimes delayed installation. Gayathri Junior workers not trained by the Non-conventional Energy Development Corporation or the technical backup unit usually assisted SEWs. The SEWs were paid Rs 20 (US\$ 0.42) per stove constructed. The chulha development agencies provided workers food and transport expenses.

Local manufacturers were involved in making the portable improved stoves, which were constructed of mild (low-carbon) steel, aluminum, and cast iron. The technical backup unit was responsible for stove testing and certification.

AN UNCERTAIN FUTURE

The national program in Andhra Pradesh succeeded, in large part, because of close interagency coordination, along with strong support from local stove producers. Close interaction and information exchange between the Non-conventional Energy Development Corporation of Andhra Pradesh and the technical backup unit at the Regional Engineering College at Warangal, in particular, were instrumental in ensuring that feedback from the field was

adequately communicated and incorporated into stove design modifications, which stressed customer satisfaction. Large installation subsidies—as much as 90 percent in certain cases—were provided to the Corporation, allowing for greater program participation. In addition, the Corporation provided extensive rural outreach through its 22 district offices. Finally, a whole-village approach emphasized complete coverage within a village, resulting in many more households using improved stoves. By contrast, states that stressed the total number of villages covered often failed to achieve significant coverage within villages.

At the same time, the program faced its share of quality-control challenges, including a lack of prescribed standards for certain key stove parts and the failure of officials of the Non-conventional Energy Development Corporation to seek qualitative feedback at the time they verified the number of stoves installed. In addition, poor supply-chain management and selection guidelines of the Ministry of Non-conventional Energy Sources hindered commercialization. Finally, the failure of SEWs to provide free after-construction operation-and-maintenance services, as required by the Ministry, led users to make their own design modifications, which reduced stove performance and ultimately user satisfaction.

Unlike other states, Andhra Pradesh did not abandon the program after centralized funding was withdrawn in 2002. The state's annual target of 150,000 improved stoves was reduced by two-thirds (Winrock International 2005), and the Non-conventional Energy Development Corporation became the sole implementing agency. Though smaller in terms of human and financial resources, the new program has maintained its earlier institutional structure and approach. Yet, without support from national agencies or international donors, the program faces an uncertain future.

NOTES

1. Over the same period, West Bengal installed some 2 million improved stoves.
2. In 1999–2000, for example, the State Council of Science and Technology distributed 8,820 improved stoves, compared to 141,400 by the Non-conventional Energy Development Corporation of Andhra Pradesh Ltd (NEDCAP) and 45,000 by the Khadi and Village Industries Commission.
3. Users were dissatisfied with the size of the second pot and the height of the feed opening.
4. Of the many women trained in Mahabubnagar, only four became SEWs. Older women were more likely to take on this role because it was easier for them to travel to far-off villages during stove construction; younger women were willing to travel to such villages only if accompanied by their husbands or brothers.

8

West Bengal

Nongovernmental Organizations

The national program in West Bengal was implemented almost entirely through a network of more than 150 local NGOs. The use of implementing NGOs began in the early 1990s and grew consistently. The technical backup unit provided support for stove development, training of traditional potters, and entrepreneurship development. In response to user feedback, the technical backup unit developed a coal-fueled Kalyani model, with a 40 percent energy efficiency rating, which users widely accepted. Some 2 million improved stoves were installed over a five-year period, representing one out of every six households.¹ As of 1999, West Bengal accounted for one quarter of all improved stoves installed throughout India.

This case study focused on three districts: Jalpaiguri in the north and Medinipur and South 24 Parganas in the south (Figure 8.1). All three were chosen for their high penetration of improved stoves over the 1995–2000 period. Their success factors were documented at three levels: individual (user), community (SEWs and promoters), and institutional (nodal agencies, NGOs, and the technical backup unit).

BACKGROUND

West Bengal, one of India's largest states, is situated in the northeastern corner of the country; it encompasses 8.88 million hectares, stretching from the Himalayas in the north to the Bay of Bengal in the south (see Figure 8.1). The state shares international frontiers with three countries: Nepal to the northwest, Bhutan to the north, and Bangladesh to the east. Neighboring states include Sikkim to the northwest, Assam to the northeast, Orissa to the southwest, and Jharkhand and Bihar to the west. Home to more than



FIGURE 8.1 Map of West Bengal, Highlighting Case Study Districts

Source: General Services Department Printing, Graphics and Map Design, The World Bank, Washington, D.C., 2011.

80 million people (GoI 2001), West Bengal has the highest population density in India. Amid growing industry and urbanization, four-fifths of residents remain engaged in agriculture or agriculture-related activities. The state boasts three major forested areas: the northern mountain temperate forests

and tropical forests of the Duars; the deciduous forests of the plateau fringe; and the mangrove forests of the Sunderbans, a major portion of which is located in adjoining districts of Bangladesh.

The national program in West Bengal began in the early 1980s. Over a 20-year period, three institutions—Social Welfare Department, Khadi and Village Industries Commission, and West Bengal Renewable Energy Development Agency—served as the main nodal agencies for implementation. The Social Welfare Department, whose participation began in 1984 through the child care (anganwadi) program, covered all 18 districts. Four years later, the Khadi and Village Industries Commission, a central-government organization, began participating, covering 10 districts. Finally, in 1993, the West Bengal Renewable Energy Development Agency joined, covering 18 districts.

Before the Ministry of Non-conventional Energy Sources approved the establishment of the technical backup unit at the University of Kalyani in 1989, three two-pot models of improved stoves—Nada, Thapoli, and Sahayog—were popularized under the national program. Developed by agencies outside the state and constructed by trained SEWs, these designs proved unsuited to users' needs.² Of the 2 million improved stoves distributed during 1995–2000, the Khadi and Village Industries Commission accounted for 49 percent of all installations, while the Social Welfare Department and West Bengal Renewable Energy Development Agency accounted for 40 and 11 percent, respectively. Nearly all distribution was handled by NGOs. Given the variations in NGO capacity within and among districts, distribution across the state was uneven. Table 8.1 lists the most popular models distributed during 1994–2002.

TABLE 8.1 Improved Stove Models Distributed in West Bengal, 1994–2002

<i>Model</i>	<i>Description</i>	<i>Thermal Efficiency (%)</i>
Sohini Seva	Fixed mud single-pot, with chimney	18–22
Sugam Seva	Fixed mud two-pot, with chimney	22–4
Kalyani	Fixed mud one-pot, with chimney (biomass and coal burning)	22 (biomass), 40 (coal)
Paribarbandhu (durable, types I and II)	Fixed cement one- and two-pot, with chimney	26–8
Kalyani Vishwavidyalaya	Fixed mud one-pot, without chimney	28

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

In addition to the three main nodal agencies, two state-funded programs—the Integrated Rural Energy Program and Indira Awas Yojana, a housing

scheme for households below the poverty line—distributed improved stoves on a more limited scale. In certain districts, the NGOs linked the national program with these state programs to achieve their targets. On rare occasions, SEWs in certain districts took the initiative to build unsubsidized stoves. Finally, the Forest Department and other state government departments, made sporadic efforts to install improved stoves in villages near protected areas.

USER PERCEPTIONS AND PRACTICES

Across the three districts surveyed, users cited smoke removal, reduced health concerns, and time savings as major benefits of the improved stoves. Some households recognized that a smoke-free kitchen was linked to better health and the opportunity for other productive activities, such as supervising children's studies in the kitchen area while cooking. At the same time, a lack of training in operation and maintenance, combined with unreliable after-sales service, led users to make their own stove modifications, rendering quality control difficult.

Most users were satisfied with the improved stove performance. The major benefits cited were removal of smoke from the kitchen, acknowledged by about nine out of ten stove users, along with reduced health concerns and time savings (Table 8.2). Smoke removal via the chimney resulted in such tangible benefits as cleaner kitchen walls, cooking vessels, and clothing. The smoke-free environment enabled some users to simultaneously cook and supervise children's studies in the kitchen area. In addition, less direct exposure to heat decreased the risk of burns. An unintended economic advantage of reduced exposure to heat and smoke was that roof tiles needed replacing less often. In terms of health benefits, many users cited reduced burning and watering of the eyes while cooking. In one village, a pharmacist said that the number of

TABLE 8.2 Perceived Benefits from Improved Stoves, 2000–1

<i>Perceived Benefit</i>	<i>Households (number)</i>				<i>Respondents (%)</i>
	<i>Medinipur</i>	<i>Jalpaiguri</i>	<i>South 24 Parganas</i>	<i>All</i>	
Smoke removal	26	34	30	90	87
Better health	27	14	25	66	64
Time savings	19	13	18	50	49
Fuel savings	24	15	4	43	42
Less soot	29	3	3	35	34

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

patients with respiratory ailments had been reduced since stove installation. In terms of time savings, some users of two-pot improved stoves confirmed reduced cooking time, but were unable to quantify it; more than half reported no significant decrease in cooking time.

Fuelwood savings ranked only fourth among the perceived benefits, probably because of users' easy access to fuelwood and agricultural residues. Since most households owned cattle, dung was also readily available. About two-fifths of users agreed that the improved stoves resulted in fuelwood savings of about 10–30 percent. Some mentioned that they used the residual heat from the stoves for simmering milk and keeping food warm during the winter. In peri-urban areas, some households that used LPG used the improved stoves during gas shortages.

While the transition from traditional to improved stoves went smoothly for most users, some complained of difficulty in performing key maintenance tasks, such as chimney cleaning, and other problems related to design deficiencies. Regular chimney cleaning, which required climbing onto the roof, was a major concern for women users. They found it physically difficult to perform, and male family members rarely assisted them in this task. Only about one-fifth of household users cleaned their chimneys weekly (Table 8.3).

TABLE 8.3 Frequency of Chimney Cleaning, 2000–1

<i>Frequency</i>	<i>Households (%)</i>
Weekly	21
Bi-monthly	36
Monthly	38
Never	5

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Some women who lived in houses with thatched roofs decided not to adopt the improved stoves because they feared extending the chimney through the roof might cause fires and water seepage. Users' perception of deficient design, combined with their lack of training in operation and maintenance procedures—the survey revealed that only about one in five users had attended training programs—led to their making modifications that diminished stove performance and household satisfaction (Table 8.4).

Lacking proper training, users were reluctant to cut fuelwood to the required size for feeding. Instead, they used large wood pieces, which often damaged the firebox mouth; to correct the problem, they plastered the mouth opening with a clay-dung mixture, which changed its size. They also changed

TABLE 8.4 Common Types of User Modifications, 2000–1

<i>Modification</i>	<i>Households (number)</i>	<i>Households (%)</i>
Pothole size	26	26
Firebox size	6	6
Tunnel diameter	4	4
Chimney diameter	3	3
None	64	65

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

the depth of the firebox to accommodate a variety of fuels (for example, agricultural waste, leaves, and dried dung). In addition, they often enlarged the tunnel diameter of the two-pot stove to facilitate heat flow to the second pothole. To reduce the frequency of chimney cleaning, they used a chimney pipe with a 10 cm, instead of the required 7.5 cm diameter.

Some users, especially elderly women, complained that the flame was not visible during cooking, which led to increased fuel consumption. Because the Sohini and Sugam models did not permit the use of differently sized cooking vessels, which prevented cooking large amounts of food at the same time, most users retained their traditional stoves or installed an additional improved stove to meet family needs.

In short, maintaining quality control was difficult. The SEWs, on whom users had to rely for after-sales service and instruction in operation and maintenance, were not readily available during the construction season. In response, the users requested a permanent arrangement akin to a repair shop where they could register complaints and receive service on payment. The West Bengal Renewable Development Agency initiated such services in Jalpaiguri, where it planned to establish repair cells in association with NGOs at the block level.

Users were reluctant to replace fixed stoves. After gaining operation and maintenance experience, most preferred to make their own repairs, calling on SEWs only for extensive work. Some users constructed their own replacement stoves using discarded chimneys from abandoned stoves, relying on measurements copied from existing installations.

Users' acceptance of technical design features varied by geographic area. In the plains region, for example, fixed models were widely accepted because of their suitability for cooking local dishes. Among the popular Sohini, Sugam, and Kalyani models, the Sohini was the most popular because it fit the needs of smaller households and could easily be constructed by SEWs (Table 8.5). Portable models, by contrast, were widely accepted in the hill regions, tribal

TABLE 8.5 Key Features of Popular Improved Stove Models

Stove Model	Description	Average Efficiency (%)	Expected Life (years)	Cost, Rs. (US\$)	Fuel Required
Sohini Seva	Fixed mud one-pot, with chimney	22	2–3	130 (2.8)	Wood, agri-waste
Sugam Seva	Fixed mud two-pot, with chimney	23	2–3	150 (3.2)	Wood, agri-waste
Swarna Jayanti	Fixed mud two-pot (wood and coal), with chimney	23, wood; 40, coal	5	145 (3.1)	Wood, coal briquette
Swarna Jayanti	Fixed cement two-pot (wood and coal), with chimney	23, wood; 40, coal	5 or more	274 (5.8)	Wood, coal briquette
Kalyani	Fixed mud one-pot, with chimney	40	2–3	110 (2.3)	Coal briquette
Kalyani Vishwavidyalaya	Fixed mud one-pot, without chimney	28.5	1–2	60 (1.3)	Loose biomass waste
Community chulha	Fixed mud one-pot, with chimney	25, wood; 40, coal	3–5 3–5	250 (5.3) 221 (4.7)	Wood, sawdust, rice husk, coal briquette
Sahayika	Fixed mud three-pot, with chimney	24	2–3	152 (3.2)	Wood, agri-waste
Kesari-100	Mud one-pot, with chimney (institutional use)	Not available	3	Not available	Wood
Paribarbandhu (durable model, types I and II)	Cement one- and two-pot, with chimney	24	5 or more	170–250 (3.6–5.3), without liner; 300–75 (6.4–7.9), with liner	Wood, agri-waste
Central Power Research Institute (medium/large)	Portable mild steel, without chimney	25–30	5 or more	160 (3.4), medium; 250 (5.3), large	Wood

Source: Technical backup unit and Ministry of Non-conventional Energy Sources.

Note: Stove cost excludes charge of the SEWs.

belts, and flood-prone areas. Despite their high cost and low incentive for SEWs to produce them, users valued their portability and durability. They also met local users' needs for curing meats, drying vegetables and fuelwood, and heating small spaces during the winter months.

The proposed introduction of a durable improved model evoked mixed user response. Given the benefits of an improved mud stove, users said they would be inclined to buy a durable version if it required less maintenance (for example, plastering and cleaning). While rural users were unwilling to pay more than Rs 20 (US\$ 0.42) toward the stove cost, peri-urban users said they would pay Rs 150–200 (US\$ 3.2–4.3), but wanted the product guaranteed for at least five years. Users' reservations related to high product cost, fear of cracking when exposed to extreme heat, inability to make required repairs, and dependence on SEWs and NGOs for procuring construction materials

SUBSIDY STRUCTURE

In West Bengal, national program subsidies were directed toward stove cost; service charges for the SEWs; and support for capacity building, awareness generation, and related activities. The program depended on the Ministry of Non-conventional Energy Sources,³ more than 50 percent of whose support was directed toward the stove cost.⁴ The nodal agencies were funded according to their annual performance and target allocations, and the implementing NGOs were usually paid on completion and inspection of their work.

The Ministry of Non-conventional Energy Sources paid the nodal agencies promptly in two equal installments: (a) at the beginning of the fiscal year (after setting the target allocation), and (b) on completion of the target activities and submission of relevant supporting documents. Funding for NGOs was linked directly to their target achievements, including capacity-building programs. The Social Welfare Department and the Khadi and Village Industries Commission did not provide their NGOs an advance for stove operations, while the West Bengal Renewable Energy Development Agency advanced half of the implementation target. All NGO expenditures under the national program were reimbursed by the nodal agencies on a monthly/quarterly/annual basis after activities were completed. The NGOs were required to submit utilization certificates supported by vouchers and certificates of installation from the village council (panchayat).

