DISSEMINATION OF IMPROVED COOKSTOVES IN RURAL AREAS OF THE DEVELOPING WORLD:
Recommendations for the Eritrea Dissemination of Improved Stoves Program

A Study Conducted for the Eritrea Energy Research and Training Center (ERTC)

by

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EXECUTIVE SUMMARY

Biomass fuels such as wood, charcoal, dung, and crop residues account for approximately half of the industrial and household energy consumption in developing countries. Domestic cooking makes up a major portion of the total energy used in these nations, (close to 60 percent in Sub-Saharan Africa) and nearly three billion people worldwide cook their meals on simple stoves that use biomass fuels.

Efforts to improve the efficiency of biomass cookstoves date back to the 1940s. In recent decades, urban areas in developing nations have experienced higher penetration rates of improved stoves; indeed, many urban households have made the switch to cleaner fuels like liquid petroleum gas (LPG) or kerosene for cooking. Most rural households in these countries, on the other hand, are not endowed with the infrastructure that would bring them cleaner fuels, nor do they have the adequate income to pay for the fuels if they were available.

The author believes that low-income communities located in rural areas without access to markets or energy infrastructure are most likely to benefit from improved cookstove projects. The dissemination of increased-efficiency cookstoves in these households can be a step taken toward curbing indoor air pollution, decreasing time and money spent on fuelwood, and preventing the use of animal waste for fuel, which results in less fertilizer being available for agriculture. Eritrea, with a rural annual per capita income of only $200 and with less than one percent of its rural households having access to electricity, could greatly benefit from increased efforts in improved cookstove dissemination.

This paper addresses the problem of low adoption rates of improved cookstoves in rural settings in the developing world in an effort to provide recommendations to the Eritrea Dissemination of Improved Stoves Program. To identify key determinants of successful improved cookstove programs, four programs that target rural settings were examined. The analysis of improved cookstove programs in India, China, Eritrea, and Ethiopia enabled the author to come up with the following recommendations for the Eritrea Dissemination of Improved Stoves Program:

1. The Eritrea Dissemination for Improved Stoves Program should **continue the subsidy approach** to make the stoves affordable to low-income rural communities. However, the program should **avoid setting quotas** for improved stove dissemination, as was done in India. In addition, the program should be closely monitored to ensure that subsidies are not leading to the distribution of unused stoves or stove parts.

2. As the program moves on to national scale, Eritrea should **promote commercialization and mass production** of the stoves. This will allow stove producers to benefit from economies of scale and bring improved stove prices down. As the stoves become more affordable, subsidies can be phased out. As mass production of stove parts becomes a reality, the Eritrea Energy Research and Training Center (ERTC) should **encourage competition between stove producers** and ensure that the parts are of high quality.

3. Eritrea should **encourage competition between villages** that can prove to the government that they are ready and organized for a village-level switch to improved cookstoves. This approach helps identify those villages that represent households that have greater use for the stoves.

4. The Eritrean program should **rely on a stronger promotional strategy** as the project moves to national scale. The program might want to investigate ways in which it could further promote the improved cookstoves. The author believes that the program could greatly benefit from a project promotion survey, which could direct the program administrators to the most effective avenues for promoting the improved cookstoves. Finally, Eritrea should **evaluate the effectiveness of the current promotion strategies.** This will be useful in ensuring that funds for promotion are being spent on the right strategies.

5. Eritrea should continue to **solicit feedback from the users** of the improved stoves and make sure that the stoves continue to adequately address the needs of the rural households. This can be possible through conducting more user surveys or visiting villages to talk to stove users. There should be a feedback mechanism put in place as the program branches out to more villages in the country. Since, some degree of heterogeneity in user needs among different regions should be expected, the Eritrean program should make sure these are not overlooked by building a strong channel of communication between program administrators, technical staff, and local communities.

6. The Eritrean ERTC should **monitor the results of the improved cookstove program** and aim to **complete annual evaluations** on the progress of the program.

7. The enlargement of the scale of the program to the national level will require increased levels of funding, especially if the subsidies are to be sustained. Eritrea should find ways to **inform international donors and NGOs about the program's success** in the initial two phases. The Eritrean Technical Exchange can be instrumental in these efforts.

8. The survey of the four improved cookstove programs has shown that the maximum rate of adoption ranges between four to five percent, as realized by the Chinese National Improved Cookstove Program. The Eritrean program should view this number as a target while monitoring the dissemination efforts closely to make sure that the adoption of cookstoves results in the use of cookstoves. Eritrea has to **significantly increase the dissemination of improved stoves** as it moves to the Sustained National Promotion Phase. Currently, an average of 2900 stoves are being installed annually. This number has to increase to approximately 25,000 stoves to achieve a dissemination rate similar to that of the Chinese program, which is the most successful program surveyed in this study.

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LIST OF ABBREVIATIONS

ANRS	Amhara National Regional State
BEPE	Bureau of Environmental Protection and Energy
ARTI	Appropriate Rural Technology Institute
CNISP	Chinese National Improved Stoves Program
ERTC	Energy Research and Training Center
GTZ	Deutsche Gesellschaft fur Techniche Zusammenarbeit
HEPNR	Household Energy/Protection of Natural Resources Project
MNES	Ministry of Non-Conventional Energy Sources
NEDCAP	Non-Conventional Energy Development Corporation of Andhra Pradesh
NPIC	Indian National Programme of Improved Chulhas
KVIC	Khadi and Village Industries Commission
REO	Rural Energy Office
RTPC	Rural Technology Promotion Center
SEW	Self-Employed Workers
TBU	Technical Backup Unit

I. FOCUS OF THE STUDY.

Since the 1940s, efforts have been made to increase the efficiency of biomass cookstoves by governments, international development organizations, and NGOs. Although many of these programs have been successful in urban areas, improved biomass cookstoves have not reached enough households in rural settings in developing countries where three quarters of the world's 1.2 billion extremely poor people reside. This leaves the rural poor without access to increased efficiency stoves, preventing a reduction in indoor air pollution, greater time spent collecting firewood, as well as the use of dung and crop residues, which would otherwise be used as fertilizer, for fuel. In order to identify determinants of success, this paper will focus on four improved cookstove projects from around the world, which have concentrated their efforts to increase stove dissemination in rural areas. These programs are the Chinese National Improved Cookstove Program, the Indian National Program of Improved Chulhas, the Eritrea Dissemination of Improved Stoves Program, and the Ethiopia Improved Biomass Stoves Program.

The paper will identify parallel characteristics in programs in which high adoption and use rates have been achieved in an effort to provide recommendations to the Eritrea Dissemination of Improved Stoves Program. It is outlined in the following way: Section II provides background on improved cookstoves and improved cookstove programs in the developing world. Section III discusses alternatives to improved cookstoves and why improved cookstoves programs are appropriate interventions for low-income rural communities without access to markets and energy infrastructure. Section IV lays out the methodology that the author will use in evaluating the success of the case studies as well as the certain limitations encountered during the analysis. Section V introduces the four case studies from India, China, Eritrea, and Ethiopia, whose characteristics will be analyzed with a general overview of the improved cookstove programs. Section VI discusses the regional environments these four programs operate in with a special emphasis on rural poverty and fuelwood scarcity in these regions. Section VII focuses on program characteristics of the four case studies such as coordination, the use of subsidies, promotion strategy, technical assistance and monitoring. Section VIII discusses the cookstove characteristics in each case study, including the affordability and durability of the cookstoves, and the degree of user involvement in the design of the stoves. Sections VII and VIII include recommendations for the Eritrea Dissemination of Improved Stoves Program. Finally, Section IX concludes with some recommendations for improved cookstove programs.