Pricing and Subsidies

In West Bengal, most installations under the national program were fixed one-pot improved stoves. Subsidies of the Ministry of Non-conventional Energy Sources covered about 40 percent of the total stove cost, while users contributed 60 percent (Table 8.6). But West Bengal had no formal pricing policy, and the contributions varied substantially by NGO.

TABLE 8.6 Pricing Guidelines for Fixed One-pot Stoves in West Bengal, 2000–1

<i>Model</i>	<i>Raw Materials, Rs (US\$)</i>	<i>SEWs, Rs (US\$)</i>	<i>Total Stove Cost, Rs. (US\$)</i>	<i>Government Subsidy (Ministry of Non-conventional Energy Sources)</i>	<i>User Contribution*</i>
Sohini Seva	130 (2.8)	20 (0.4)	150 (3.2)	60 (1.3)	90 (1.9)
Sugam Seva	150 (3.2)	30 (0.6)	180 (3.8)	70 (1.5)	110 (2.3)
Kalyani	110 (2.3)	20 (0.4)	130 (2.8)	60 (1.3)	70 (1.5)
Durable	220 (4.7)	20 (0.4)	240 (5.1)	100 (2.1)	140 (2.9)
Portable	160 (3.4)	5 (0.1)	165 (3.5)	45 (1.0)	120 (2.5)

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Note: * Includes in-kind contributions (for example, mud, dung, straw, and labor).

Without advance payments from the national program, the NGOs under the Khadi and Village Industries Commission and the Social Welfare Department were forced to cross-subsidize activities with funds from their other rural development projects. Without such cross subsidies, the NGOs believed they would be forced to reduce annual installation targets and geographic coverage. The resulting financial stress prompted many staff members of the Social Welfare Department to switch to working with the West Bengal Renewable Energy Development Agency.

To avoid installation delays, the NGOs often assisted households who could not afford the one-time contribution through installment payments, cost-sharing arrangements with the panchayat, reduced contributions (for example, for backward classes), and free installations (for example, under the patronage of political parties). The nodal agencies did not interfere with NGO policies on user contributions; but the West Bengal Renewable Energy Development Agency instructed its NGOs to charge users according to Ministry guidelines.

Although the NGOs' annual expenditure on stove activities was modest, they had to adjust their operations because of them. The NGOs used household contributions to make advance payments to stove parts suppliers; they paid the suppliers' administrative and travel expenses, which government support did not cover. To compensate for the nodal agencies' delayed release of funds, the NGOs diverted resources from other development schemes with contingency grants or rolling funds in order to pay SEWs and motivators. They avoided asking users to contribute more, but some began charging SEWs membership fees for administration and publicity.

The SEWs' late deposits to the NGOs of contributions collected from users sometimes delayed stove construction activities; but the NGOs had little control over such issues since the workers were not under their purview. The users were aware that the national program provided a subsidy toward stove cost, but they were uninformed about the prevalent price of improved stoves or the subsidy pattern. Consequently, they did not question the contribution requested by the NGOs and SEWs. Although instructed by the NGOs to collect a uniform contribution from the users, the SEWs sometimes took advantage of users' lack of information on stove prices, collecting higher amounts than required.⁵

The SEWs, as well as some NGOs, believed that service reimbursements under the subsidy scheme were not commensurate with their level of input. The SEW's average daily earning, equivalent to the construction of three improved stoves [Rs 60 (US\$ 1.3)], was less than the state-stipulated wage of a skilled laborer. According to the workers, subsidy rates for existing improved stove models should have been raised. Thus, the decision of the Ministry of Non-conventional Energy Sources not to increase the SEWs' charges for durable stoves may have hindered these workers. Despite such difficulties, the NGOs continued to participate in the national program. Indeed, the opportunities created for them to develop personal contacts with users greatly enhanced their ability to execute other rural development schemes.

CRITICAL ROLE OF TECHNICAL BACKUP UNIT

The technical backup unit at the University of Kalyani was critical to development and production, providing technical support to both the nodal and implementing agencies and stove parts suppliers. Staffed by a director who also served as principal investigator, five co-investigators, one scientific officer, one technical assistant, two potters, and one office assistant; the technical backup unit conducted an array of research and development initiatives.⁶ These included modifying, designing, and testing stove models and conducting field trials. It also implemented capacity-building activities for users, SEWs, and unemployed youth; conducted feedback surveys; and designed and produced printed and audio-visual outreach materials. Finally, in collaboration with local government agencies, it adopted villages in order to create 'smokeless' settlements and measure indoor pollution.

To decide administrative and technical policy issues, the technical backup unit established advisory and coordinating committees. The advisory committee—comprising representatives of the Ministry of Non-conventional Energy Sources, nodal agencies, University of Kalyani, and technical backup unit—met annually to formulate the technical backup unit's action plan. The coordinating committee—comprising the technical backup unit and nodal agencies—met as needs arose to determine contracts for stove parts

manufacturers, model testing, and capacity-building programs. The nodal agencies used this forum to convey to the technical backup unit technical problems encountered in the field.

In consultation with the nodal agencies, the technical backup unit trained users, NGOs, government officials, and SEWs.⁷ Training modules were organized at both its Kalyani facilities and in other parts of the state. Participants were selected and sponsored by the NGOs and nodal agencies. Preference was given to the physically challenged and women candidates. Applicants for entrepreneurship development training, for which a nominal fee was charged, were selected through advertisements in local newspapers. On successful completion of training, participants received certificates. On behalf of the nodal agencies, the technical backup unit conducted state-level management training. In addition, it shared results with the technical backup units of other states, the academic community, and research institutes working on improved stove design.

Before production, all short-listed suppliers were required to test their products at the technical backup unit. To do so, they had to pay a fee. For fixed parts, testing was conducted annually, according to the technical backup unit's testing and certification guidelines (although Bureau of Indian Standards norms existed). Out of eight chimney-set manufacturers in the country's eastern region, only one had the technology to qualify for Bureau certification. It paid the Bureau a certification fee, but later discontinued the practice for lack of demand by the nodal agencies. The technical backup unit reserved the right to conduct repeated parts testing if dissatisfied with field performance. Given the directive of the Ministry of Non-conventional Energy Sources to distribute durable improved stoves, suppliers voiced the need for Bureau certification of stove parts. For portable models, quality-assurance testing was conducted twice yearly at the technical backup unit, according to Bureau specifications, in addition to the Bureau's own regular inspections.

INSTITUTIONAL STRUCTURE: NGO PARTICIPATION

In West Bengal, responsibility for the national program was shared by nodal agencies, the technical backup unit, and affiliated NGOs. The Ministry of Non-conventional Energy Sources allotted three nodal agencies—Social Welfare Department, Khadi and Village Industries Commission, and West Bengal Renewable Energy Development Agency—annual installation targets based on their requests and prior-year performance. In turn, the nodal agencies supervised the installation of both fixed and portable improved stoves, emphasizing fixed models suited to local sociocultural traditions (Figure 8.2). The target beneficiaries were rural households, with 22 percent of installations reserved for backward classes and those below the poverty line.

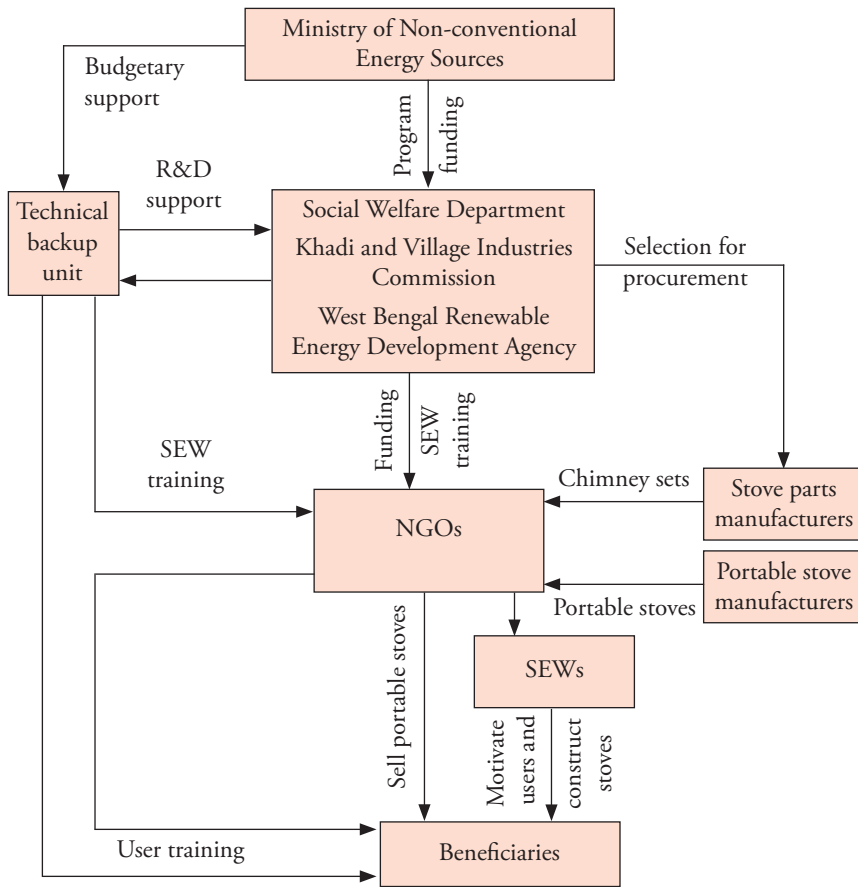


FIGURE 8.2 Implementation Structure in West Bengal

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

The NGOs were required to submit their targets, along with details of the blocks, villages, and households to be covered, to the nodal agencies with which they were affiliated. Based on their input, the respective nodal agencies finalized their annual action plans and submitted them to the Ministry of Non-conventional Energy Sources for approval. On receiving approval, the nodal agencies distributed targets and training courses among the NGOs, based on prior-year performance. Given their limited manpower and funds, the nodal agencies often had to curtail the NGOs' target demand, which exceeded the Ministry allotment. Following the finalization of NGO targets, the nodal agencies prepared their quarterly action plans, which included training camps for users and SEWs, awareness-generation campaigns,

management training courses, and feedback surveys in the various districts. The nodal agencies verified stove installation, and submitted quarterly reports outlining field progress to the Ministry.

Nodal Agencies' Effectiveness

Of the three nodal agencies, the Social Welfare Department—possibly the only state agency to have installed 1 million improved stoves—was the most experienced. It coordinated all aspects of the national program, including allocating targets to NGOs, training SEWs, disbursing funds, undertaking publicity campaigns, and providing feedback to the Ministry of Non-conventional Energy Sources. For its training instructors, it used the staff of the technical backup unit. It held monthly meetings with NGOs to discuss the program's progress. Periodically, it invited stove parts suppliers to these meetings to express their grievances regarding delivery of goods and payment delays.

Unfortunately, a lack of manpower, infrastructure, and state financial support hindered the Social Welfare Department from increasing its targets and implementing effective monitoring. Also, pressure from the state government to install stoves in socioeconomically backward districts resulted in low penetration rates, harming overall performance. Because such groups received the improved stoves nearly free of charge, they lacked motivation to properly maintain and replace them. Moreover, by confining targets to the poor, other socioeconomic groups remained unaware of the stoves' benefits, perceiving the products as inferior.

For the West Bengal Renewable Energy Development Agency, whose primary task was distribution of renewable energy technologies, the national program was a secondary activity. Nonetheless, its supervisors undertook all administrative work related to the national program, including evaluation studies, and visited the field to interact with and guide the affiliated NGOs. Lacking training instructors, the Agency enlisted the support of trained SEWs associated with its NGOs and held quarterly meetings with the NGOs to discuss progress. The NGOs were required to cover 80 percent of households in selected villages. The Agency organized annual state-level meetings of the NGOs and their SEWs to discuss the action plan for the coming year and praise those NGOs that had shown exemplary performance.

The main task of the Khadi and Village Industries Commission was to promote rural and cottage industries development and generate employment opportunities in the rural non-farm sectors. The Commission's high penetration level under the national program may have been attributed to the extensive, focused institutional structure established for distribution of renewable energy technologies, greater attention to operations owing to fewer districts covered, a network of six NGOs working exclusively on

improved stoves and biogas distribution, and direct infrastructure support from the GoI.

The Khadi and Village Industries Commission's non-conventional energy cell was responsible for distributing improved stoves and biogas plants across the country. This cell made policy decisions regarding national program implementation and allocated targets to state offices. It relied on the technical backup unit for support in organizing capacity-building programs. To improve the national program effectiveness, the Commission stipulated that, in each target block, every household in at least one village should be covered. Furthermore, it encouraged the selection of village clusters to facilitate monitoring and evaluation. With the participation of its central office, it conducted annual state-level meetings with the NGOs and the technical backup unit to discuss the annual action plan and implementation progress. In addition, five to seven district-level meetings were held each year with the NGOs and SEWs to review field progress.

NGOs: Backbone of the National Program

In West Bengal, the 150 NGOs working under the nodal agencies were engaged primarily in implementing various rural development schemes (for example, health, primary education, sanitation, micro credit, and afforestation). Thus, their participation in the national program complemented work in these existing programs.

To qualify for national program participation, the NGOs were required to undergo a thorough verification process. Through field visits, their financial background, experience and capability in undertaking rural development schemes, and infrastructure facilities were ascertained. In addition, the respective district collectors and local panchayats were requested to certify the bona fide status of the NGOs. Preference was given to those organizations with the credibility to undertake rural development projects. On completing these formalities, the NGOs were registered with the respective nodal agencies and short-listed for the current year's improved stove installations. In certain cases, applicants were requested to work in NGOs already engaged in the national program to gain qualifying experience for registration.

To achieve their targets—geographically restricted to about two districts—within the stipulated time frame, the NGOs delegated improved stove activities to motivators, SEWs, and supervisors. The motivators built rapport with panchayat members, motivated villagers, and selected households. After finalizing the user list, the SEWs and their assistants constructed the improved stoves. The supervisors—usually NGO staff members or experienced SEWs—managed program operations, from village selection to inspection of newly constructed stoves. They guided the motivators and SEWs to meet their commitments within the specified time frame.

The NGOs were required to undertake capacity building for stove construction, repair, and maintenance services; but most had no prior expertise in these areas. Thus, once registered, the NGOs nominated their staff members and SEWs for technical training (four to six persons per course). Selection criteria stipulated that training participants be local residents, economically backward, and sufficiently educated to complete national program formalities in writing; in addition, they needed a proven record of working at the grassroots level. Preference was given to women. Although the minimum required educational qualification was middle school, the qualification for most SEWs ranged from high school to graduate level. While the NGOs ensured that their SEWs were trained by the technical backup unit or nodal agencies, many were self-trained because the NGOs or nodal agencies could not meet the high demand for training.

National program implementation began with target allotments ranging from 200 to 20,000 installations. For newly established NGOs, the targets were fewer than 500 stoves. The nodal agencies provided distribution guidance and monitored its progress; but they did not interfere with distribution modalities, which were at the discretion of the respective NGOs. Within a 10-month period, the NGOs were expected to have completed all installations, training, and outreach activities. Each month, they informed their respective nodal agencies of the progress made. In turn, the nodal agencies forwarded the Ministry of Non-conventional Energy Sources consolidated reports each quarter that included details of the stoves installed, training courses organized, and publicity campaigns undertaken by the NGOs.

CONSTRUCTION AND SERVICE

All households in a targeted village were surveyed to assess their need for improved stoves.⁸ Information was collected on family size and income, dwelling construction, types of vessels and cooking fuels used, and sites of existing traditional stoves. Most users procured the main construction materials from the local environment free of charge; these included clay, sand, cattle dung, straw, and husks. For those who could not procure their own materials, the SEWs did so for a fee. The NGOs obtained stove-parts sets—two asbestos-cement pipes, tunnel, and cowl—from eight approved manufacturers, most of which were based in the state capital of Kolkata. Sales involved direct transactions between the suppliers and NGOs.

Stove construction, for which the SEWs were responsible, was a three-stage process. It began on a predetermined day after delivery of the chimney set and was conducted in beneficiaries' kitchens—often in many households simultaneously to save time and effort. Users' inability to arrange for receiving raw construction materials on time often delayed installation; even so,

the SEWs constructed an average of three to four single-pot stoves per day. Households were advised to wait several days before using their newly constructed stoves.

After installation, the NGOs were required to provide consumers one year of mandatory service, including regular inspections and repairs on receipt of user complaints. To increase the effectiveness of service delivery, the NGOs implemented various practices in their respective areas. These included monthly or twice-monthly visits to users' households by the SEWs, quarterly inspections of all improved installations by supervisors, weekly or monthly meetings between the supervisors and SEWs to discuss the functional status of the stoves, undertaking corrective measures during feedback surveys, replacing parts, assisting households in stove maintenance tasks, and setting up consumer assistance cells at the block level to cover village clusters or blocks. When the mandatory service period ended, the NGOs continued to provide paid after-sales service through their SEWs.

Without a formal policy on payment for stove repairs, users were reluctant to pay for the services rendered; but some did pay a nominal fee per task. Without a monetary incentive, the SEWs sometimes took more than a week to attend to users' complaints. To make after-sales service economically viable, the SEWs suggested formulating a policy stipulating fixed rates for undertaking repair services.

PRODUCTION AND DELIVERY CHALLENGES

The technical backup unit maintained reasonable control over the quality of stove parts; however, by failing to adequately address the design and training concerns of users, SEWs, and NGOs, it could not prevent non-certified SEWs from installing improved stoves or making inappropriate design modifications at the request of users. In 1999–2000, more than 0.5 million improved stoves were installed, but only 650 user training courses were allotted.⁹ Furthermore, the monitoring and evaluation of installations was inadequate.

Under the national program, no SEW could conduct construction and installation training without prior approval of the technical backup unit. But in practice, this directive was often ignored. Indeed, nearly 60 percent of SEWs in the field were not certified. Without sufficient support from the technical backup unit, non-certified workers made their own design modifications and trained others, which led to poor-quality workmanship and associated problems in certain districts.

User requests to alter the original stove design included increasing the pothole diameter (often done by the users) and depth of the firebox for feeding non-wood fuels (for example, dung cakes, leaves, and straw); using bent chimneys to prevent fire hazards; increasing the chimney diameter for

greater ease of cleaning and smoke removal; increasing the tunnel diameter of the two-pot stove for uniform heat flow; and using bricks for firebox construction. Households were willing to pay for these changes, which lured the SEWs to make them.

Interaction between the SEWs, nodal agencies, and technical backup unit was limited to initial training courses and subsequent feedback survey and training sessions held in the target villages. The SEWs usually conveyed the design modifications users sought to the affiliated NGOs, who, in turn, informed the nodal agencies for further action. But the technical backup unit had a poor track record in responding to user complaints. It lacked a working relationship with the NGOs, who believed that users' suggestions should be viewed according to consumer needs.¹⁰ Because its priority was to meet annual installation targets, the technical backup unit often ignored the quality of the stoves installed. The resulting poor quality, however, had little effect on penetration because of the superior marketing efforts of the NGOs and SEWs.

Although the technical backup unit developed a number of stoves models, only the Sohini Seva and Sugam Seva were popularized by the NGOs because of the limited interaction between the technical backup unit, SEWs, and users. According to the NGOs, the design modifications sought by the users and SEWs could have been incorporated, but the technical backup unit, which made no attempt to field-test the improved stoves during the development cycle, was concerned more with efficiency standards than user suitability. The technical backup unit, on the other hand, believed that it could not address all stove design issues, given the large scale of installations, combined with its inadequate manpower and limited financial support from the Ministry of Non-conventional Energy Sources and the state government.

To verify target fulfillment, the nodal agencies undertook spot checks with the involvement of village institutions. Panchayat members and other rural development officers at the block and district levels were required to physically verify the number of installations in the target villages, but such spot checks overlooked the monitoring of technical design and performance. Each year, the technical backup unit and nodal agencies conducted concurrent feedback surveys in all districts to assess the functional status of the improved stoves distributed by the NGOs. To cover the maximum number of NGOs and blocks, these surveys randomly selected two target villages out of every ten, wherein all user households were evaluated. But such one-time exercises in selected villages could not substitute for a true technical evaluation of the installed stoves. To obtain a more objective assessment of technical performance and its effect on users, the technical backup unit suggested regular third-party evaluation studies.

WINDING DOWN

The national program in West Bengal succeeded beyond expectations because of the active involvement of the many innovative NGOs that helped to build the capacity to promote, build, and service improved stoves across the state. Being close to users, local NGOs could better anticipate their needs and provide more effective after-sales service than could the nodal agencies. Close rapport between the NGOs and the three nodal agencies enhanced a bottom-up approach to target setting. Indeed, to determine their annual installation targets, the nodal agencies depended on applications received from their affiliated NGOs. Another noteworthy feature was the competition among NGOs, as evidenced by their heavy demand for installations, which often exceeded nodal agency targets. By allocating annual targets among the various NGOs based on past performance, the nodal agencies helped to improve NGO performance. Finally, flexible pricing based on the policies of individual NGOs allowed for the development and promotion of a wider variety of stoves and helped SEWs to earn extra income by claiming higher user contributions in peri-urban areas where residents purchased fuel wood.

Despite the technical backup unit's limited interaction with users and SEWs, the national program succeeded in achieving high levels of penetration through the superior marketing efforts of the NGOs and SEWs, as well as collaboration between the NGOs and the three nodal agencies. Surprisingly, after central assistance was withdrawn in 2002, both the Social Welfare Department and the West Bengal Renewable Energy Development Agency stopped implementation (Winrock International 2005). More predictably perhaps, several NGOs involved in the national program continued to distribute improved stoves under their own programs.

NOTES

1. Based on the 1997 district census and assuming one installation per household.
2. The shallow pothole limited the amount of fuelwood that could be fed, and use of a mold prevented modification of the pothole diameter to accommodate vessels of various sizes.
3. In addition, the centrally funded Indira Awas Yojana provided households in backward classes free improved stoves on a limited scale. Under state rural-sanitation schemes, households were offered discounts on stove parts if they accepted an improved stove, along with the sanitary facility package.
4. While the state government did not contribute directly toward the stove cost, it funded a portion of administrative costs and salaries of nodal agencies' national program staff.
5. In focus group discussions, users stated that without current subsidy levels, purchase of improved stoves would be difficult. Non-users stated that they could not afford the one-time contribution, but could pay in installments; some who could not afford any

contribution said they would wait to receive a free improved stove under the centrally-funded Indira Awas Yojana.

6. The Ministry of Non-conventional Energy Sources provided the technical backup unit an annual grant of Rs 1 million (US\$ 21,186) for research and development, capacity building, and training; while the state offered Rs 0.5 million (US\$ 10,593). In 1999–2000, Ministry funding of the technical backup unit for such activities accounted for only 6 percent of total funds received.

7. Although concerned primarily with providing administrative support to their affiliated NGOs, the nodal agencies also provided technical training to SEWs and users. This training consisted of a 10-day course based on the technical backup unit's main training curriculum and the hands-on training schedule of the Ministry of Non-conventional Energy Sources. Some 20 potential SEWs were selected for such training. Requests for participation were accommodated, but such candidates had to pay for logistics. Preference was given to women, but men's participation was higher. The construction of five improved stove models—Sohini Seva, Sugam Seva, Kalyani, Kesari-100, Kalyani Vishwavidyalaya—was taught, and a lottery was held among participants to choose the model to be built. For practical classes, the NGOs procured raw materials. Participants were not awarded certificates on completion of training.

8. Most NGOs preferred to promote the national program in villages where they had previously worked and were reluctant to work where the panchayat response was poor.

9. Only 17 percent of surveyed users had attended training sessions. Kitchen-performance testing provided a limited opportunity for the technical backup unit to interact with users and was restricted to areas within the vicinity of the technical backup unit.

10. Most NGOs were dissatisfied with their low level of interaction with the technical backup unit. Informal complaints were made against it for not considering the suggestions of users and SEWs. The technical backup unit claimed to have considered such suggestions and incorporated the desired features. Its initiative to send letters to the SEWs to ascertain the status of the improved stoves was met with a poor response; perhaps face-to-face meetings would have resulted in a more productive outcome.

9

A New Path for Better Stoves

One may wonder why improved and more advanced stoves have not enjoyed more consistent worldwide popularity. After all, the intertwined issues of fuelwood use, deforestation, and energy efficiency were first highlighted more than 30 years ago. In the interim, stove programs have been initiated in nearly every corner of the developing world. In addition, the potential benefits of better stoves are high. Compared to traditional stoves, the newer stoves offer greater fuel efficiency and ease of cooking with less smoke permeating household kitchens and other indoor living spaces. The improved health of rural women and children alone may be enough to justify efforts resulting in cleaner hearths and home environments for millions of developing-country residents—mainly rural people—who will remain dependent on biomass as their main cooking fuel in the foreseeable future. Added to these benefits are time savings for fuel collection and indoor cleaning. For those who purchase solid fuels, there are the benefits of avoided cooking-fuel expenditures. Even so, some stove programs in many countries have been dogged by poor performance, short life cycles, and few success stories. What factors have hindered these programs; why has success been limited to so few countries?

The difficulty in program implementation is multifaceted, as the case studies in this book illustrate. Because cooking with biomass energy is as old as human civilization, addressing the issue has often lacked a sense of urgency. In addition, the problems of women, who suffer disproportionately from the adverse health effects of biomass cooking smoke, have often been invisible to society at large (Parikh *et al.* 1999; Ramani and Heijndermans 2003); thus, gender plays an important role. Also, the intended beneficiaries are the world's poorest people, who usually cannot afford any type of stove and also fail to understand the health problems caused by biomass cooking smoke. Finally, most programs have been implemented on a small scale; they

have continually worked to customize stove models to the variety of local cooking customs and concerns of particular populations, thereby limiting the scope for more widespread adoption. As suggested by the case studies in the previous chapters, a wide variety of stoves with divergent capabilities are available. Some emphasize improved smoke removal or fuel combustion, while others stress ease of use for cooking.

An obvious alternative to reducing the problems associated with traditional biomass cookstoves—one that should not be ignored—is the adoption of stoves that use liquid fuels, such as kerosene or LPG, which are cleaner to use than most improved biomass stoves. India's most recent national figures indicate that, in many states, up to 20–50 percent of rural populations now use either kerosene or LPG to meet a portion of their cooking needs (IHDS 2007). These fuels are more convenient to use and offer higher combustion efficiencies. They nearly eliminate pollution or emit less harmful pollutants than even the better biomass stoves (Smith 2002; Smith *et al.* 2005). But stoves that use liquid fuels are usually well beyond the means of poor rural people who depend on biomass cooking fuel (Barnes and Floor 1996; Reddy 1999; World Bank 1996). Thus, for those who cannot afford to switch to modern fuels to eliminate or reduce the problems associated with using traditional stoves, an intermediate approach is required.

As already pointed out, the problems associated with using biomass energy in traditional stoves are too important to ignore. Despite the history of flawed approaches to implementing stove programs, such as overemphasis on energy efficiency at the expense of usability or capacity to reduce indoor pollution, many lessons have been learned (Barnes *et al.* 1993). Drawing on the best of Indian and international experience, this chapter explores how the benefits of better stoves might be achieved through more effective programs. We are heartened by the recent initiative by the GoI to rededicate itself to the promotion of better stoves in India. It is hoped that the new generation of stove programs in India and around the world can benefit from the lessons derived from past programs. The goal is to lessen the drudgery of fuel collection, to promote better local environmental conditions, and to improve family health.

INDIA'S EXPERIENCE FROM THE LEGACY PROGRAM

The diverse ways in which India's national program was implemented provide a rich context for understanding its strong and weak points. Although supported by an overall national structure, the states found creative ways to experiment with implementation, which resulted in unique program features. Considered individually, all six of India's best state cases had mixed results (Table 9.1). Indeed, it must be admitted relatively few rural residents continue to use the improved stoves today (IHDS 2007), in part, because

TABLE 9.1 Key Attributes of India's Best Improved Stove Programs

<i>Attribute</i>	<i>Andhra Pradesh</i>	<i>Gujarat</i>	<i>Haryana</i>	<i>Karnataka</i>	<i>Maharashtra</i>	<i>West Bengal</i>
Financing & subsidies/pricing	** Large subsidies of about 80–90% were provided for built-in stoves under rural housing schemes, which undermined market development for stoves.	* Ongoing reliance on large subsidies of more than 90% caused users to neglect stove maintenance and did not lead to sustainability.	** Large subsidies of about 75% ensured affordability for poor households and that the government met its targets.	** Target setting sometimes resulted in unmet demand and lack of sense of ownership among poorest users, for whom stoves were 100% subsidized. Subsidies were about 50%, but consumers were willing to pay more if stove durability and performance could be assured.	** Subsidies of about 50% ensured distribution but not sustained demand; those that purchased non-subsidized stoves outside the program had the best maintenance, reflecting higher education and economic levels. Backward classes who paid nothing did not value the stoves and they broke down.	** Ministry of Non-conventional Energy Sources covered 40% of the total cost of one-pot improved stoves, while users contributed the remainder. NGOs were paid on completion and inspection of their work, which acted as a disincentive for them to promote stoves.
Market development	* Poor supply-chain management and ministry selection guidelines led to little market	* Targeting those living below the poverty line meant inability to pay for stoves and poor	* Because of the target- and subsidy-driven nature of the program, SEWs	* Stove users reported that they would refurbish their stoves or even pay higher amounts if quality	*** Participation of traditional potters as entrepreneurs was beneficial because they made	*** Despite installing improved stoves with incorrect specifications, the NGOs and their

development. market development. could not become independent entrepreneurs capable of scaling up the program. were improved. But in reality, they could not acquire parts, and the rate of repurchasing stoves was negligible. a reasonable profit and sold stoves via both the national program and open market. SEW's conducted superior marketing efforts.