II. BACKGROUND ON IMPROVED COOKSTOVES AND IMPROVED COOKSTOVE PROGRAMS

A. What are improved cookstoves?

The most common method of cooking used in developing countries is an open fire. The fire is usually shielded or surrounded by "three or more stones, bricks, mounds of mud, or lumps of other incombustible material." (Foley and Moss, 1983, pp.27) For short, such fires are called "three-stone" fires, where the stones or surrounding materials act as a support for the cooking pot over the fire. These three-stone fires have continued to be used for cooking and heating purposes, mainly due to their simplicity. They are easy to build and virtually free. They can use a range of fuels. They can be adapted to different forms quite easily – i.e. placed on waist-high platforms for more convenience for the user. There are more sophisticated types of traditional stoves, ranging from mud stoves to heavy brick stoves to metal ones (see Figure 1 for different types of cookstoves ranging from the three-stone to metal stoves). Most sources cite the fuel-efficiency[1] of traditional stoves as five to ten percent. Since nearly three billion people in the world use traditional stoves to cook their meals, efforts to improve the efficiency of cookstoves have been increasingly popular in the developing world. Improved stoves come in different forms and sizes. Improved cookstoves can be designed and built in various ways, depending on the local conditions. "At their simplest, improved stoves rely on providing an enclosure for the fire to cut down on the loss of radiant heat and protect it against the wind. In addition, attention can be given to devising methods of controlling the upward flow of the combustion gases, so as to increase the transfer of heat to the cooking pot" (Foley and Moss, 1983, pp.16). Many of these stoves are made of mud or sand since both are almost free and readily available.

Figure 1. Different Types of Cookstoves Source: RWEDP

One should be careful in concluding that traditional stoves are inferior and inefficient and therefore account for the high consumption of biomass resources, as a family's fuel consumption is largely dependent on the fuel scarcity it faces and not necessarily the efficiency of the stove. Studies show that in areas that experience fuel scarcity, consumption is about one third of that in areas where fuel is in abundance. This indicates that households already take measures to cut down on fuel use when they feel the "energy pinch" by "feeding fuel into the fire more carefully, using smaller pieces […], and using the fire for shorter periods" (Foley and Moss, 1983, pp.15). Moreover, one finds that most of the claims citing the inefficiency of traditional stoves in the literature are more anecdotal than scientific and *not all* "improved" stoves have been more efficient than traditional ones (Gill 1985). Traditional stoves have been around for thousands of years and have evolved to meet the local needs in a way that is affordable for the users. Even when the considerable progress in increasing efficiency of cookstoves is taken into account, it is a hard task to offer these stoves at an affordable price to households. This is a daunting task that many improved cookstove programs face all around the world.

[1] Fuel efficiency is the proportion of energy released by fuel combustion that is converted into useful energy (U.S. Environmental Protection Agency, http://www.epa.gov/OCEPAterms/fterms.html). When the term efficiency is used throughout the paper, it relates to "thermal efficiency" which is defined as "the ratio of heat actually utilized to the heat theoretically produced by complete combustion of a given quantity of fuel (which is based on the net calorific value of the fuel)" (http://rwedp.org/acrobat/fd41.pdf).

B. History of Improved Cookstove Programs.

In industrial countries, the switch to more efficient stoves took place smoothly as fuelwood prices increased and stove makers increased efforts to build more efficient models. This was followed by a transition to cleaner fuels for cooking, such as coal and petroleum-based fuels.

As the availability of and access to petroleum-based fuels began to increase at the beginning of the 20ieth century, many urban households in developing countries switched to stoves using oil-based products such as kerosene or liquid petroleum gas (LPG) as fuels, just like their developed nation counterparts. On the other hand, rural households continued their dependence on the burning of biomass fuels for cooking and heating purposes. This was mainly due to weak delivery channels for petroleum-based products and rural people's inability to afford these fuels especially compared to biomass resources, which were more freely available (Barnes et al, 1994). When oil prices increased in the 1970s, even urban households found it hard to pay for fuels such as kerosene and LPG and many of them stepped back down the energy ladder and started using biomass fuels for household energy.

Domestic cooking makes up a major portion of the total energy used in developing nations, close to 60 percent in Sub-Saharan Africa, so that nearly three billion people worldwide cook their meals on simple stoves that use biomass fuels (Kammen, July 1995). As noted before, many of these stoves operate with low efficiencies and use six or seven times more energy than non-biomass-burning stoves (Barnes et al, 1994). The goal of improved cookstove programs is to develop "more efficient, energy-saving, and inexpensive biomass cookstoves [that] can help alleviate local pressure on wood resources, shorten the walking time required to collect the fuel, reduce cash outlays necessary for purchased fuelwood or charcoal, and diminish the pollution released to the environment" (Barnes et al, 1994, pp.1).

One of the first improved stoves was the "Magan Chula", introduced in India in 1947. A publication called "Smokeless Kitchens for the Millions" (Raju, 1953) advocating the health and convenience benefits of increasing efficiency in the burning of biomass further stimulated the promotion of improved cookstoves. The initial wave of cookstove programs focused on the health aspects of such interventions. The general objective was to uplift the living conditions of the poor in the developing world (Karakezi and Ranja, 1997, pp.51). Attention subsequently shifted to the potential for saving biomass fuels and limiting deforestation. Currently, there is a refocus on the health-related aspects of improved cookstove programs, as the benefits of moving from traditional stoves to improved ones are increasingly stressed by public health specialists. In addition, factors such as cooking comfort, convenience, and safety in the use of the stoves are starting to get incorporated into program design (RWEDP No:44, pp.5).

III. WHY IMPROVED COOKSTOVES?

The benefits associated with improved cookstove programs fall in two categories: those that are internal to the household and those that are external.

Internal benefits include:

- Reduced concentrations of smoke and indoor air pollution;
- Money and time saved in acquiring fuel; and
- Reduced biomass use, ability use animal dung as fertilizer instead of for fuel.

External benefits include:

- Less pressure on forest and energy resources;
- Reduced greenhouse gases; and
- Skill development and job creation in the community (Barnes et al, 1993, RWEDP No:44).