Improved stove identification and development	***	The technical backup unit modified stoves based on qualitative feedback from the field.	*	The program suffered from a lack of standardized stove-construction materials and government-approved dealers, as well as design problems (Sneha model).	**	The technical backup unit developed cement and high-efficiency pottery stoves; but, for lack of appropriate incentives, performance of the SEW's, who constructed the stoves, was only satisfactory.	***	The program featured use of pre-fabricated molds from private manufacturers, high-quality research on stove technology, and strong research and development (for example, field testing, improved stove demonstrations and training).	***	The technical backup unit modified stove design to meet user needs. It involved traditional potters in design and took a quasi-commercial approach, including training and certification of potters in business and other skills. Village selection was based on demand.	**	The technical backup unit reserved the right to conduct repeated testing of stove parts if dissatisfied with field performance, but SEW's and some NGOs believed their earnings were not commensurate with the amount of work involved in stove construction.
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Table 9.1 (contd)

<i>Attribute</i>	<i>Andhra Pradesh</i>	<i>Gujarat</i>	<i>Haryana</i>	<i>Karnataka</i>	<i>Maharashtra</i>	<i>West Bengal</i>
Customer service/satisfaction	* The program lacked prescribed standards for key stove parts. SEWs failed to provide free after-sales operation and maintenance services.	* The program failed to initiate entrepreneurial production and maintenance of existing stoves.	** A well-defined strategy was developed for after-sales service. Pre-installation household surveys were followed up by household visits within one year to assess stove functioning. Despite the well-designed strategy, SEWs sometimes produced poor-quality stoves.	* The program lacked after-sales technical assistance (e.g., skilled masons and parts replacements). Customers with thatched roofs feared fire from hot chimneys (this was a reason potential users cited for non-adoption).	*** The program was built on the strength of tradition; each village had one or two potters. The level of consumer satisfaction was medium to high. Most households used the improved stoves; poor users, who received significant subsidies, were given poor-quality stoves.	*** Most users were satisfied with stove performance. Implementing NGOs were required to provide free after-sales service for one year, after which time they were to provide paid after-sales service via SEWs. Local repair shops were used as backups when NGOs failed to provide service.
Operations/procedures	*** The program featured close cooperation between implementing agencies and the technical backup	** The integrated rural development approach taken via housing schemes harnessed organizational synergies; at the	*** The program had a well-defined institutional structure and implementation strategy for distribution	*** The implementation method was changed from target-driven to one that focused on SEWs and NGOs, who were trusted by villagers.	*** The technical backup unit adopted a unique approach of involving traditional potters in stove design, construction,	*** Four nodal agencies executed the program via a network of 150 NGOs with whom they interacted closely. There was some

<p>unit. It took a whole-village approach to coverage.</p>	<p>same time, field officers were severely understaffed, and 20% of NGOs failed each year.</p>	<p>(including pre-installation surveys) and women's guidance.</p>	<p>promotion, and sales.</p> <p>competition among the NGOs, and target setting was more bottom-up than top-down. The technical backup unit was weak.</p>
<p>Communi- cations/ promotion</p>	<p>** Rural outreach was extensive; but the nodal agency failed to seek qualitative feedback from users at the time it verified the number of stoves installed.</p>	<p>** User-based feedback surveys were conducted. Women's participation helped female family members become more aware of preventive maintenance and repair; mahila mandals were key factors in motivating women users, yet interaction between stove designers and users was lacking.</p>	<p>***</p> <p>NGO-guided motivators were responsible for building rapport with panchayat members, motivating villagers, and selecting households; at the same time, the technical backup unit failed to field-test stoves to make them more user friendly.</p>
	<p>* The program lacked effective awareness-raising activities, which could have been linked with the phasing out of subsidies; as a result, users lacked awareness of the link between reduced indoor smoke and better health.</p>	<p>** SEW's and masons conducted door-to-door campaigns; but there was a lack of interaction between stove designers and users and training on stove use and maintenance.</p>	<p>** Having one or two traditional potters who constructed and sold both improved and traditional stoves located in each village resulted in users' greater awareness about technology and its benefits. But there was little communication with the poorest households.</p>

(contd)

Table 9.1 (contd)

Attribute	Andhra Pradesh	Gujarat	Haryana	Karnataka	Maharashtra	West Bengal
Local perceptions	** Users valued time savings, fuel savings, and reduced eye irritation, and cleaner kitchens; drawbacks included back-smoking and increased fuel consumption.	** Users valued reduced smoke, fuel savings, and time savings. But design failed to accommodate the cooking needs of large families.	** Users appreciated reduced smoke. With better information about the benefits of the improved stoves, users said they would likely be willing to pay more.	** Users valued reduced smoke, cleaner kitchens, fuel savings, and time savings; but they complained of back-smoking and increased fuel consumption.	** Users appreciated that the stoves were developed by traditional potters. They valued reduced smoke, fuel savings, and time savings; some households recognized the cleanliness and health benefits. Perceived drawbacks included technical problems with chimneys and inconvenient grates.	** Users appreciated smoke removal, cleaner kitchens, reduced health concerns, time savings, decreased risk of burns, and reduced need to replace roof tiles. Drawbacks included climbing onto the roof to clean the chimney and non-visibility of the flame, which was perceived to increase fuel consumption.

Source: World Bank background reports prepared by TERI and Winrock International India, New Delhi, 2001.

Notes: * barely adequate (poor); ** adequate (medium); *** very satisfactory (good).

of the stoves' short lifespan. But collectively, lessons from India's best cases (Barnes and Kumar 2003), along with experience from other countries, provide an excellent guide for designing future stove programs.

All six Indian cases included significant subsidies for the improved stoves, ranging from about 50 percent to nearly 100 percent of the stove value. Generally, the subsidies were never less than half the value of the improved stove. Large subsidies had both positive and negative consequences. While they enabled the poorest households to afford the stoves provided under the national program, they also prevented the development of markets for improved stoves and their component parts, thereby hindering the repurchase and refurbishing of stoves after the program ended. Generally, the program components with the largest improved-stove subsidies had the worst records.

One of the strongest features of India's national program was the development of technical backup units to support the design and testing of various improved stove models and construction parts. In fact, many of these former technical backup units even today still are involved in the design and promotion of stoves. However, there were difficulties with them as well. In certain states, the technical backup units had difficulty collaborating with other implementing partners, which adversely affected stove design. Implementing partners covered a broad spectrum of institutions and organizations, ranging from government agencies and corporations to state and local women's groups and NGOs. Generally, these groups were dedicated program partners, as evidenced by their innovations in implementation. Finally, the six states varied widely in the level of communication between implementing partners and stove users: Some had excellent results, which brought about stove modifications desired by users, while others suffered because of poor communication with users.

After the central government terminated financing in 2002, the six states in the study either abandoned the national program altogether or continued it in a fragmented manner (Winrock International 2005). Haryana officially terminated its stand-alone program. Its staff members were absorbed by the technical backup unit, NGOs, and agencies; while its SEWs had to turn their skills to other initiatives. West Bengal also stopped implementation, but several NGOs involved in the national program continued to distribute improved stoves under their own programs. For a short time, Gujarat continued a program similar in structure to the national program on a smaller, more focused scale. Andhra Pradesh did not abandon the national program, even though it significantly reduced annual targets. In Maharashtra, improved stoves remained part of rural development initiatives related to housing and cleanliness campaigns in rural households. Despite the lack of central-government support, Karnataka continued significant work on improved

stoves. Distribution was conducted under the housing schemes of two large programs: Swacha Grama Yojana and Jal Nirmal, a state-led, World Bank-funded program that included market development and women's awareness-raising components. Today, the level of improved stoves in that state is high compared to other states. The positive side of this loss of support for the state programs is that this offered an opportunity to evaluate the potential for the development of future programs in both India and other developing countries.

RECENT DEVELOPMENTS IN INDIA

Today, India has taken the bold step of initiating a very ambitious new national program that is just in its beginning stages. The program is focusing on the right issues and will involve a combination of activities on many of the topics addressed in this book. This large initiative for advanced biomass stoves is expected to reach millions or even hundreds of millions of people who currently use biomass energy to meet their daily cooking needs (IIT and TERI 2010). Still under development, the program will focus on five key areas:

- Technical issues, including research and development (R&D), related to testing and standards;
- Cookstove delivery procedures;
- Potential programs for fuel processing and supply;
- An innovation contest for next generation cookstoves; and
- Focus on what can be accomplished with community stoves.

The new program recognizes that there is a need to adopt new protocols for testing and qualifying improved stoves based on both energy efficiency and stove emissions. Testing facilities are now being planned to measure the performance of the new stoves in anticipation of qualifying stoves for participation in the program. It is anticipated that new manufacturers would be involved in the program. Subsidy design also will be an important part of this work, and this might include the use of carbon credits. After this initial work, there is likely to be pilot programs to evaluate the new approach followed by a longer-term implementation strategy. Hopefully, some of the past insights gained from the old programs will help inform the way forward for this innovative new effort to improve the lives of hundreds of millions of people still dependent on solid fuels for cooking in India.

The lack of government support during the last 10 years actually spawned a number of state, private, or commercial activities. For instance, the ARTI in Maharashtra which was a technical support unit under India's old cookstove program has taken its focus on the commercialization of better stoves to a

higher level. In the absence of support from the central government there were two possible ways for the ARTI to continue to develop and promote clean cooking. The first is a conventional marketing or commercialization approach that targets those who can afford more modern biomass cooking devices. To achieve the first approach, the ARTI has created a commercial entity to promote its clean cooking technologies. This is done through encouraging the development of rural entrepreneurship based on these new technologies. This company provides a wide range of cooking energy solutions including efficient stoves, gasifiers, and biogas energy systems. The current focus of the company is mainly on biomass cooking devices and clean burning biomass fuels developed to meet the needs of rural and peri-urban populations in India. The second approach is more for very poor communities whose residents cannot afford to pay for stoves. With donor partners, the ARTI has developed programs to cover entire villages with better cooking devices. In this instance, the commercialization focus of their program eliminates poor performing products that then can be offered on a grant basis to communities with the greatest needs. Recently, the ARTI has expanded its technical assistance to several countries in Africa as well.

In addition to the continued work by some of the technical support units from the older programs, there also has been the development of several new models of stoves that have been supported mainly by foundations of large international organizations. These companies have moved from supporting stoves that are locally built by artisans to producing them in factories for commercial sale. The idea is to develop a superior biomass stove that meets the needs of those who cannot afford fuels, such as LPG. For instance, Envirofit International has an extensive program in India for the development and sale of modern biomass stoves (Winrock International 2005). The program has used grant funds to develop and commercialize products, but the stoves are manufactured in large factories and then sold commercially mostly without any subsidies. This approach has required financial assistance to support innovative designs, good quality control, and development of supply and distribution chains along with a focus on retailing and marketing strategies.

In the past, many stove programs focused on the development of products to meet specific cooking styles, but a more market oriented approach requires stove designs that have a more universal appeal. Although many of these efforts are still in an early stage, the extensive work on stove design, quality control, and product marketing are at the heart of efforts to have successful program. The work of India and international programs for commercializing better stoves along with both the positive and negative experience from past programs provide some useful lessons for charting a new path for achieving cleaner cooking in both India and other countries in the world.

THE DEVELOPMENT OF BETTER STOVE DESIGNS

One might rightly ask whether governments should be involved in promoting better stoves. After all, as previously indicated people have cooked in traditional ways for thousands of years. Without substantial incentives to promote behavioral changes, entrenched customs tend to persist. Subsidies may offer a major if somewhat distorted incentive, as they did in India's national program. But the most important incentive is when users recognize that switching to better stoves has a high value for them. Despite traditional cooking patterns, people with higher incomes have no problem switching over to the use of easier-to-use fuels, such as kerosene and LPG. These fuels have higher energy per unit weight than unprocessed biomass and are used in more energy-efficient stoves that can be mass produced. Today, there are some innovative biomass stoves that are may be able to compete with LPG, and these include gasifier stoves and others that use fans or process fuels to improve combustion. However, these stoves are still at the beginning stages of marketing and it remains to be seen whether consumers will adopt them on a large scale.

Why then do many households fail to perceive a similar value when it comes to better biomass stoves? One possible reason is that the health costs associated with using traditional stoves are either unknown or unproven. Another is that a design focus that resolves one problem may create other difficulties for users. For example, emphasis on achieving greater stove efficiency via the use of a small firebox may inadvertently decrease usability because cooks are not accustomed to using smaller pieces of wood that are required to fit into the stove. As a result, the value of the more fuel-efficient stove is diminished in the eyes of the consumer. Such design trade-offs as usability, ease of cooking, combustion, and end-use efficiency must be addressed in an integrated way in order to develop viable markets for better stoves.

Technical Design Problems: Evidence from India

Stove design has been widely recognized as a key part of developing markets for better stoves both internationally and in India. It is well-established that, without extensive consumer testing, stoves developed in the laboratory are bound to fail. From the outset, India's national program rightly recognized stove design as an important component, assigning the respective technical backup units in each state the task of stove design and development. But, as the previous chapters reveal, after many years of stove development by the technical backup units, users still had complaints and often made design modifications to improve usability.

User modifications typically involved the chimney length and diameter, firebox size, and pothole size. In Karnataka, for example, household users lengthened the chimney by attaching a spare broken pipe so that the prescribed

3.05 m chimney could exit the roof. Users with thatched roofs sometimes removed their chimneys during the rainy season to avoid indoor leakages via the roof hole made for the chimney. In Haryana, the Gujjar community preferred to increase the firebox size to accommodate the baking of traditional bread (roti) inside the box. In some households where users were unwilling to bore a hole through their roofs, the chimney outlet was left indoors. In Gujarat, the firebox size was enlarged to accommodate larger pieces of wood. In Maharashtra, users commonly made the pothole size smaller and removed the grate because of the difficulty in removing hot ash from under it. In West Bengal, users increased the tunnel diameter to facilitate heat flow to the second pothole; they also increased the chimney diameter 7.5–10 cm to facilitate cleaning and smoke elimination. In Andhra Pradesh, users changed the pothole size, removed the grate, and raised the pothole height to make the flames visible while cooking. These modifications led to increased fuel consumption and back-smoking, and this in turn led to dissatisfaction with the stoves.

Complicating matters further there are tradeoffs between producing stoves that are affordable and durable. To solve durability problems, the Ministry of Non-conventional Energy Sources in the later stages of the national program redirected subsidies to only durable stove models with chimneys. Due to improved materials, these models were more expensive. While many households were willing to pay more, users from backward classes could not afford them. Experience from developing countries worldwide has revealed similar tradeoffs between quality and affordability.

Need for Better and More Diverse Designs

Since the overall cost-effectiveness of better stoves is related to the extent of their lifetime reliability, one may question the emphasis on low-cost designs. In hindsight, India's national program probably relied too heavily on developing low-cost stoves. The results proved costly. Within the first year of purchase, the stoves began to malfunction and the program got a bad name. Past problems could have been avoided if the design process included more effective interaction among stove users, builders, and designers. Also required are after-sales monitoring and evaluation to reveal the satisfaction or dissatisfaction of consumers for various stove design features might have reduced the problems. Today, a new generation of technologies being developed worldwide is in a position to better apply these basic principles.

Importance of Interaction between Stove Users, Builders, and Designers

The world's best stove-design programs have featured significant interaction between users, builders, and designers. Effective stove design must take the

household's general cooking requirements into account. Accommodating household cooking customs and preferences, combined with resolving stove design, engineering, and production issues, can result in more popular stoves that also perform very well.

Experience from China and Africa shows that extensive consumer testing and marketing preceded program success. In Rwanda, for example, several charcoal stove designs were field-tested to determine the most suitable ones for meeting household cooking requirements; the best one was further modified to better serve the users (World Bank 1991). In China, later stove designs were based on durable components manufactured in factories; thus, household assembly was made easier and the stoves were more robust (Sinton *et al.* 2004; Smith *et al.* 1993). The stoves had to meet certain engineering standards in the laboratory to ensure effective smoke removal and energy conservation. It was also recognized that, if consumers found the stoves impractical or difficult to use, the high-efficiency findings in the laboratory would not likely translate into similar results on the ground. Thus, China's improved stove program conducted extensive evaluations in every county to ensure that households used the stoves as intended.

As the previous chapters illustrate, India's national program included inconsistent interaction between household stove users, builders (SEWs), implementing NGOs, and the technical backup units. The national program rightly conceived that the technical backup units were necessary to ensure program quality; hence, they were assigned responsibility for quality control, stove testing, and stove design. At the same time, no uniform policy was put in place regarding the technical backup units' cooperation with and understanding of desired stove modifications observed by the NGOs or SEWs. By contrast, in Karnataka and Maharashtra exceptionally strong technical backup units initiated such cooperation on their own, which in part accounted for their success.

With more sustained attention to consumer needs and operation under field conditions, most of the design problems encountered in India's state programs probably could have been avoided. One common user complaint was that the firebox opening did not accommodate all sizes and types of wood. In response, household cooks enlarged the firebox opening or removed the door, which reduced the stove's efficiency. The solution would have been to design a better stove to accommodate various sizes of wood. Alternatively, appropriate tools could have been provided to cut the wood to size. This could have led to a local specialist charging for his or her services of cutting wood to size and perhaps densifying residues with hand machines.

Other common complaints were that chimneys were difficult to clean and allowed rainwater to seep through roofs into homes. These complaints

indicated that the improved stoves did not burn fuel cleanly; that is, cleaner-burning stoves would have required less cleaning. In one state, some installed chimneys did not reach the roofs and thus provided no relief from smoke buildup in the home. If chimneys were to pass through the roofs, then suitable sealing methods should have been introduced. Chimneys could have been designed with a bend to exit via an outside wall with an opening at the bend to facilitate cleaning upwards and sideways.

Users also complained of cracking stoves and the materials and mixtures used. India's standard stovepipe was made of an asbestos-cement mixture, which could easily break. In other countries, chimneys are made locally out of mud and straw in a wooden outer box mold with a pipe as the inner mold. When mud is used for stove-making, the mixture is important. Use of appropriate materials and mixtures should reduce incidence of cracking. In the first year following installation, stove builders should have inspected stoves and corrected defects. Many of the problems involving the use of local materials have prompted companies that are promoting the newer generation of stoves to build either the stoves or components in factories with strict quality control measures. This eliminates many of the problems involved in using local materials for the stoves essential components such as the fireboxes, the grates, or the chimneys.

Necessity of Field Monitoring and Evaluation

Field monitoring and evaluation of both technical performance and social acceptance is essential for stove programs to succeed. Better programs generally have had some type of built-in monitoring systems for the stoves they produce and market. A technical group is needed to evaluate stove designs to determine whether they are technically correct and meet local cooking needs. This group should obtain timely feedback from users both formally (via market surveys and focus group discussions) and informally (via extensive field visits). Once the stove designers receive this feedback, they can incorporate the suggestions and respond with better stove designs. This is actually a process that can continue as more and better stoves are designed, refined, and produced for consumers. This monitoring and evaluation of course also should include field measurements of energy efficiency and smoke reduction of various stove types.

In the case of India, an ongoing monitoring and evaluation program could have led to better technical performance and social acceptance. As the six case studies show, household users were not concerned whether the improved stoves conformed to technical specifications. Rather, their primary interests centered on convenience—having a stove that caused less eye irritation; generated adequate heat in the firebox to suit their cooking needs; and produced less soot and, thus, required less cleaning of kitchen walls and pots and pans.

Without an ongoing monitoring and evaluation program in place, it was not possible to assess the degree to which such alterations reduced the stoves' energy efficiency or increased smoke emissions inside the home.

For any stove program to succeed, it is vital that users adopt the stoves as an integral part of their customary cooking techniques; only in this way will they seek to replace the stoves when they wear out. Effective social marketing can inform potential customers about the benefits of better stoves and encourage them to purchase them. Once they have acquired stoves that are much better than their old ones, whether at subsidized or full market prices, consumers will continue using them only if they deliver the promised social, as well as technical, benefits. The knowledge that this is taking place can be obtained through monitoring stove use in households.

Support for Technical and Design Infrastructure

Successful programs require both national coordination and development of technical infrastructure that can support stove standards and designs. In the past, most improved stoves have been designed either by the project team that has been commissioned to do the work or via established government institutes. Lack of coordination between programs has meant a proliferation of designs customized for specific projects. In addition, most programs have lacked adequate technical infrastructure for testing the safety and certifying the performance of new models. Recently a report that tested both the energy and combustion efficiency of stoves highlighted the need for better technical information even for existing stoves (MacCarty *et al.* 2010).

China's national program offers a constructive example. Early on, the technical design work was done in a national stoves training and design center, with responsibilities later transferred to a university (Sinton *et al.* 2004). To lower stove costs while ensuring quality, the technical design unit developed standardized inserts. Close association with stove retailers and cooperation with customers played a vital role during the stove design phase. In addition, government grants were used to support stove testing, artisan training, and other activities not directly involved with retailing. Today, it is expected that most stoves will be designed by the entrepreneurs who sell them.

Today, in India's new program there is some current sentiment that suggests the need for greater quality control through the establishment of a program that tests and certifies the stoves. Perhaps the development of national centers of excellence for better stoves also could perform this role. The role of developing new designs could originate with NGOs, the private sector, engineers, and various other sources. The national or regional centers could assess the new models with the help of laboratory and field testing. They could promote a set of standards or labeling mechanisms and also could publicize the new products through media campaigns. Design competitions

also might be an effective way to promote innovation and offset the upfront costs of new stove design.

The need for such efforts is equally valid across developing Asia, as well as for Africa and Latin America and the Caribbean. Testing and certification procedures are especially important for guiding other development projects that are not directly involved in the development of stove models. Without rating systems that specify stove performance, other sector projects such as rural development or health may be reluctant to support such promotion of stoves as part of their projects. Thus, supporting this aspect of stove programs may be critical to their success.

Better Quality Control

Ensuring the quality of stoves and their component parts has been another hallmark of successful programs. Many countries have achieved better quality control through centralized production of stoves and stove parts. This solution has proven effective in countries with a high degree of urban charcoal use. The stoves are made of metal or ceramic and are produced and sold in the marketplace along with other consumer goods. Such stoves are relatively small and can be purchased off the shelf. But in countries like India, biomass stoves were hand-built on site. During the process of customized household installation, non-certified artisans often altered stove dimensions, which reduced product effectiveness. China's national program had a similar experience early in their program. The problem was solved by producing key stove components in small factories and training artisans to assemble the stoves in consumers' homes (Sinton *et al.* 2004; Smith *et al.* 1993). This often was done with the participation of those in the home.

Since the inception of India's national program, quality control had been of great concern. Early on, alterations of stove sizing and dimensions were made by artisans during home installations. As the six case studies illustrate, the national program permitted only SEWs certified by the technical backup units to construct the improved stoves. However, in practice, non-certified artisans often installed the stoves and this led to problems. Similarly, stove parts were supposed to be purchased from suppliers approved by the technical backup units, but instead many stove builders often purchased inferior materials from the marketplace. As has been observed earlier, people commonly made modifications to their stoves to suit their cooking preferences. The end result was that the improved stoves—primarily mud stoves—lost their effectiveness and failed to achieve the promised benefits of improved energy efficiency, better combustion and reductions in household smoke.

In most states, the SEWs were expected to provide one year of service after installation. But the national program had no mechanism in place to enforce this requirement once the SEWs had been paid for installation. Poor after-

sales service contributed to non-sustainability. Repeatedly, it was observed that stove masons were not offered sufficient incentives to provide appropriate after-sales service. In Andhra Pradesh, for example, the government-determined compensation rate for maintenance services was so low that stove masons preferred to forgo this payment as it cost them significantly more to provide maintenance. This forced stove users to perform their own maintenance, sometimes resulting in reduced performance. Consequently, when the improved stoves wore out, unhappy consumers were reluctant to repurchase them.

In Haryana, effective quality-control systems and maintenance incentives were part of the program; these features, in turn, highlighted the need for a maintenance manual and a better communication system for those concerned. For example, a designated individual could have covered a specific area to spot-check for quality problems. This person could have been responsible for frequent stove-performance monitoring, pointing out problems and successes, and reporting back to stove builders and technical support units. Such an individual could also have recruited new customers.

With regard to non-availability of component parts, India's national program required greater coordination to manufacture good quality, less expensive stove components with the help of technical support units and component makers. As China's experience shows, having a few factories producing parts—designed to withstand local transport to households—would have eased the quality-control process. Greater use of standardized stove parts would have improved quality, in addition to lowering costs. Shops selling kerosene, for example, could have been encouraged to stock stove components, initially on a sale or return basis, until the market had been established.

The seriousness of addressing stove quality issues eventually was realized in the later stages of the India national program. After being discouraged by recurring stove quality-control issues, the program moved toward standardization of parts and designs. This included the use of ceramic molds and inserts to ensure that stoves were built according to specifications. For instance, Karnataka and Maharashtra developed templates for stove production, while Haryana set up a testing-agency approval system with a technical group to assure stove quality. During the last phase of the national program it was recommended that only durable cement or metal stoves be financed under the program.

Many international stove programs has struggled with the tradeoffs between the costs of better quality stoves and their affordability by the mainly poor populations that use solid fuels for cooking. The reasoning is that to reach the poorest household, the stove cost has to be very low. Although this is true, it is also necessary to have products that satisfy consumer needs for

attractive, efficient, and durable stoves that preferably also are available in the marketplace. The goal would be to find ways to encourage or finance the development of various types of stove perhaps for consumers with different levels of income. This is not an easy issue to resolve, but it is clear that at the minimum, there is a need to have some type of performance rating or standard that can guide consumers in their choice or purchase of stoves.

WELL-TARGETED SUBSIDIES AND EQUITABLE PRICING

International experience shows that subsidies or grants are an integral part of all stove programs. The issue is not whether subsidies are needed but how they are administered. In many countries, some donor-funded programs—especially small ones with targeted communities or households—have provided large stove subsidies. But when scaled up to the national level, such programs may not be financially sustainable. Moreover, when donors or governments are involved in selecting particular stove technologies, programs often go awry. As already indicated, the most successful programs have involved little or no stove subsidies; rather, subsidies mainly have been directed toward technical assistance, quality control, and the broad array of design and testing activities that support market development.

The Basics of Subsidy Design and Financing

Policymakers and economists often evaluate subsidies based on the commonly used criteria of efficiency, equity, and effectiveness. Efficiency refers to maximizing social or economic benefits. To be an efficient investment for society, a project's economic rate of return must be calculated and should be positive. Equity refers to the efficacy of the subsidy; that is, whether the subsidy reaches the intended groups, who are usually poor people. Effectiveness refers to subsidies that make a program work. Continuing to provide subsidies to a poorly working program that reaches only a small percentage of people is an unwise use of government resources (World Bank 2002b).

In this context, even well-intended subsidy programs might not be without problems (Barnes and Halpern 2000; Komives *et al.* 2005). A common problem is associating subsidies with specific technologies that might well diminish both their effectiveness by limiting consumer choice. For example, early photovoltaic household programs in many countries provided subsidies for systems of a certain size for lighting and other uses of electricity, but some consumers desired either smaller or larger systems and not the ones selected for them.

Another common problem is the difficulty of administering certain types of subsidies. India's ration program and also social welfare programs of developed countries often target poor households to promote equity. These

programs require what is commonly known as means testing; that is, some sort of test or evidence is required to determine whether people are poor and therefore qualified to receive subsidies. The difficulty with means testing is that it is a significant administrative burden on the agencies providing the subsidy.

Applying these subsidy principles to the stove program, there are many programs that have directly subsidized the stoves with little or no market development. Such subsidies pass two of the three tests as they are both efficient and equitable. They are efficient because the stoves have significant benefits compared to their costs. They are equitable because poor households are the main biomass-using groups in need of better stoves so they are the main ones that would take advantage of the subsidy. But they are not effective because they cause problems in the development of commercial markets for the stoves which means such subsidies may then reach only a small proportion of the population. Thus, direct stove subsidies may diminish acceptance of the stoves beyond a specific program. On the other hand, supporting the costs of designing, marketing, and promotion of stoves will help to keep their price at levels that are affordable.

Possible Subsidy Applications

The world's most successful stove programs actually have stressed the criterion of effectiveness, but they also can be considered equitable as well. With few exceptions, stoves should be sold at market price through retail stores or organizations that promote particular stove types. If consumers purchase the stoves, the marketing of retail groups and after-sales service will develop. But market development does not preclude lowering stove costs or providing the poorest households a chance to purchase the stoves. Providing support for many of the factors necessary for support the commercial development of better stoves obviously is an indirect way to keep their prices at reasonable level.

Generally, subsidies can be applied as follows:

- Stove design (perhaps through grant competitions), laboratory and field testing, research and development, customer-friendly designs, feedback, quality control, standardization, and innovation.
- Development and administration of product labeling with regard to energy efficiency and smoke removal.
- Market surveys to determine where demand is strongest, the type of stove required, and stove attributes.
- Technical support and assistance, product development, training of stove builders and users, and local support services, including monitoring and evaluation, feedback, marketing, and information distribution.

India's national program subsidized stove distribution and technical support, along with most of the stove cost. The relatively large stove subsidies ensured distribution, but not sustained use or demand. In the six states surveyed, the central subsidy accounted for approximately 50 percent of the stove cost—in certain states, up to 100 percent for the poorest households. In Maharashtra, where the poorest households received the highest subsidies under the national program, stoves fell into disuse. In Haryana, many users declared that, after the improved stoves broke down, they would revert to using traditional stoves. The lifetime of most improved stoves distributed averaged only two years or less, depending on stove type and required maintenance.

Providing subsidies to universities, private firms, and NGOs in the form of government contracts, grants, and technical assistance may be perceived as inequitable because the subsidies do not target users. But such subsidies can reach consumers indirectly through incentives for developing good stoves, lowering stove cost by eliminating expenses involved in R&D, training stove producers or providing incentives for manufacturers, and developing appropriate dissemination strategies. In China and Sri Lanka, for example, centralized component production enabled both programs to maintain stove prices at reasonable levels so that they could be made affordable to local residents who lacked significant cash resources and spent much time collecting fuel. Such consumers are willing to pay for the better stoves for improvements in health and reducing the drudgery of fuel collection as long as cooking practices are improved rather than hindered. These somewhat indirect subsidies actually are fairly well targeted. Without such subsidies it is unlikely that companies could afford the upfront development costs that would be necessary to engage in the business of production and selling of stoves targeted towards poor customers

Many programs subsidize promotion campaigns that advertise stoves and the alleviation of problems associated with indoor pollution. This approach increases the demand for well-designed stoves. The key is to provide government support as an incentive to developing sound products and strategies to reach stove consumers who will appreciate the benefits of better health and reduced drudgery of fuel collection. The benefits of better stoves can be taught in schools as part of science and social affairs courses. In addition, mass media campaigns can promote stoves as a way to improve health. But before embarking on such campaigns, much work is needed to assure that the stoves being promoted actually reduce household air pollution in people's homes.

Methods of Financing

One potential method to improve the efficacy of stove subsidies without causing significant market distortions is to issue poor households rebates

or vouchers for stoves that meet certain standards. Such a subsidy would be both well-targeted and equitable. Since better-off households already use such modern fuels, as LPG, the subsidy would reach the right populations. This, in turn, would stimulate demand, which would encourage market development. Such vouchers or rebates could be used to purchase any stove in the marketplace approved by a qualified testing laboratory.

Alternatively, financing could be made available for customers to pay for approved stoves through monthly or bimonthly installments. This is a quite common feature of energy efficiency and renewable energy programs. Many of the better programs have been implemented by microfinance organizations or NGOs which have a good track record for actually collecting the monthly installment payments. Poor people generally have a hard time with high upfront costs of any appliance purchases. For those purchasing wood or other biomass products for fuel, this spreading of the monthly costs over time may actually allow them to recoup the cost of the stove in a matter of months. This is common for the better charcoal stoves because charcoal is a purchased fuel, but it may not be as applicable for those households that collect biomass energy.

For financing stove programs, today there are interesting varieties of new financing sources available. These include both private and public carbon funds, the Global Environment Facility and others funds that are more directed towards improving the sustainability of local woodlands. Many of these grant facilities that can provide support for specific costs involved in the promotion of better stoves. However, as of today the funds have been used extensively for biogas cooking, but there have been only very small efforts for supporting better stoves.