Not all the benefits listed above are experienced or perceived by improved cookstove users. Since the households feel the impacts of internal benefits directly, these have a greater influence on the decision to adopt the improved stove. Another important point is that most of the internal benefits work to improve the condition of women, who are predominantly responsible for cooking and collecting fuelwood. Additionally, in many rural settings, women cook with their children strapped on their backs. Any reduction in pollutants emitted from cookstoves, therefore, will be beneficial for children's as well as for women's health. [2]

The external benefits are less likely to be perceived by rural households although this is certainly a gross underestimation of the capability of the poor to understand the ecological problems that face them. However, some of these benefits are hard to quantify and even if quantified, they are not realizable in monetary terms. [3]

Although the internal and external benefits listed above differ significantly along regional and cultural lines depending on the type and use of improved cookstoves, it is safe to say that a combination of these benefits are felt by most users.[4] The reader at this point may justifiably wonder whether there are alternative policy interventions that would help resolve the very problems that improved cookstove programs tackle. The author focuses on some of those interventions that address at least one or more of the above-cited benefits in Table 1.

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[2] When biomass fuels are burnt inefficiently they give rise to high concentrations of pollutants – the main culprits for acute respiratory infections (ARI). According to the WHO World Health Report 2000, the top five respiratory diseases account for 17.4% of all deaths and 13.3% of all Disability-Adjusted Life Years (DALYs). Lower respiratory tract infections, chronic obstructive pulmonary disease (COPD), tuberculosis and lung cancer are each among the leading 10 causes of death worldwide. (World Health Organization Chronic Respiratory Diseases, http://www.who.int/ncd/asthma/strategy-1.htm, Smith., et al. 1999).

[3] For instance, it has been shown that the entire project budget of the Eritrea Improved Cookstove Program (whose goal is to double the efficiency of cookstoves in 15% of the country's rural households) is less than the value to the international community of the reduced carbon emissions resulting from the rural efficiency program at the expected market value of $6 per ton of avoided carbon emissions. (Improving Traditional Stove Efficiency in Eritrea: *Efficient Stove Testing And Promotion Benefits, Eritrean Energy Research and Training Center*, http://www.punchdown.org/rvb/mogogo/StoveEff032000.html) Smith et al state that the current household fuel situation in India and other developing countries offer possibilities to achieve cost-effective greenhouse gas reductions while giving local communities higher quality fuels and healthier environments. (Smith et al, 2000)

[4] Barnes and Kumar, to be published Summer 2003.

Table 1. Alternatives to Improved Cookstove Programs

Benefit	Alternative Intervention[5]
• Reducing indoor air pollution	➢ Transition to less polluting fuels for cooking, such as LPG, ethanol, or solar energy. [6] ➢ Improving indoor environments with the addition of chimneys, flues, hoods, and ventilation. ➢ Changing household behavior, i.e. modifying cooking practices, keeping children away from the fire. ➢ Rural electrification.
• Less pressure on forest and energy resources • Reduced biomass use • Reduced greenhouse gases	➢ Reforestation programs. ➢ Transition to less polluting fuels for cooking. ➢ Rural electrification.
• Money and time saved in acquiring fuel	➢ Income and/or fuel price subsidies.
• Skill development and job creation	➢ Programs concentrating on income generating activities. ➢ Microfinance projects.

Naturally, there are some cases when the implementation of one or a combination of these policy interventions may be preferable to improved cookstove programs. Some rural communities, especially those in close proximity to urban areas and those that have higher incomes, are more likely to benefit from rural electrification programs because electric grids are more likely to reach them in the near future and they will be able to afford the electric appliances necessary. Similarly, these households are more likely to make the switch to cleaner fuels since they have easier access to fuel delivery infrastructure. However, considering that 2 billion of the world's 6 billion people live in rural areas with no electricity (Electricité de France, 2000), it is hard to imagine that access to electricity can be provided for everyone in the near future. Furthermore, studies show that even in electrified rural areas, households do not switch to using electric appliances quickly. This is partly due to the fact that rural households cannot always afford the cost of electric appliances or electricity itself (Bose, 1993). Hence, intermediate steps that will improve the conditions of rural households may be necessary.

Interventions that encourage the transition to less polluting fuels for cooking are another solution to the problems addressed by cookstove programs. These fuels include LPG, ethanol, or even solar energy. As in the case of rural electrification, not all households will be able to afford these alternative fuels, or the appliances that are required to use them.

As a result of all the factors explained above, the author believes that communities with low incomes located in rural areas[7] without access to markets or energy infrastructure are most likely to benefit from improved cookstove projects. It is with these households in mind that this paper is written.

[5] Most alternative interventions taken from Indoor Air Pollution Newsletter Energy and Health for the Poor, Issue No. 1; September 2000.
[6] Kirk Smith, in his editorial piece in Science Magazine (Vol 298, December 6, 2002) states that "there are no realistic resource or greenhouse constraints to keep us from targeting the needs of the poorest with LPG in places where renewable technologies are not yet appropriate or sustainable."
[7] Low-income households are defined as those below the poverty lines estimated by international development organizations.

IV. CASE STUDIES: METHODOLOGY AND LIMITATIONS

The four case studies this paper will focus on are the:

A. Chinese National Improved Stove Program (CNISP)
B. Indian National Programme of Improved Chulhas (NPIC)
C. Eritrea Dissemination of Improved Stoves Program
D. Ethiopia Improved Biomass Mirt Stoves Program

This paper will focus on the latest developments in the efforts to disseminate improved biomass cookstoves in China, India, Eritrea, and Ethiopia – with the exception of China for which recent data was not available.

The Chinese National Improved Cookstove Program will be analyzed at a national level due to lack of data availability at the regional level. In India, regional data was easier to obtain, allowing the author to pick programs in different states for analysis. The states of Andhra Pradesh and Maharashtra have been chosen for this purpose (See Map 1). The two state programs function under the umbrella of the Indian National Program of Improved Chulhas, despite having different implementing agencies and dissemination strategies. The main reason for concentrating on these two states is their relatively similar annual income levels (at $370 and $510, respectively[8]) and comparable levels of rural poverty (39 and 42 percent, respectively) (ESMAP, 2002).

The Eritrean and Ethiopian improved cookstove programs will be analyzed at the national level, even though the Ethiopian Improved Biomass Stoves Program is only active in three regions of the country, Amhara, Oromiyo, and Southern (see Map 2 for the location of these regions). The author will use national statistics for Eritrea and Ethiopia since regional data is hard to obtain. The assumption is that rural households in Ethiopia and Eritrea are more or less homogenous in income levels and energy resource profiles.

The common justification for choosing these four case studies is their targeted populations of rural households. Availability of comprehensive information on cookstove statistics and program characteristic details was also an important factor in the selection of cases. More specifically, the author believes that the Indian and Chinese programs, while taking a different approach in dissemination strategy, are similar in terms of their scale, moderate levels of deforestation, and lower incidence of rural poverty. The Chinese and Indian programs are also in the same phase of implementation, switching from the Sustained National Promotion Phase (Phase 3) to the Maintenance, Support, and Improvement Phase (Phase 4).

The Eritrean and Ethiopian programs, on the other hand, also operate under analogous conditions such as high deforestation and very low rural per capita incomes. These differences between the two pairs of countries will allow for a discussion on the role of subsidies and fuelwood scarcity in improved cookstove programs. Moreover, the analysis of the programs in the latter countries may serve as a guide for African countries similar to Ethiopia and Eritrea in terms of economic and natural resources.