To summarize, the most successful stove programs have directed subsidies and incentives toward product and market development rather than extensive stove subsidies. This approach has facilitated an enabling environment that has stimulated entrepreneurs to build stoves and create a viable market for them. Effective subsidies support an array of R&D and training activities. This includes the development of technical facilities for stove testing. There is also a need to monitor stove functionality and gather users' opinions that in turn are used to inform stove design and manufacturing. There can be training of stove makers or incentives for manufacturers. Finally, once efficient and relatively clean burning stoves are in the marketplace, funds can be used for promoting the stoves widely to the public.

EFFECTIVE IMPLEMENTATION, MARKETING, AND CUSTOMER FOCUS

Most successful stove programs have had dedicated implementation groups. Whether China's rural energy units or Bangladesh's NGOs or Vietnam's

Women's Union, such outreach groups have focused on improving energy services for consumers. Sometimes women's groups, NGOs, or microfinance agencies have succeeded in promoting stoves (Cecelski 2000; Shailaja 2000). However, it should be kept in mind that these organizations are not likely to have the technical ability to develop better stoves, so they must have access to products that are rated or certified to perform well.

Integration with Social and Health Objectives

If integrated into broader social initiatives that enhance village welfare and improve overall cooking practices, stove programs are more likely to succeed. In Guatemala, for example, where many rural households now use improved stoves, multiple ways have been found to promote the stoves. The primary mechanism was a government social fund that communities could have used for a variety of purposes. The communities had choices between improving roads, schools, and other development projects. However, assistance for community members to purchase government-approved stove models was quite popular under this program. The particular stove that was qualified for the program was valued at US\$ 50–100. In addition to the government stove program, local NGOs without access to the social fund, but with strong support from international development agencies, have offered rural consumers a wide variety of stove designs.

To date, health ministries and other agencies have had little involvement in stove programs. They should be at the forefront of such efforts—in cooperation with local governments, schools, and health services units—to remove indoor pollution and improve household air quality. At the local level, the focus could be on causes of respiratory illness; at the national level, an awareness-raising campaign could be considered. Such efforts could be linked to educating consumers about the need for better ventilation; the role of chimneys in smoke removal; promote use of dry wood; and the importance of keeping children, especially infants, away from smoke-filled environments. There have been some recent considerations in India to provide better stoves to women enrolled in neo-natal programs.

Microfinance organizations, notably Grameen Shakti in Bangladesh, have been effective in promoting stoves. The participation of such organizations has been beneficial in several ways. Many of them have women as their main customers. Also, by offering small loans that can be paid off over time, appliances beyond the financial means of poorer households become more affordable when paid for with credit. The expense of stoves with a lifespan of five to ten years typically can be paid off within several years. Such organizations have cared about the quality of the appliances offered under their programs and some have guaranteed their products for designated time periods.

Effective Decentralization

India's national program effectively devolved responsibility to the implementing NGOs, women's groups, and other grassroots organizations to ensure a successful outcome. The NGOs of West Bengal, the village councils of Gujarat, the rural women's groups of Haryana, and the traditional potters of Maharashtra are all noteworthy cases. West Bengal is perhaps the best example of effective decentralization. After allocating annual targets to the various NGOs, the implementing agency did not interfere in the day-to-day operations of the NGOs. By virtue of being located close to potential stove users, the NGOs could anticipate and cater to users' needs more effectively than could the implementing agencies. In addition, allocating annual targets based on past performance resulted in greater competition among the NGOs, which improved their performance. NGOs wishing to participate in the program were required to undergo a thorough verification process after submitting a formal application to the implementing agencies, which ensured that only qualified organizations were involved in the program.

Like West Bengal, Gujarat also ensured that those closest to the beneficiaries implemented the improved stove program. Under the three-tier government system (Panchayati Raj), local staff estimated stove demand and communicated the results to state-level agencies. The implementing agency used NGOs with a thorough understanding of local issues. Free from cumbersome bureaucratic procedures, the NGOs adapted swiftly to changing circumstances and modified strategies as required. Through such an adaptive management process, the implementing agency was able to extend the program to all districts using a minimal number of staff members, resulting in significant cost savings.

Reaching the Right Populations

The setting of numerical goals or specific quantitative targets is a sound management principle in the design of large public programs. But great care must be taken to ensure that the targets are meaningful. India's national program, for example, frequently emphasized the number of villages involved or stoves installed in their program. This meant a stress on reaching a certain target number of stoves as opposed to promoting the social acceptance and actual use of the stoves. Karnataka and Andhra Pradesh were noteworthy exceptions; success in those states resulted, in part, from following a whole-village approach—that is, 100 percent coverage within a village—to avoid spreading resources too thinly. China's national program, through a request for proposals, selected 200–300 new counties each year based on prospects for success. It chose the most promising counties first, expanding gradually into more difficult areas.

The best international programs have targeted regions with significant biomass shortages and emerging fuelwood markets or areas where residents have a history of purchasing stoves. India's national program shows that residents in areas of biomass scarcity accustomed to spending a long time collecting fuelwood supplies or paying cash for them placed greater value on the improved stoves. In those with the greatest need for the improved stoves, the programs enjoyed greater success even without significant government financial incentives. Furthermore, India's national program experience in Maharashtra shows that users with a history of purchasing biomass stoves or paying to have them built are more likely to value even better stoves. In short, these experiences suggest that selecting villages for program participation should be based on more meaningful targets considering such factors as biomass shortage and customs involving stove purchases. In regions with abundant biomass supplies, establishing markets for better stoves may prove difficult. But emphasizing the health aspect of better stoves may overcome initial skepticism.

Stove Promotion and Market Development

Most successful stove programs aim to promote the commercialization of stoves. But it is impractical to expect the private sector, usually small entrepreneurs, to bear all the costs of stove development and promotion. Governments and donors could assist in the formulation of policies that provide private-sector operators incentives to produce and sell stoves.

India's national program experience in Maharashtra offers a good example. The ARTI, the state's technical backup unit, initiated an entrepreneurship training and development program for traditional potters to participate in the design, promotion, and sale of stoves. This innovative approach focused on the development of easy-to-assemble portable molds for making improved stoves, setting up an entrepreneurship development program for traditional potters, and training potters in the installation of community stoves. Because of their familiarity with local markets, traditional potters could apply sales techniques that rural householders found more convincing than those of government officials or NGOs. The entrepreneurial potters were more capable than targeted government programs in delivering improved stoves (Hanbar 1993; Karve 1993, 1999). The entrepreneurs sold their products both in the open market through the national program. With modest investments, they earned reasonable profits and were keen to expand their businesses. Today, this approach has been even further enhanced by the ARTI through the development of a commercial company that sells clean cooking devices.

An interesting international example in the market development of improved stoves was the training initiative of the Kenya Energy and

Environment Organization (KENGO) (Hyman 1987). Capitalizing on the successful improved charcoal stove program which was started in 1981, this program developed a ceramic Jiko stove based on the design of the Thai bucket model. This stove was safer and more efficient than the traditional metal Jiko. The stove itself was not subsidized; rather, program grants were used for stove testing, training, and promotion of a stove that consumers clearly valued.

From the outset, the KENGO program was commercially driven. Government agencies, NGOs, and private entrepreneurs initially from eastern and southern Africa were trained in all aspects of improved stoves, from materials collection to product marketing. The main teaching model was the above-mentioned improved portable Jiko, which consisted of a ceramic liner and grate, an insulation layer of vermiculite, and an outer painted metal casing. This stove burns charcoal, but portable wood-burning stoves of similar designs were also marketed. The popularity of the Jiko stove resulted from its fuel efficiency, ease of use, attractive painted exterior, and low cost. The improved stove program paid significant attention to user preferences, making compromises between energy efficiency and ease of use.

The rapid expansion of LPG in India offers another useful lesson in the promotion of clean cooking. A network of public distribution companies was developed that was responsible for the marketing of both the stoves and the fuel. LPG is used across all Indian states that have many types of cooking customs. The ability to turn on a burner and instantly have a wide variety of heating levels has made the lives of women more comfortable by alleviating many time-consuming cooking activities, including starting and managing the fire and removing soot from pots and pans. The government conducted extensive safety testing of these stoves before they were marketed to the public.

Finally, the development of more specialized cooking devices might also be a step forward in the promotion of clean cooking. For India, the design and marketing challenge is not about adapting a myriad number of stoves to local customs throughout the country. To the contrary, it is how to incorporate the features desired by a wide variety of sociocultural groups into a small set of better designed or specialized cooking devices. For higher-income households, a variety of specialized cooking devices, including toasters, microwave ovens, and tea or coffee makers already are available to perform specific cooking tasks in a clean and efficient manner. In Haryana, a successful program promoting rice and pressure cookers has already been implemented in rural areas. To improve energy efficiency and lower indoor pollution in rural households, future programs might consider a wider range of cooking devices in addition to stoves. Indeed, many food-specific appliances could be developed for poor or rural households.

NEW APPROACH FOR INDIA AND THE DEVELOPING WORLD

The problems of implementing stove programs are not unique to India. In the context of India's eventual frustration with implementing its national program and similar problems experienced elsewhere, what new directions can India and other countries pursue to achieve more successful outcomes? How can the principles derived from India's best case practices and worldwide international experience be applied in an effective manner?

The six state cases clearly imply that there are several common aspects that provide lessons for successful programs. Putting these lessons into practice has institutional, marketing, and funding implications. These suggestions are not all-encompassing and do not lay out a program blueprint. Rather, they point to a way forward and offer insights that can benefit other developing countries as well. To achieve this, there may be a need to establish one or more organizations to function as centers of excellence for stoves.

The role of such organizations might encompass the support of measures that ensure product quality, provision of information on markets for stoves, work on the role of financing and grants in supporting business development, and support for design innovations and policy studies. Once better stoves are in place in the market, then there would be a need to have ways to share information on successful programs along with an assessment and strategy for consumer education on the benefits of stoves.

The support of measures to ensure the quality and performance of new stoves is essential to any new program for better stoves. One problem with many past programs has been that the products have either not performed as advertised or the stove life was shorter than expected due to poor construction or materials. A key aspect would be the development of stove technical standards and regular monitoring and evaluation of new products. The setting of standards might involve product labeling for stove energy efficiency, combustion efficiency, safety, and durability so that consumers would know what they are getting when purchasing a stove. Besides standards, it would be desirable to encourage the development of new generations of stoves and ways to market them to the public. It might be possible to provide financing for grant competitions periodically to support innovations in technical development, marketing, and new business development. To broaden marketability, grant competitions could be used to promote the development of a wider variety of stove models or to improve promising new ones.

Market information is essential for any form of business development. Generally it is perceived that people are unwilling to spend money on better stoves. However, this perception can be questioned. Many stove programs in various countries have been quite successful, and as indicated in China over

100 million stoves were purchased by families mostly in rural areas. Also, past studies have found that the initial marketing of stoves should be limited to areas where fuelwood shortages are evident and perhaps people actually purchase stoves or fuelwood and other forms of biomass energy. The support for the development of market information for new stoves would encompass fairly extensive market studies and surveys that would initially at least identify areas where people are most inclined to adopt or purchase stoves. As new models are developed, studies could be conducted to assess customers' preferences or concerns for new stove models. This market information would be publically provided to those interested in promoting the new stoves.

The method of providing financing for better stoves has proved to be critical to the success or failure of most programs. Significant subsidies to make stoves more affordable or free to poorer populations have proven ineffective. Conversely, subsidies for marketing and stove development activities, which do not target poor households directly, have sometimes been criticized for not reaching the neediest populations. Despite this, the lessons learned from successful programs would indicate that subsidies should be directed mainly toward market development, encouraging innovation in design and making sure stoves actually perform well.

Nevertheless, there are some programs that provide subsidies for the stoves themselves that actually help to develop the market for stoves. For example, some programs made subsidies available through social development funds; local organizations or communities could use such funds to purchase stoves with proven technical benefits and social acceptance for an entire community. Such an approach is more demand-oriented because the community actually participates in the decision to promote better stoves. Some emerging programs use rebates for approved energy-efficient equipment as an incentive to develop the market for such products. The value of the rebates is often linked to the tested value of energy saved. Such programs could easily be connected to the new carbon funds being set up by international finance organizations, all of which require monitoring and evaluation of the actual project benefits. These are just a few methods for encouraging stove development through financing and subsidies, but the main principle is that they should encourage rather than discourage commercialization of the new stoves.

The importance of information sharing is illustrated in the many programs that seem to want to reinvent stoves for each new project. There still is a need for strong links between technical design, local implementing organizations, manufacturers or producers, retailers, and, of course, consumers. Due to the quite different nature of these groups, there is a tendency for them not to communicate with one another. Sociologists need to talk to engineers, and health specialists need to talk to project designers. This effort would likely require cooperation among energy, health, and environmental agencies. Sometimes

stoves have been developed almost on a community by community basis. Today, some new organizations have come forward to fill this information void. Some standard stove models are becoming well established along with the principles governing technical aspects of stove design.

Once the basic technical and social-acceptance issues are resolved for stoves, a national social marketing strategy can be developed to promote the commercial acceptance of them. However, it should be cautioned that until there are better-performing, safe, and durable stoves available in the marketplace, it would be unwise to have any national or regional market promotion. Good-performing well-tested products must be available before advertising the ill-effects of household air pollution on health or the reduction in fuel collection time for more efficient stoves. Such promotion campaigns could be done by health, energy efficiency, or other agencies.

In addition, the wide acceptance of LPG stoves perhaps contains lessons for the development of better biomass stoves. The benefits of such stoves are that they are efficient, burn fuel very cleanly, can be turned on and off quickly, and permit variable control over heat output. The legacy of the term 'improved' stove involved the judgment of new stove performance compared to cooking over open fires or traditional closed stoves. Perhaps the real comparison should be with the high end of the stove market. The new standard might be how well such new stoves perform compared to cooking with LPG which is very popular worldwide once it becomes an affordable option.

One last issue is whether stoves should be manufactured or constructed in local communities by local artisans. Today there is disagreement over the possible ways to achieve the goals of commercializing stoves that both perform well and are durable. There are a small number of private companies or organizations that are producing stoves in factories or workshops. These groups feel that to achieve the level of quality control and economies of scale necessary, the old method of having stoves constructed of local materials by artisans should be avoided. Another group feels that quality standards can be achieved with proper supervision and screening of materials and those that produce the stoves. A middle approach is to produce key product components in a factory-type environment, and have them installed locally by trained artisans. The resolution of these disagreements may actually have to wait until the stoves promoted by various programs have been field-tested by the agencies responsible for assuring the quality of the stove. There is certainly room for a wide variety of approaches as long as the stoves meet country or local standards and perform well for satisfied customers.

* * *

Today in India and many other developing countries, fuels such as kerosene, natural gas, and LPG, as well as electricity, are promoted and subsidized to

varying degrees. To date, the main beneficiaries have been better-off urban populations. Around the world, programs that promote inter-fuel substitution have achieved remarkable success in urban areas. Ironically, efforts to help poor rural and urban populations dependent on biomass energy switch to more efficient and less polluting biomass stoves have been problematic. As a result, these populations have had little opportunity to improve their energy status. As the pressure on local forest resources increase, many more poor people are forced to switch down the energy ladder to less desirable fuels, such as agricultural residue or animal dung.

In the foreseeable future, better biomass stoves offer the rural and urban poor an intermediate solution that can improve their health, free up their time, and reduce pressure on local resources. This is not an argument against inter-fuel substitution. To the contrary, among households that can afford it, promoting the use of fuels such as LPG is a sound policy that saves people time and improves their health. As societies evolve and their use of commercial cooking fuels becomes more common, the benefits of inter-fuel substitution will eventually spread to rural areas and poor people generally. However, the biomass energy will be burned for cooking in most developing countries for many years to come, and India is taking a promising step in dedicating itself to a new path for better stoves.