[8] Although the annual income levels between these two states may seems to be large at first glance, the income differential between other Indian states were comparatively larger. Also, since the only income figures available for Andhra Pradesh and Maharashtra were did not distinguish between rural and urban households, the author has discounted the statewide figure by 75% to arrive at a more realistic rural income level.

A. Methodology and Limitations.

The purpose of this paper is to associate certain program, cookstove, and regional characteristics to the success of improved cookstove programs with the help of the four case studies analyzed. There are certain limitations in comparing the success of these programs, however. Because the programs are at different stages of implementation, their performance in terms of dissemination figures and rates of dissemination will be dissimilar. The author believes that different criteria should be used for evaluating the success of programs in different stages. For this purpose, four stages of implementation for cookstove programs are identified:

1. Research and Development (R&D) Phase
2. Growth and Scale-up Phase
3. Sustained National Promotion Phase
4. Maintenance, Support, and Improvement Phase

The Eritrea and Ethiopia programs studied in this paper have recently moved from the "R&D Phase" to the "Growth and Scale-Up Phase", when pilot projects are used to increase the acceptance and support for the program to allow it to be implemented at the state or national level. The Chinese and Indian programs, on the other hand, are on the last stages of development. The third stage, "Sustained National Promotion Phase" is when large number of stoves is disseminated in an effort to maximize the number of households using improved stoves. The last stage, "Maintenance, Support, and Improvement Phase" is reached when the maximum number of households is penetrated and the program moves on to ensure the continued use of the improved stoves as well as making incremental improvements in performance and adoption.

To allow for a fair comparison, the author will assign separate measures of success to each of the phases of improved cookstove programs. The criteria for the R&D Phase are stove performance in terms of fuel savings, improved air quality, and the affordability of the stoves. In the Growth and Scale-Up Phase, the annual growth rate in the dissemination of cookstoves and the degree of dissemination to low-income rural populations will be considered. In the Sustained National Promotion Phase, the criterion will be the annual growth in the percentage of new households adopting the stoves. Finally, for the Maintenance, Support, and Improvement phase, the net increase in improved stove use, and net improvements in stove performance will be considered. See Table 2 for a summary of the criteria that will be used to evaluate the success of improved cookstove programs in different phases.

Table 2.
Criteria for Evaluating Improved Cookstove Programs in Different Phases.

	Phase 1. Research and Development (R&D)	Phase 2. Growth and Scale-Up	Phase 3. Sustained National Promotion	Phase 4. Maintenance, Support, and Improvement
Criteria for Success	○ Fuel savings ○ Improved air quality ○ Affordability	○ Annual growth rate of in dissemination ○ Degree of dissemination to low-income populations	○ Annual growth in the number of households using the ICS	○ Net increase in improved stove use. ○ Net improvements in stove performance

V. OVERVIEW AND EVALUATION OF IMPROVED COOKSTOVE CASE STUDIES

A. Chinese National Improved Stoves Program.

The Chinese National Improved Cookstove Program (CNISP) started in 1980 with the leadership of the Department of Environmental Protection and Energy, which operates under the Ministry of Agriculture. The CNISP promoted the use of approximately 10 different types suitable for users in different regions of China, mostly made of prefabricated cast iron, ceramic, or concrete slabs. These stove models were primarily of three types: cooking only, cooking and space heating, and a furnace designed for use in crop processing or other process heat generation (RWEDP No:40). See Figure 2 below for examples of models distributed. The price of the improved biomass stoves is around 45 Yuan or $12 in 2002 dollars (Smith et al, 1993)[9] but can go up to 100 Yuan depending on the capabilities and materials used for construction. This study will assume that the Chinese improved stoves cost $12 on average. The average annual income for a Chinese rural household is 1400 Yuan[10] or approximately $170, which puts the average stove price at approximately seven percent of the household's annual income. The amount of direct government subsidy for the stoves is approximately 4.2 Yuan or 10 percent of the cost of the average stove, total government contributions per stove increase to 15 percent of the stove when we include government wages and foregone taxes. Most of the government subsidy goes to producers of the stoves whereas households pay the full cost (Smith et al, 1993).

The CNISP has disseminated 144 million improved cookstoves by 1994; this number is said to have increased to approximately 180 million by the turn of the century. This translates to 62 percent of all rural households by 1994. (Qiu and Gu, 1996). The Chinese program has been active for a long time and the author thinks it reasonable to place it between the third and fourth phases of implementation. The criterion for success in Phase 3 is the annual growth in the number of households using improved cookstoves. This averages 5% of households per year for China (Qiu and Gu, 1996). Among the criteria for the last phase of dissemination are net increases in dissemination and net improvements in stove performance. China seems to be performing well under each criteria, increasing the number of stoves distributed by an average of 6 million annually since 1994.

Figure 2. Examples of Chinese Improved Cookstoves.

Cast Iron Components of the Domestic Fuel-Saving Heating Stove

Model FL-CCS showing complete metal parts (left)
Model FL-PCS in use (right)

Source: RWEDP 40

[9] Conversion at $1=5 Yuan in 1993. In 2002 dollars, this figure becomes approximately $12.
[10] http://www.tibetinfo.net/reports/trecon/TAR_incomes.htm

B. Indian National Programme of Improved Chulhas

The Indian National Programme of Improved Chulhas started in 1983 under the auspices of the Ministry of Non-Conventional Energy Sources (MNES). It is hard to find a consensus on the total number of stoves disseminated for the national program but the number ranges from 28 million to 32 million. This paper focuses on the two Indian states of Andhra Pradesh and Maharashtra. In Andhra Pradesh, a total of 2.4 million stoves have been disseminated between 1984 and 2000. In Maharastra 2.9 million stoves have been disseminated in the same time period. Since a NPIC evaluation report puts the use of the stoves at 65 percent, these numbers can be discounted to 1.5 million stoves in Andhra Pradesh and 1.9 million stoves in Maharashtra.[11]

Although close to 80 stove variations were disseminated (Meshram 2001), the stoves can be grouped into 6 main categories:

(a) Mud-built, fixed chulha with or without chimney,
(b) Mud-clad, pottery-lined fixed chulha with or without chimney,
(c) Portable metallic chulha without chimney,
(d) Portable metal-clad, ceramic-lined chulha without chimney, and
(e) Portable chulha with a separate hood chimney system.(RWEDP No:41)

The cost of the cookstoves is approximately $9, with some variation depending on the region and social status of the households . The support for households comes in the way of direct cash subsidies, ranging from 50-75 percent of the cost of the stove (RWEDP No.41). The rural per capita income for these states is approximately $370 and $510, respectively. The price of the stove is approximately one to two percent of average annual rural income for these states, without the subsidy to end-users. As of 2000, approximately 20 percent of rural households own improved chulhas.[12]

Like the Chinese program, the NPIC is also between the third and fourth phases of implementation. It is hard to get a sense of the annual increase in the number of households that adopt improved Chulhas because of the quota system employed by the MNES. Currently, the increase in the number of households using the improved cookstoves is approximately 100,000 stoves per year in Maharashtra. This number has averaged 130,000 in Andhra Pradesh between 1995 and 2000.[13]

[11] The number of stoves disseminated were discounted by 65% because the National Council of Applied Economic Research (NCAER) of India found that only 65 percent of improved chulhas was working and in use. (http://mnes.nic.in/html_folder/ch3_pg11.htm)
[12] Assuming 77 and 65 percent of total population in Andhra Pradesh and Maharashtra is rural, respectively (www.censusindia.net) and family size is five.
[13] Personal Communication with Doug Barnes, April 30, 2003. The number of stoves disseminated were again discounted by 65% to reflect more accurate numbers of improved stoves in working condition and in use (http://mnes.nic.in/html_folder/ch3_pg11.htm).

Figure 3. Selected Cookstoves Disseminated in Andhra Pradesh and Maharashtra

Source: RWEDP 41

Figure 4. States of Andhra Pradesh and Maharashtra

Andhra Pradesh

Maharashtra

Source: http://www.thebharat.com

C. Eritrea Dissemination of Improved Stoves Program

The Eritrea Dissemination of Improved Stoves Program was initiated in 1996, with the first field-test taking place in 1999. The Ministry of Energy through the Eritrean Energy Research and Training Center (ERTC) coordinates the program. The *mogogo* stoves are mostly used for baking *injera,* which is a staple food in countries like Eritrea and Ethiopia.[14] In Eritrea, the stoves promoted are in-built ones with ceramic grates, made mainly with metal parts and brick. The non-local inputs for the stoves are subsidized which means that the village households only contribute for the construction phase of the project. Close to 85 percent of the cost of the improved stove is subsidized, out of the total cost of $20. Eritrea's rural household income per capita is $200, which means that the cost of the stove is approximately 10 percent of annual per capita income.

Figure 5. Eritrea Improved *Mogogo*

The Eritrean program is young and has recently moved to the second or Growth and Scale-Up phase of implementation. As of 2003, 7000 improved *mogogo* stoves have been disseminated, reaching about one percent of traditional stove users. Since the program has been active in rural areas and almost all households in rural areas use traditional stoves, we can assume that the stoves have reached approximately one percent of rural households. Although this number seems relatively low compared to the Indian and Chinese programs, the relevant criteria for the Growth and Scale-Up phase are the annual growth in the dissemination rate and degree of dissemination to low-income populations. The program has been successful in reaching low-income households in the areas it has been active in. The project evaluation report for the energy-efficient stoves program states that acceptance of the new stoves is "wide-spread but not universal".[15] The annual growth in the dissemination rate of stoves is around 17 percent, which corresponds to 2900 installations per year.

[14] Sixty percent of household energy use is taken up by injera cooking in Eritrea (ERTC 2000).
[15] Some households which are renters in their current dwellings indicate problems getting the improved mogogo since their landlords object to having it built in the house. Other renters state that they do not want to invest in building a new stove since they are not sure if they are going to be living in their house for a long while (Design, Promotion, and Dissemination of Energy-Efficient Stoves Project Evaluation Report, August 2001).

D. Ethiopia Mirt Improved Biomass Stoves Program.

The Ethiopia *Mirt* Improved Biomass Injera Stoves Program originated in 1991 and continued under different names and programs since. The Ethiopian programs have been coordinated by international development agencies, the Ministry of Agriculture (MoA), and Rural Energy Technology Centers. Since dissemination of the Mirt stoves started in 1995, over 400,000 stoves have been disseminated mostly in urban areas. This paper will focus on the latest efforts in dissemination, which started in 1999. The project works in the Amhara, Oromiyo, and Southern Regions of the country (see Figure 7) and is joint-implemented by the Ethiopian Ministry of Agriculture and the Deutsche Gesellschaft fur Techniche Zusammenarbeit (GTZ).

Figure 6. Mirt Improved Biomass Stove

The *Mirt* stoves distributed were fairly homogenous although the construction materials changed from region to region depending on the availability of inputs. The improved stoves cost around three dollars in Addis Ababa and between four and five dollars in other areas depending on the transport costs. This is 5 percent of the per capita income of a rural household in Ethiopia. The program does not offer subsidies to stove-owners.

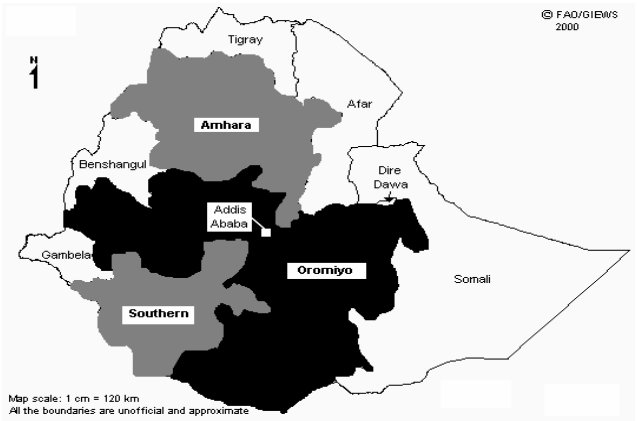

Figure 7.
Regions the GTZ project is active in.
Source: FAO

Like Eritrea, Ethiopia is at the second phase of program implementation. Since the inception of the program in 1997, approximately 5000 stoves have been disseminated in rural or semi-urban areas. This is a very small percentage of rural households, approximately 1%.[16] However, the growth in the annual dissemination rate and the degree of dissemination to low-income rural households are more relevant criteria for the Growth and Scale-Up Phase that the Ethiopian program is currently in.[17] The author could not get access to data on the growth in the annual dissemination rate for the Ethiopian program. However, a Winrock study evaluating the effectiveness of the Mirt stove dissemination in the country, suggests that many women that belonged to rural households suggested that the stoves were too expensive for them to afford.

[16] Assuming the population of the three regions is approximately 50 million and average family size is 6.
[17] It should be noted that there are other active cookstove programs in Ethiopia. An example is the promotion of the *Lakech Charcoal* stove. The dissemination efforts for some of the cookstove programs go hand in hand and the agencies responsible for technical back up or promotion of the stoves may be common.

Table 3. Overview of Improved Cookstove Programs in the Four Case Studies

	CHINA	INDIA		ERITREA	ETHIOPIA
Name of Program	**Chinese National Improved Cookstove Program**	**National Programme for Improved Chulhas**		**Eritrea Dissemination of Improved Stoves Program**	**Improved Biomass Stoves Program**
Initiation Date	1980	1983	1983	1999	1998
Regions of Focus	National	Andhra Pradesh	Maharashtra	National	National
Top Agency	Ministry of Agriculture	Ministry for Non-Conventional Energy Sources	Ministry for Non-Conventional Energy Sources	Ministry of Energy	Ministry of Agriculture
Implementing Agency	Department of Environmental Protection and Energy	Non-conventional Energy Development Corporation of Andhra Pradesh (NEDCAP), Khadi and Village Industries Commission (KVIC), Housing Schemes	Rural Development and Water Conservation Department, Maharashtra Energy Development Agency, KVIC	Eritrea Energy Research and Training Center (ERTC)	Natural Resources Management and Regulatory Department
Targeted Setting	Rural	Rural	Rural	Rural	Rural and Urban
# of Stoves Disseminated	180 million (2000)	1.5 million (2000)	1.9 million (2000)	7000 (2003)	6000 (2001)
% of Rural HHs	62%	20%	20%	1.4%	1%
per year	5%	2%	2%	0.3%	0.02%

Sources: Smith et al, 1993.
Barnes and Kumar, to be published.
Personal Communication with Doug Barnes, April 30, 2003.
India Ministry of Non-Conventional Energy Sources.