Simply put, the international development community can no longer afford to ignore the energy, human health, and environmental problems caused by the burning of biomass in traditional stoves and open fires. The weight of evidence regarding the toll on human health alone increases with each new study, and is already well accepted by the world's established international health organizations. Innovative solutions are required to help all affected populations—those who can afford the transition to modern ways of cooking with gas or liquid fuels, and, more importantly, those who will remain dependent on cooking with biomass energy or solid fuels for years to come.

Glossary

Adivasi	Indigenous people
<i>Anganwadi</i>	Childcare centers for children under 5 years
Awas Yojana	Housing scheme
Backward Classes	Generic term encompassing three lower-class categories (Scheduled Castes, Scheduled Tribes, and Other Backward Classes) entitled to certain rights and preferences under modern central-government policy
<i>Chulha</i>	Cookstove that uses biomass energy (for example, wood, agricultural residues, dung, or charcoal); stove or hearth
Gram panchayat	Village-level self-governing body
<i>Gram sabha</i>	Village assembly
<i>Gram sevak</i>	Government servant appointed to work as secretary to the gram panchayat
<i>Gram sevika</i>	Female village-level worker
Harijan	Poor family dependent on wage labor
<i>Mahila mandal</i>	Women's community group
<i>Mukhya sevika</i>	Female supervisor
<i>Nagli rotla</i>	Leavened millet bread
Panchayat	Rural self-governing institution
Panchayati Raj	Three-tier system of rural local government
<i>Pradhan</i>	Head
<i>Roti</i>	Indian flat bread
Sarpanch	Village head
<i>Talati</i>	Village-level revenue-collection official
Taluka	Administrative block

Tandoor	Traditional stove used for making bread
<i>Tava</i>	Frying pan
Tehsil	Division of land for administrative and taxation purposes
Vana Samrakshana Samiti	Forest protection committee
Zamindar	Landowning farmer
<i>Zilla parishad</i>	Local government body at the district level

Annexure

Research Methodology

Historically, improved stove studies in India have been based on large quantitative surveys from which it has been difficult to extract in-depth, qualitative data regarding local people's perceptions; at the same time, it has been difficult to generalize from smaller studies. This study's research method was innovative in its broad, systematic application of both qualitative and quantitative research instruments. Qualitative research methods were based on a careful selection of districts, blocks, villages, and households, and included focus group discussions; quantitative methods focused on shorter household surveys. For each of the six best-practice case studies, pilot studies were conducted to test the proposed field-research method, which was then customized to fit each state's situation. The pilot studies were well coordinated, and there were extensive discussions between the research teams working in all six states. To avoid redundancy, this annexure is limited to results from the Haryana pilot study.

STUDY GOAL AND OBJECTIVES

The overall study goal was to examine India's implementation of six best-practice case studies of improved biomass stoves in order to enhance the design of future improved stove programs and strategies to alleviate indoor air pollution. The study objectives were to systematically assess the six case studies to isolate factors that contributed to program outcomes and thus identify best practices that future programs should emulate and problems they should avoid. For each of the six states, key decisions made over the course of program implementation were evaluated.

Within the context of international experience, the case studies were examined in terms of the following:

Financing and subsidies/pricing: Most successful programs worldwide have not involved large stove subsidies; rather, subsidies have targeted market development and technical assistance. For the India case studies, stove pricing was examined in terms of production and marketing costs. The issue of whether to produce less expensive stoves made of local materials or more expensive ones using higher-quality component parts was analyzed in relation to marketing.

Market Development: Most successful improved stove programs around the world have used surveys and other techniques to identify stove markets. The India case studies examined how markets were identified as part of program development.

Improved Stove Identification and Development: The development process of many successful international programs has been iterative, involving test marketing under field conditions and ongoing interaction between designers and targeted users, mainly women.

Customer Service: The case studies evaluated the effect of improved stoves on rural communities and consumer satisfaction.

Operations/Procedures: The case studies examined the allocation of institutional responsibilities, work, and community and artisan training.

Communications/Promotion: The case studies assessed communication management between executing agencies, stove manufacturers, and rural beneficiaries. They considered whether outreach programs were in place to inform consumers about available services.

Local Perceptions: The case studies examined how local people valued their improved stoves in terms of energy and time savings, convenience of use, and indoor cleanliness and health-related concerns. Via focus group interviews, users were questioned about their reasons for household adoption and satisfaction.

PILOT STUDY RESULTS: THE HARYANA EXAMPLE

The pilot survey in Haryana, conducted in 2001, focused on two villages in Panchkula District: Bunga and Khangesara. These villages were selected in consultation with implementing agency staff at state and district levels. In Bunga, 193 of the village's 225 households had improved stoves installed during 1998–9. In Khangesara, 50 out of 150 households received stoves in 1995–6. Focus group discussions, the main instrument for information collection, were conducted with users, implementing agency staff (gram sevikas and mukhya sevikas), and SEWs. Bunga had two focus groups: landowning farmers (zamindars) and poorer families dependent on wage labor (harijans).

Khangesara, which has a large Muslim population, had one focus group comprised of Muslim women.

The focus groups were homogeneous and were not dominated by single groups or individuals. All participants knew each other and were comfortable expressing their views openly. No men were present, with the exception of India project team members from Winrock International. The gram sevikas and community group heads (*mahila mandal pradhans*) helped to initiate discussion; once the process was underway, many other participants voluntarily began to share their views. Facilitated discussions were based on issues jointly identified by TERI and Winrock International. No direct questions were asked, and only certain issues were raised; no problems occurred in following the checklist, and participants were forthcoming with their responses. In both villages, user profiles were generated using a one-page questionnaire. Women were individually administered the questionnaire at the end of focus group discussions or, for those who could not attend, via home visits.

Key Findings

Market Demand and Stove Subsidies: Users paid SEWs Rs 22 (US\$ 0.46) for the improved, two-pot mud stove constructed in their homes. While most women found these improved stoves useful, they were unwilling to pay more. Community members differed in their willingness to pay; for example, the zamindars were open to the idea of some price increase over the years, while the harijans were unwilling to pay more than the current cost. Enthusiasm for the proposed cement chulhas was high, despite concern about the potential for cracking when hot. Some zamindars were willing to pay Rs 40 (US\$ 0.84) for the cement chulhas, but most believed they should pay the same price as for the two-pot mud stove. The gram sevikas and mukhya sevikas corroborated this view: Even in villages where the positive response to improved stoves was strong, obtaining Rs 22 (US\$ 0.46) from users was already difficult; finding buyers for stoves priced above this amount would be even more difficult.

Discussions with village men indicated that, while they were aware of the improved stove program, they were not interested. As long as stove prices were ‘insignificant’—that is, Rs 20–5—women could have the improved stoves installed without their husbands’ involvement in the decision. But raising prices above this range would mean women would have to approach their husbands, who would likely be unwilling to incur any expenditure.

Institutional Structure: In Haryana, the national program was carried out through lady circle supervisors at the district level, who worked directly under the Women and Child Development Department, the state’s nodal agency for the national program. These district-level supervisors were responsible for other department activities, including the organization of mahila mandals,

health, family planning, and social forestry. At the block level within each district, a mukhya sevika was designated to supervise the activities of gram sevikas, who worked at the village level in collaboration with SEWs.

At the village level, the mahila mandal and the mahila mandal pradhan played a crucial role. Each mahila mandal had 20–40 women who worked on various programs, including health and education. The mahila mandal pradhan, who acted as the gram sevikas' village contact, helped to identify and motivate potential beneficiaries and played an active role in user camps. The mahila mandal pradhan was also responsible for storage of stove-building materials before construction and helped in the building process.

For prospective user households, the gram sevikas conducted a pre-installation survey in order to collect information on potential site availability, the chimney pipe (whether it could extend through the roof), and ceiling height (if the roof was higher than the standard 1.8 m length of the chimney pipe, two pipes needed to be joined together).

Purchasing Criteria: Both villages had ample fuel. Most families had access to adequate biomass fuels; these commonly included crop residues (mainly cotton stalk) and dung cake, which was readily available as most households owned several buffalo. Non-landowning households usually traded crop residue for agricultural labor. Many households also had LPG connections. Because fuel shortage was not an issue, fuel savings was not an incentive for women to adopt the improved stoves. According to users, the motivating factor was smoke reduction. Many women purchased the improved stoves because others in their village did. For members of the mahila mandal, the primary reason was that the mahila mandal pradhan asked them to do so.

Interaction between Designers and Users: Users' only points of contact with the implementing agency and stove designers were the SEWs, gram sevikas, and mukhya sevikas. In focus group discussions, village women stated that they were unaware of other agencies involved in the improved stove program. Some communities, including the Jats, perceived design problems—the firebox opening was not large enough for making roti, their staple diet—which they conveyed to the gram sevikas. In many cases, the SEWs made stove modifications at the time of construction to suit users' needs. The gram sevikas, who were aware of this practice, considered these modifications minor and not ones that would significantly affect the stove's efficiency.

In Khangesara, the chimney outlet in some Muslim households was left inside the kitchen. When the improved stoves were being built, male household members were unavailable, for which reason women could not make a decision regarding the hole in the single asbestos-sheet roof. Although the men understood that taking no action defeated the purpose of the improved stove, they were unwilling to make a hole in the asbestos sheet to allow the chimney pipe to extend through the roof. The SEW who lived in the nearby

village of Nangal visited the households regularly, but did not report this issue to higher authorities.

Perceived Benefits: As mentioned above, users perceived the improved stove's primary benefit as smoke reduction. Additional perceived benefits were fewer soot deposits on cooking vessels and kitchen walls and the convenience of using two cooking pots at the same time.

Non-users gave a variety of reasons for non-adoption. The most common one was that those women who had differences with members of the mahila mandal did not receive the improved stoves. Another key reason was that limited village targets prevented many women from getting improved stoves, despite their desire to have them installed. Additional reasons included lack of installation space, uncertainty about the benefits, and lack of information because they had not been approached by the gram sevikas.

Adopted Recommendations

Based on results from the Haryana pilot study, the initial method was modified, as follows:

- For focus group discussions, the pre-selected list of issues was used, and found appropriate.
- A village profile was conducted to gather general information on the local fuel situation, communities, accessibility, and presence and efficacy of the mahila mandals and other government programs.
- Non-user household surveys were conducted to collect information on why non-users were not motivated to participate in focus group discussions.
- Discussions with men were included as a separate activity to obtain their views of the program.

TYPICAL SAMPLING METHODS

Sampling was conducted at district, block, village, and household levels to examine areas with high concentrations of improved stoves. Study districts were identified in consultation with nodal agencies during a reconnaissance visit to the state. A major selection criterion was the number of improved stoves constructed within the previous five-year period. Next, blocks in the selected districts were identified in consultation with nodal agencies and NGOs. Selection was based on the number of improved stoves distributed in the previous five years, involvement of NGOs, and the logistics of undertaking field surveys in such areas. Given the extensiveness of distribution, selection of villages and households was entrusted to groups involved in stove distribution in the short-listed blocks. Given the absence of collated records of target villages and user households and the enormity of the compilation task, rural and peri-urban villages with varying socioeconomic characteristics

were selected. It was also important to include areas where local cooperation could be assured.

DATA-COLLECTION INSTRUMENTS AND TOPICS

After pilot-testing the method, data were collected from various groups on topics related to the pre-selected issues. Data-collection instruments included focus group discussions and interviews. The key groups questioned were implementing agencies, improved stove users and non-users, technical backup unit staff, stove builders (SEWs), and raw materials and parts suppliers. In addition, brief questionnaires were used to collect household- and village-level data from selected improved stove users and village heads (sarpanches).

Implementing Agencies (Focus Group Discussions and Interviews)

Through interactions with the implementing agency staff, the study documented the chronology of the improved stove program. This included historical information on reasons/motivation for getting involved (fuelwood shortage, demands from constituencies, need for expansion, and available funds), key decisions made, constraints faced, lessons learned, and suggested improvements. These issues are described below.

Stove Pricing and the Role of Subsidy

1. Strategy for pricing improved stoves.
2. Price fluctuations of improved stove models.
3. Component prices and potential for lowering prices.
4. Effect of lowering or eliminating subsidy on demand.

Institutional Structure

1. Agencies involved in national program implementation and their roles.
2. Stages of the distribution process (needs assessment, beneficiary identification, planning, raw materials procurement, transport, construction, and quality control).
3. Organizational support and incentive system for staff members.
4. Participation of users, especially women, in the distribution process.
5. Mechanism to monitor and evaluate program performance.
6. Implementation problems confronted.
7. Suggestions for program improvement.

Criteria for Improved Stove Selection

1. Reasons for adoption or non-adoption.
2. Typical characteristics of people who initially adopt the improved stoves.
3. Reasons why communities adopt improved stoves at a later stage.

Market Development, Communications/Promotion, and Customer Service

1. Promotional activities and publicity campaign undertaken.
2. User education and training.
3. Interaction with other implementing agencies.
4. Technical training programs: selection criteria, adequacy of funds, and effect.
5. Supply infrastructure (servicing network, manpower, and availability of spare parts).

Funding Barriers

1. Current funding sources.
2. Contribution (own funds) to the national program.
3. Views and recommendations on subsidy patterns by the Ministry of Non-conventional Energy Sources.
4. Adequacy of funds received to implement program operations.
5. Barriers.
6. Incentives/profits system.

Interaction between Stove Designers and Users

1. Information flow between SEWs, promoters, and users: frequency of meetings, feedback, and conflict resolution.
2. Interaction with technical backup unit on design modifications and field testing of models.

Improved Stove Users (Focus Group Discussions)

Stove Pricing and the Role of Subsidy

1. Prices paid for improved stoves and awareness of government subsidy.
2. Willingness to install if subsidy were withdrawn or stove cost increased.
3. Cost of constructing/acquiring a traditional stove.
4. Willingness to pay stove builders (SEWs) higher service charges.
5. Willingness to pay higher prices for better stoves.

Criteria for Improved Stove Selection

1. Perceived benefits (fuel and time savings, better health, convenience, less workload) and level of use.
2. Problems with traditional stove use, if any.
3. Willingness to install improved stove or replace parts when needed.
4. Attitude of older women in the household toward improved stoves.
5. Problems with improved stove use, if any.
6. Suggestions for improvements in design and installation.

Promotion, Customer Service, and Feedback

1. Improved stove information sources and motivation for adoption.
2. Information about and participation in awareness camps.
3. Attendance in user-training camps and their effectiveness.
4. Levels and types of interaction between implementing agency staff and users before and during program implementation.
5. Information provided by stove builders (SEWs) on use and maintenance.
6. Interactions with nodal agencies, technical backup units, and NGOs regarding installation and design modifications.

Interaction between Stove Designers and Users

1. User involvement in construction process.
2. Method of informing SEWs about complaints and user attempts to rectify.
3. Improved stove information for which agency is responsible for disseminating in the village.

Improved Stove Non-users (Interview Questions)

1. What cooking device(s) do you use at home?
2. Do you know about the improved stove program in your village and about improved stoves in general (sources of information, levels of knowledge)?
3. What is your idea regarding the benefits from an improved stove?
4. Why have you not adopted an improved stove?
5. Do you plan to adopt an improved stove in the future? Do you know which agency to approach?

Technical Backup Unit Staff (Focus Group Discussions and Interviews)

Stove Pricing and the Role of Subsidy

1. Cost of improved stove models and process of fixing prices.
2. Manufacture of low-cost, efficient improved stoves.
3. Market potential for purchase of high-cost, durable improved stoves.
4. Market dependence on price or quality of improved stoves and price fluctuations.