VI. COMPARISON OF REGIONAL CHARACTERISTICS.

This section will provide a general overview of regions in which the improved cookstove programs were initiated. The regional elements that will be discussed are:

- Rural incomes
- Scarcity of fuelwood

A. Rural Poverty.

In the four countries studied, Ethiopia and Eritrea have the highest percentage of people living in rural poverty, 57 and 48 percent, respectively. An average Ethiopian rural household has a per capita annual income of $100 whereas the rural per capita income for Eritrea is $200. In India, Andhra Pradesh and Maharashtra are also experiencing high levels of rural poverty, with 39 and 42 percent of their population living below the poverty line, respectively. The annual per capital income for a rural household in Andhra Pradesh is approximately $370 whereas the number is $510 for Maharashtra. China's rural households are comparatively the most well-off, with only 9 percent of them living in poverty.[18] The average rural per capita income in China is $500.

The incidence of rural poverty is an important determinant for the adoption of improved cookstoves. It is hard to imagine a rural household which is barely meeting its subsistence needs being able to afford the whole cost of an improved cookstove. In later sections, this paper will revisit the issue of rural poverty as it relates to the affordability of improved cookstoves.

B. Scarcity of Fuelwood.

Improved stoves are more attractive to those households that experience a scarcity in biomass resources since they will benefit significantly (be it in terms of time saved from collecting firewood or money saved from the purchase of firewood) from the increased efficiency of the stoves. In regions with fuelwood shortage, people have to spend more time collecting wood or move down the energy ladder and start using straw or dung as fuel. This has serious implications for countries like Eritrea and Ethiopia whose populations could use animal waste as fertilizer to improve the already tough agricultural conditions. In Ethiopia "residue fuels are usually collected freely from farms. Agricultural and crop residues have become important source of fuel for the rural mass, as fuelwood is becoming scarce. For example in 190/91 2.5 million toe (tons of oil equivalent) of residues fuels are supplied for energy. Using these fuels for fuel contributes for gradual reduction of soil nutrients" (EHSER, 2000, pp.10). Less than three percent of Ethiopia and Eritrea is covered with forests, with coverage decreasing rapidly over the last few years[19]. While reforestation efforts are undergoing in both countries, over 90 percent of rural households continue using biomass as a source of energy. Since improved cookstoves offer a way for rural households to decrease their dependence on biomass fuels, cookstove programs have a higher chance of success in these areas because households will place high value on their stoves.

Deforestation is less of an issue in India and China where the forest coverage is 22 percent and 15 percent, respectively. Furthermore, both countries report increasing tree cover.

[18] Rural population in poverty is calculated as percentage of households with incomes below the poverty line, an index calculated by development organizations for specific countries taking into account the minimum requirements necessary to cover basic food and living needs.
[19] Sustainable Energy in Eritrea, Dissemination of Improved Cookstoves, Ethiopia Household Energy Status Report.

Due to a large amount of heterogeneity in different areas within these countries however, it is hard to conclude that Indian and Chinese households are not feeling the "energy pinch". For instance, even though forest cover is approximately 15 percent in Maharashtra, residents place "fuel scarcity" as the number one benefit they perceive from improved cookstoves. In other regions in India, fuel savings is secondary to benefits such as "faster cooking" in Andhra Pradesh. Unevenness of forest cover is much greater in China, with most remaining forests on the periphery (Manchuria and Yunnan Provinces).[20]

Availability and scarcity of fuelwood will be discussed in later sections when we turn to the perceived benefits of improved cookstoves.

Table 4. General Overview of the Regions[i]

	CHINA	INDIA		ERITREA	ETHIOPIA
Name of Program	Chinese Improved Cookstove Program	NPIC - Andhra Pradesh	NPIC- Maharashtra	Eritrea Dissemination of Improved Stoves Program	Mirt Improved Biomass Stoves Program
Region of Analysis	National	Andhra Pradesh	Maharashtra	National	National
Land Area	9,326,410 sq km	275,045 sq km	307690 sq km	121,320 sq km	1,119,683 sq km
Total Population	1,284,303,705	75,727,541	96,752,247	4,465,651	67,673,031
Percent Rural	63%	77%	65%	84%	86%
Rural Population	809,111,334	58,310,207	62,888,961	3,751,147	58,198,807
Annual per Capita Rural Income	$320 (1994)*	$370 (1996)**	$510 (1996)**	$200 (2000)	$100 (2000)
% Rural Poverty	9%	39%	42%	59%*	45%
Scarcity of Fuelwood (Remaining Forest Cover)	14% (1995)	16% (1993)	15% (1993)	2% (1996)	3% (1990)
% of Rural Households Using Biomass	61%	75%	75%	80% (whole country)	99%
% of Rural Households with Access to Electricity	95%	64%	96%	2%	0.2%

** The average annual per capita income can be misleading because of the heterogeneity of rural incomes in China. For instance, per capita income can be as low as $130, as in the Sichuan Province (China on the Move, The Economist; London; Jul 6, 1996).
** The state per capita incomes were the only available data for Andhra Pradesh and Maharashtra. These figures were discounted by 25% to get a more realistic estimate of rural incomes.
*with food aid, Eritrea Rapid Appraisal Survey 1993-4, Eritrea World Bank Poverty Assessment, 1996, without food aid this number is around 67%

[20] Personal Communication, Professor Bob Acker, Department of Geography, University of California, Berkeley, May 10, 2003.

VII. COMPARISON OF PROGRAM CHARACTERISTICS.

This part of the paper will focus on a few program implementation features that the author believes play an important role in increasing the dissemination and adoption of cookstoves. These features are:

A. Program Coordination
B. Subsidies
C. Promotion Strategy
D. Technical Assistance, Monitoring, and Maintenance

After an analysis of these characteristics for each of the improved stove programs, the author will identify important elements that the Eritrea Dissemination of Improved Stoves Program should pay attention to in the implementation of its project.

A. Program Coordination.

This section examines the nature of coordination in each of the four improved cookstove programs. More specifically, the relationship between national and local governments and local organizations in the implementation of the programs will be examined. In each of the four efforts, the programs were spearheaded by a government agency. In the case of China and Ethiopia, it was the Ministry of Agriculture, which took the lead. In Eritrea and India, the Ministry of Energy and the Ministry of Non-Conventional Energy Sources (MNES), respectively, were responsible for administering the programs.

i. India.

In India, the Ministry of Non-Conventional Energy Sources (MNES) implements its programs through state governments. The special agencies for renewable energy development are responsible for the actual implementation of the improved cookstove program. The MNES sets annual targets of improved chulhas to be installed at the national level and passes the implementation to state level. Some national level governmental and non-governmental organizations are given separate targets, as well. Grassroots non-governmental organizations (NGOs) and self-employed workers (SEW) implement the program at the village and household level. In addition, the MNES has Technical Backup Units (TBUs) in thirteen states which develop and test improved cookstoves and train locals in the manufacturing and installation of improved chulhas. In other words, the TBUs are responsible for technical assistance, monitoring, and maintenance of the NPIC.

Since the NPIC follows a multi-model and multi-agency approach, this paper will concentrate on the efforts in two states, Andhra Pradesh and Maharashtra, to capture the effect of program implementation on dissemination levels and adoption of improved chulhas.

Andhra Pradesh.

In Andhra Pradesh, the NPIC was implemented through the Non-Conventional Energy Development Corporation of Andhra Pradesh (NEDCAP) along with the Khadi and Village Industries Commission (KVIC) and other housing schemes. Regional Engineering College in Warangal was responsible for support and training for the stove builders and users (Barnes and Kumar, 2003, pp.7).

Maharashtra.

In Maharashtra, the implementing agencies at the local level were the Maharashtra Energy Development Agency and the KVIC. The technical backup unit for the state was the Appropriate Rural Technology Institute (ARTI) (Barnes and Kumar, 2003, pp. 6).

Implementation of the NPIC has been less than impressive at the state level. The following excerpt describes the frustration of one TBU employee about the process in Maharashtra:

> In Maharashtra, our TBU is very active, but every time the secretary of the state department in charge of NPIC changes, my colleagues in the TBU have to convince the fellow that MNES is paying money to his department for getting this work done, and it is indeed a part of his assigned duties!
>
> On top of this, MNES keeps on giving new directives every now and then with total disregard to ground realities: The decree to promote cement stoves is the latest one!
>
> Unfortunately, when MNES finally decided to incorporate IAP concerns in the programme, it went for a 'short cut' solution. Instead of giving time to the TBUs to come up with user-friendly easy-to-install non-polluting stoves, and to make systematic efforts to make the chulha users aware of the hazards of IAP, it simply sent a directive that every fixed stove installed under NPIC henceforth must have a chimney.
>
> The consequence in Maharashtra was this: The choice that was offered under NPIC was between fixed stoves with chimney and metallic portable stoves. Due to the various practical problems associated with installing fixed stoves with chimney, the state government's implementing agencies went in a big way for the metallic portable stoves. Consequently, most of the users ended up with having to accept the portable stove due to 'non-availability' of the fixed one. Now, in this region, traditionally the portable stoves are never used as the main daily-cooking-stoves. These are used only if some extra cooking is to be done (large number of guests, big festivals, etc.), or at the most for heating water for bathing (which traditionally is done outside the house on a three-stone-fire). The result is that the 'target' of stoves has been fulfilled, but the 'beneficiaries' continue to use their traditional stoves for daily cooking. Also, the rural potter-entrepreneurs (who make the fixed stoves) who have been trained and nurtured over the years, have lost a lot of business that they used to get through the NPIC, while the city-based industrialists, who fabricate the metallic stoves, have earned handsome profits. [21]

This narrative describes the lack of coordination between the state-level agencies and the national government in addressing the needs of the stove users' and the realities that exist in the field. According to Dr. Karve, the State Government was supposed to implement the

[21] Dr. Priyadarshini Karve, Shell Foundation Sustainable Energy Programme Household Energy and Health Dialogue Daily Digest, 4/08/01.

program, but the government officials were totally disinterested. This caused the TBU to take on more tasks than originally included in its mandate.

ii. China.

The CNISP is coordinated by the Bureau of Environmental Protection and Energy (BEPE), which oversees a system of administration, research, rural energy manufacturers, and extension service organizations covering 38 provinces and approximately 1500 Rural Energy Offices. The rural energy system in China is very extensive; it is functional at every level of the administration in China, starting at the Ministry level down to the villages (Smith et al, 1993). These counties compete for the contracts by submitting proposals for the implementation of the program, setting targets for stove dissemination. Rural Energy Offices at the province-level are responsible for monitoring these contracts. They also analyze ongoing and completed programs and fund and supply construction materials to counties.

China has a very straightforward and organized approach in the dissemination program. Much of the success of the program has been attributed to the fact that BEPE establishes direct links to counties at the implementation stage of the program by skipping the provincial authorities. [22] This cuts back on the amount of bureaucracy that local level officials have to deal with as well as empowering the local decision-makers. Even though dissemination targets are set for the stoves, local agencies decide on what these targets should be, unlike in India where the national government dictates the total number of stoves to be disseminated throughout the country. The Chinese program also avoids the disconnect between implementing agencies and the national government that is present in India by leaving it up to local Rural Energy Offices as to what kind of technology should be used and the types of stoves that should be disseminated.

iii. Eritrea.

In Eritrea, the improved cookstove project is implemented by the Energy Research and Training Center (ERTC), a government agency that works under Department of Energy of the State of Eritrea. The ERTC is responsible for community education, training of local artisans in the design and construction of the stoves, provision of non-local supplies, project implementation oversight, as well as testing and monitoring of stove performance.[23] Similar to China, the villages that can prove to the government that they are ready and organized for a village-level switch to improved cookstoves become eligible to receive material and logistic support from the government. Subsequently, the ERTC and villages can negotiate on the terms, schedule, and the level of support for the program. This allows for "competition between organized village communities based on factors that are determinate for successful village level transformation."[24]

iv. Ethiopia.

The major stakeholders for the GTZ program in Ethiopia are Ministry of Agriculture (MOA), the Ministry of Water and Mines and Energy, the Bureau of Labor and Social Affairs Department, the Ministry of Trade and Industry and Micro Finance Institutions. The distribution of improved rural energy technologies occurs through nine rural technology

[22] A typical contract will have terms such as: implementation in three years, provision of 25,000 Yuan ($5000) by BEPE, 90 percent penetration of improved cookstoves, etc (Smith et al. 1993, pp.943).
[23] Van Buskirk, Robert, Project Design Document for Eritrea Dissemination of Improved Cookstoves Program, January 2003 Draft.
[24] Ibid.

centers, which are central in technology development and promotion. Until 1995, these centers were coordinated by the Rural Infrastructure Department of the Ministry of Agriculture. However, after the establishment of the Federal Democratic Government (FDRE), the country experienced a decentralization of administration and the centers came under the management of their respective Agricultural Bureaus.

A Winrock Ethiopia study finds that there is lack of coordination between the extension staff, rural technology experts, and the rural women's affairs team, which represents the end-users of the improved stoves. The lack of a national body that coordinates these organizations is seen as a major setback to the dissemination of rural technologies in Ethiopia (Winrock, 2001).