Institutional Structure

1. Reporting mechanisms and arrangement with the state nodal agency.
2. Types of training programs conducted, course content, and participant selection criteria.

3. Eligibility of SEWs trained by other agencies.
4. Levels and types of interaction with stove users and village-level functionaries.

Market Development, Communications/Promotion, and Customer Service

1. Role in developing communications/promotional materials.
2. Entrepreneurship development programs undertaken, their effect, and participants' feedback.
3. Level and frequency of interaction between NGOs, builders, and users regarding design modifications and training.
4. Mechanism for field monitoring and evaluation.
5. Other barriers to program success.
6. Recommendations for increasing program effectiveness.

Funding Barriers

1. Funding sources.
2. Adequacy of funding for implementing program operations.
3. Operational problems confronted, such as delayed payments from funding agency.
4. Views and recommendations on subsidy pattern by the Ministry of Non-conventional Energy Sources.
5. Expected effect of subsidy elimination on improved stove cost.

Research and Development

1. Improved stove models (fixed/portable) designed and modified (with design specifications).
2. Types of innovations made to models distributed.
3. Agency responsible for selecting improved stove models to be distributed.
4. Types of raw materials required for improved stoves and their availability.
5. Field testing undertaken (process, frequency, geographical area, household selection criteria).
6. Check on quality control for raw materials used and stove construction.
7. Identification of raw materials suppliers and check on quality control.
8. Availability of in-house, R&D expertise and facilities.

Stove Builders (Focus Group Discussions and Interviews)

Stove Pricing and the Role of Subsidy

1. Fee levels for SEWs.

2. Views on subsidy pattern and level.
3. The expected effect of subsidy reduction or elimination on demand.

Institutional Structure

1. Arrangements between implementing agency, stove builders (SEWs), and users.
2. Allotment criteria of improved stoves for stove builders (SEWs).
3. System for passing feedback on improved stove use to implementing agency.
4. Arrangements for supplying raw materials and installation.
5. Payment delays by users and NGOs.

Motivation for Stove Builders (SEWs)

1. Motivation for stove construction.
2. Whether stove construction is a full-time occupation or supplementary income source and number of months occupied per year.
3. Number (average) of improved stoves constructed per day.
4. Average income and profit margin.
5. Operational barriers.

Market Development, Training, and Communications/Promotion

1. Methods for market development and motivation of potential stove adopters.
2. Induction into initial training program and role of gender in selecting SEWs.
3. Training program contents and types of improved stove models constructed.
4. Travel for training outside the block or district.
5. Communication undertaken with all sections of the community.

Interaction between Stove Designers and Users

1. Quality-assurance system for stove installations.
2. Customer service.
3. Common user complaints and typical modifications made without SEW's consent.
4. User feedback to technical backup unit regarding design modifications.

Raw Materials and Parts Suppliers (Focus Group Discussions and Interviews)

1. Coverage of geographical area (district/blocks/villages).
2. Program's profit margins in supplying raw materials.

3. Transport to interior project sites, including compensation for damage during transport.
4. Quality-control procedure.
5. Operational barriers, such as payment delays and damage during transport.
6. Future program plans for supplying materials.
7. Suggestions for improving existing arrangements.

HOUSEHOLD QUESTIONNAIRE (INTERVIEW WITH SELECTED IMPROVED STOVE USERS)

Village:

District:

Block:

<i>Question</i>	<i>Household Respondent</i>
Number of family members	
Highest level of education in the family	
Land owned (acres)	
Type of house (permanent/semi-permanent)	
Means of livelihood (farming/service/business/other)	
Assets owned (television/cycle/mobike/tractor/other)	
Type of improved stove (with/without chimney)	
Type of improved stove (single/double pot), fuelwood/coal	
Type of improved stove (commonly used fuel type)	
Stove materials (mud/cement/metal)	
Year of improved stove installation	
Gender of SEWs	
Amount paid (Rs) for improved stove construction	
Whether traditional chulha is still used (yes/no, inside/outside)	
Present condition of improved stove (functional/non-functional)	
Good features of improved stoves: better health (1), no eye or asthmatic problem (2), cleaner kitchen (3), time savings (4), fuel savings (5)	
Poor features of improved stoves	
Attendance at user training (yes/no)	
Whether improved stove modifications were made (yes/no)	
If yes, types of modifications (firebox/potholes/tunnel/ chimney/other) and how many times	
Cost (Rs) incurred in rectification	
Frequency of chimney cleaning (weekly/twice a month/once a month/never)	
Whether and when any agency (name) requested feedback on the improved stove	

VILLAGE QUESTIONNAIRE (INTERVIEW WITH VILLAGE SARPANCH)

1. Village name: _____ District name: _____
2. Location (distance from block and district headquarters).
3. Fuel situation (main fuels used, availability, prices, and ease of transport).
4. Food habits (compatibility with the improved stove).
5. Main communities and their characteristics.
6. Government programs and village schemes.
7. Types of community-based institutions in the village (structure, internal processes, member contributions, stability, and role in other village development activities).
8. Factors for adopting improved stoves in the village.
9. Stove types (models) and approximate number installed in the village.
10. Types of people and communities that have adopted the stoves and beneficiary selection criteria.

Views on subsidy:

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Index

- Advanced biomass stoves
 - definition of 4
 - Government of India initiative 115
 - recent developments in India 122–3
 - standards for 141
 - Agricultural Tools Research Center 75
 - Andhra Pradesh
 - geographical location of 79
 - improved stove national program 78, 116–20
 - chimney cleaning frequency 82
 - chulha development agencies role in 91–2
 - construction process and models 92–3
 - development and production of 86–9
 - distribution of 80
 - focus group discussions, indication of 83–4
 - installation of subsidies 94
 - Ministry of Non-conventional Energy Sources, guidelines of 83
 - Non-conventional Energy Development Corporation, establishment of 79
 - perceived benefits from 81
 - problems faced by households 81–2
 - Regional Engineering College at Warangal, establishment of 80
 - shortcomings 83
 - structure of institution and role 89–92
 - subsidy scheme challenges 84–6
 - success of 93
 - whole-village approach 94
 - withdrawal of central fund 94
 - particulate concentration exposure from fuels of cooks and non-cooks 7
- Appropriate Rural Technology Institute (ARTI) 24, 26, 30, 34, 122–3
 - Astra Ole model 50–1
- Bangalore Centre for Application of Science and Technology to Rural Areas 18, 50–1
 - Bangladesh, biomass collection time in rural 10–11
 - better stoves
 - benefits of 5
 - reduction of fuel collection and avoided expenditures 9–13
 - development of designs
 - focus on quality control 129–31
 - need for better and diverse designs 125–9

- technical design problems 124–5
 - entrepreneurs of 5
- biomass energy, availability in rural areas 14
- biomass fuels 2
 - collection by
 - rural families 1
 - South Asia and Sub-Saharan Africa 10
 - deterioration of local environment 1
 - use and deforestation 13–15
 - women time allocation, in rural India 12
- biomass smoke, effects on health 8–9
- biomass stoves ix
 - benefits of 2
- black carbon 15, 16
- cash economy 5
- Chimney cleaning
 - in Gujarat districts 68
 - in Maharashtra districts 28
- China
 - biomass cookstoves, manufacturing of, 4
 - national stove program, 136
 - stove
 - designs, 126
 - programs in 3
- chulha development agencies, role in Andhra Pradesh improved stove program 91–2
- climate change
 - household energy and (*see* Household energy and climate change)
- coal-burning stoves ix
- cook fuels, particulate concentration exposure, in Andhra Pradesh 7
- cookstoves, international alliances on clean 2
- CPRI I and II improved stoves 87
- data collection
 - instruments and topics
 - implementation agencies 150
 - improved stove non-users 152
 - improved stove users 151–2
 - raw materials and parts suppliers 154–5
 - stove builders 153–4
 - technical backup unit staff 152–3
- Eckholm, Eric 1, 13–14
- effective improved cookstove 4
- Entrepreneurs, of better stoves 5
- Envirofit International 123
- Fine particles. *See* Particulate Matter (PM)
- fireplaces, testing of ix
- firewood, use in developed countries ix
- Ford Foundation program 36
- fuelwood-burning
 - in developed countries ix
 - in developing countries ix
- fuelwood shortages 13–14
- Gambia, study on impact of indoor pollution, on children 9
- Guatemala
 - focus on improved stove design 3
 - Lorena stove (*see* Lorena stove)
- Gujarat
 - geographical location of 64–5
 - improved stove national program 64, 116–20
 - chimney cleaning frequency 68
 - development and production activities 71–3
 - distribution of 66
 - features of 76
 - implementation agencies 66
 - organizational structure 73–5
 - perceived benefits from 67
 - quality control challenges 75–6
 - shortcomings of 76–7
 - user complaints regarding Mamta model 67
 - views on large subsidies 69–71
 - withdrew in 77

- Gujarat Energy Development Agency
66, 71–7
- Haryana
geographical location of 36–7
improved stove national program
116–20
challenges on implementation
47–8
complaints regarding 41
decentralization of 48
dissolution of 48–9
encouragement of subsidies 42
institutional structure, for
distribution 45–7
perceived benefits from 40
users of 39
women network, development
and production of 42–5
pilot survey in 146–7
adoption of recommendations
149
key findings 147–9
- hearth(s)
cleaner 2, 114
meaning of ix
- household energy and climate change
15–16
- household questionnaire, interview with
improved stove users 155
- Hyderabad Engineering Research
Laboratory chulha, 1953 18
- implementation groups, for stove
programs
effective decentralization 136
integration with social and health
objectives 135
promotion and market development,
of stove 137–8
reaching of right population 136–7
- improved cookstove 4
- improved national stove program
attributes of best programs 116–20
developments in India 122–3
features of 121
foundation of 18
Government of India (GoI) decision
to decentralize 19
to give subsidies 20
- improved stove
affecting MDGs 6
definition of 2–5
development of questionnaire, for
assessment of user profile 21
GoI decision to cancel program on x
Haryana, users in 39
links with human health 5–6
primary goal of 18
study in India
goal and objectives 145–6
survey in India 9
- Indian Institute of Science 18
- Indira Awas Yojana 34, 78
- indoor air pollution, World Bank
project on health implications of x
- indoor pollution
from solid household fuels 5
study, in India 6–7
- information sharing, importance of
140
- Integrated Rural Energy Planning
Program 31
- Jal Nirmal Project 62, 122
- Karnataka
geographical location of 50–1
improved stove national program 50,
116–20
construction and training issues
60–1
distribution of 52–3
initial delivery structure 58
junior engineers role 59
local institutions role 60
origin of 51
subsidy pattern under 57–8
survey of households and user
perceptions 54–7
targeting met under 53
timeline of events 52

- withdrawal of central funding 62
- Kenya, stove programs in 4
- Kenya Energy and Environment Organization (KENGO) 137–8
- Kenyan Jiko stove 4
- Kerosene, women time allocation in rural India 12
- Liquefied Petroleum Gas (LPG) ix, 1, 6, 8, 11, 26, 31, 39, 54, 57, 62, 77n4, 99, 115, 124, 134, 138
 - benefits for using 11
 - stoves 39, 141
 - national program 26
 - use of 11
 - survey in 2005 9
 - women time allocation, in rural India 12
- liquid fuels, use in urban areas 1
- Lorena stove, development in Guatemala 3
- Magan chulha, 1947 18
- Maharashtra national stove program 116–20
 - background of 24
 - improved stoves installed 25
 - improved stoves use 26
 - challenges on implementation 33–4
 - household characteristics and user perceptions 26–8
 - institutional structure 31–3
 - policy of subsidizing improved stoves
 - impact of 29–30
 - traditional potters, role of 30–1
- Mamta model 66, 67, 69, 72
- Market information 139
- Millennium Development Goals (MDGs) 5
- Ministry of Agriculture 4
- Ministry of Non-conventional Energy
 - Sources 18, 42, 83
- Nada chulha, Haryana 18
- Nada model 36, 42, 48
 - distribution of improved stove models 38
 - origin of 38
- Nada stoves 18
- National Dairy Development Board 52, 61
- National Improved Stove Program (NISP) 4. *See also* Ministry of Agriculture
- non-cook fuels, particulate
 - concentration exposure, in Andhra Pradesh 7
- non-smoking women, exposure to biomass
 - study in India and Nepal 8–9
- open-fire stoves, impact of cooking, on women health 1
- Particulate Matter (PM) 6. *See also* Fine particles
- PM_{2.5}
 - definition of 6
 - Guatemalan highlands exposure to 6
- PM₁₀, definition of 6
- Sahayog 80, 87
- Sampling method 149–50
- Sant Gadge Baba Swacchata Abhiyan 34
- Santayana, George 17
- Sarale Ole model 50, 52, 53, 54, 59
 - construction of 60
- Self-employed Worker (SEW) 21, 29, 73, 103, 161
 - certification camps for 43
 - designing of faulty stoves 45
 - in Andhra Pradesh 80
 - formation of chulha
 - developmental agencies 91
 - in Karnataka 57
 - in Maharashtra 32
 - in West Bengal
 - stove construction 109
 - service after installation 129
 - stove modification during construction time 148

- single cooking fuel 11
- smoke exposure 6–8
- Sneha model 66–7, 69–70, 72, 76, 133
- solid fuels 1, 3
 - avoidance of cooking-fuel expenditures 114
 - exposure concentrations, of PM₃ 7
- stove
 - programs
 - China focus on 3
 - late 1970s, early 1980s 3
 - use and fuel collection, by rural women of India 12
 - stove models
 - Astra Ole model 50–1
 - Mamta model 66, 67, 69, 72
 - Nada model 36, 42, 48
 - Sarale Ole model 50, 52–4, 59
 - Sneha model 66–7, 69–70, 72, 76, 133
 - Sukhad model 54, 60, 87–8
 - subsidy, in stove programs
 - applications 132–3
 - basics of design and financing 131–2
 - financing methods 133–4
 - Sukhad model 54, 60, 87–8
 - Swacha Grama Yojana 62, 122
- ‘the other energy crisis’. *See* Eckholm, Eric
- traditional stove(s)
 - alternative to problems 115
 - definition of 4
 - range of 2
- village questionnaire, interview with village sarpanch 156
- West Bengal
 - forest areas 96–7
 - geographical location of 95–6
 - improved stove national program 95, 116–20
 - complaints regarding 99–100
 - construction and service 109–10
 - distribution of 97
 - establishment and role, of technical backup unit 97, 104–5
 - features of popular improve stove models 101
 - institutional structure 105–9
 - origin of 97
 - perceived benefits from 98–9
 - production and delivery challenges 110–11
 - state-funded programs 97–8
 - subsidy structure 102–4
 - success of 112
 - types of user modifications 100
- World Health Organization (WHO) 5, 6, 13
- wood-burning stoves, testing of ix
- World Bank project x

Cleaner Hearths, Better Homes

New Stoves for India and the Developing World

In a largely globalized era characterized by technological advancements, many developing countries still depend on biomass energy for sustenance. Much of India's rural population still relies on the traditional *chulha* for daily needs, thus increasing environmental health risks due to indoor air pollution.

Cleaner Hearths, Better Homes draws on case studies from six Indian states—Maharashtra, Haryana, Karnataka, Gujarat, Andhra Pradesh, and West Bengal—and other stove programs around the globe. It discusses India's best improved biomass stove programs and suggests policies and practical ways to promote the use of cleaner burning, energy efficient, and affordable stoves.

The findings in this book will be of interest to scholars, students, and researchers concerned with energy and environment studies, and development studies and economics. Policymakers and administrators, activists, non-profit and aid organizations, and related government ministries and bodies will also find it very useful.

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