B. Subsidies.

Subsidies have been a part of many improved cookstove programs. There is no consensus as to whether they are necessary for the dissemination of cookstoves in rural areas. Some experts state that even the poorest of the poor will be able to come up with the funds to purchase an improved stove if they deem the investment worthy (Personal communication, Kirk Smith, March 6, 2003). Others believe that it is unrealistic to expect poor rural households, who may be on the verge of starvation (as in the case of Eritrea) to be able to afford an improved cookstove, which may cost up to ten percent of their annual income. Unfortunately, there is no hard evidence connecting the provision of subsidies to improved cookstove adoption rates in rural areas.

Analyzing the amount and form of subsidies used in the four case studies in this paper, the author finds that subsidies are not a determinant of program success. For instance, the Eritrea Dissemination of Improved Stoves Program was able to secure high adoption and use rates at its initial phase, not despite but with the support of subsidies. On the other hand, in Ethiopia, where the program was implemented with a commercial approach with no subsidies going to end-users, improved cookstoves did not reach the very poor rural households (Winrock, 2001).

The following sections will discuss the role of subsidies in the four programs in more detail. The size and type of subsidy offered by these programs depends on various factors such as the per capita incomes of the rural households, the percentage of income that needs to be diverted to the purchase of the stove, availability of local inputs, and most importantly, the price of the improved stoves.

Price of Improved Cookstoves.

The price of improved cookstoves may yet be the most important factor impacting their adoption by rural households. Rural households have very low incomes throughout the developing world. Usually, the cost of improved cookstoves are highest in the beginning phase of stove programs, when the scale of production is small and does not allow for savings from mass production. In rural areas where construction materials are hard to come by locally, the cost of obtaining these materials from non-local sources may make it harder for rural households that have very limited cash earnings to afford the full cost of the improved stoves.

In the four case studies this paper focuses on, the price of the improved stoves varies significantly. The average price for an improved Chinese cookstove is cited as approximately $12 whereas the price for the Eritrean improved *mogogo* stove is as high as $20. The Ethiopian Mirt and the Indian Chulha stoves sell at around $10 each when we do not take

subsidies into account. Naturally, when we state the price of these stoves, we have to put them in context by looking at the purchasing power of rural households in respective regions and countries. As we can see from Table 4, rural incomes and the purchasing power of rural households also vary. The purchasing power of rural households in the regions of China and India that this study focuses on is significantly higher than those in Eritrea and Ethiopia. This has a large bearing on the ability of households to afford improved cookstoves which has implications on whether subsidies should be used to assist the households in their purchase of the improved stoves.

i. India.

In India, the subsidy amount changes according to regional and household characteristics, as well as the type of stove. Poorer regions or poorer households may get to pay less per stove. The subsidy goes all the way up to 50 percent of the stove costs in some regions. Studies find that the effect of the subsidy has been negative for the NPIC since the government paid the builders to cover half of the cost for building the stove, which caused the motivation of the builders to be directed more towards the government than the consumers. This caused the production to be "hasty and faulty". "Many stoves did not accommodate the household cooking pot, or could not withstand the heat required for cooking. Others did not offer the assured savings in household firewood consumption. The heavy government subsidy for cook stoves also suppressed efforts by private entrepreneurs to disseminate their own improved stoves, as they could not possibly compete with the highly subsidized government price" (Sinha in Boiling Point No. 48).

Barnes and Kumar point out that in most cases in Andhra Pradesh and Maharashtra, household could afford to purchase the stove if the subsidies were decreased or removed completely and a more commercial approach was used.

ii. China.

In China, where the purchasing power of rural people is the highest in comparison with the remaining three countries, most of the cost of the stoves is born by users. In the Chinese case, the government, through Rural Energy Offices, has opted for the provision of subsidies to stove producers who have to use high-quality inputs in the construction of the stoves. Once the production of improved stoves begin, rural households slowly begin to purchase them. As more stoves are sold, the scale of production increases and economies of scale enable producers to supply the inputs or construct the stoves cheaper. The lower price of the next batch of stoves allows poorer families to afford them. The ability to produce the components of the stoves in small factories has helped China bring down the cost of the stoves and made the commercialization of the stoves very successful.

In China, the subsidy amount totals to 15 percent of the full cost of the stove, with most of the subsidy going to stove producers. Local energy manufacturing and retail companies are encouraged to take part in the production of improved stoves through the provision of loans as well as technical and management support. Some support also goes to training and promotion costs.

Critics of the subsidy approach applaud China's efforts in commercialization and subsequent move to mass production and advocate for a similar approach in other countries trying to increase the dissemination of improved stoves. However, such a contention neglects the heterogeneity in the types of stoves that rural households use to fulfill their cooking needs. Some stoves, especially those that are built into houses (as in some Eritrean and Indian villages), do not lend themselves well to mass production. Moreover, as will be discussed in

the coming sections, the purchasing power of rural households differs greatly between countries like Eritrea, Ethiopia, India, and China. What is affordable for a Chinese rural household may not be so for its counterpart in Ethiopia. Thus, even though the benefits that are perceived by households in both countries are similar, an Ethiopian household may not have the "cash" resources to afford the commercialized stove.

iii. Eritrea.

The Eritrean program is an example of close to full subsidies. In Eritrea, where the improved stoves cost as much as what a rural household earns in a month, the government has chosen to provide all non-local materials to stove builders – who are effectively the users themselves.[25] The builders, who are mostly women, volunteer their time for the construction of the stoves showing a willingness to pay for the benefits of shifting to an improved stove. Since all the non-local inputs for the stoves are subsidized, village households only contribute to the construction phase of the project. Assuming that the improved stove takes about two days to build, with labor costs around $1.5 per day, the total labor contribution per stove is $3. Since the rest of the materials for the stove is donated by the government and NGOs, close to 85 percent of the cost of the improved stove is subsidized. In other words, the households that decide to adopt the cookstoves do not have to make any cash contributions.

Using subsidies to increase the penetration of improved cookstoves in rural villages in Eritrea may be justified if the health costs associated with indoor air pollution are considered. Smith et al state that approximately 9.4 percent of global burden of death and disease in less developed countries can be attributed to acute respiratory infections (Smith et al 1999). If we assume that 3-4 percent of disability adjusted life years lost in Eritrea is due to indoor air pollution (which is the major cause of acute respiratory infections), then spending a comparable portion of the national income to reduce exposure might make sense. Offering improved cookstoves to five percent of the population would cost the Eritrean government approximately $900,000 per year. This corresponds to about 0.13 percent of Eritrea's GDP, proving that the intervention is cost-effective.

iv. Ethiopia.

The Ethiopian program does not include any subsidies to end-users, with minimal support going to individual producers in the initial "capacity building" phase of the project. The project strategy involves a commercial dissemination approach in which private entrepreneurs are responsible for the production of the stove. The project and public sector funding goes to the training of the producers and the promotion of the project (Winrock, 2001).

The Winrock International study focusing on rural energy technologies in Ethiopia reveals that women prefer to use technologies that do not cost much such as the closed mud stoves. The study suggests that even if the women know about more advanced technologies, they do not have the resources to buy them. In an evaluation done on the *Mirt* stove in the *Amhara National Regional State (*ANRS), a large percentage of households indicated that the price was too high.

[25] In Eritrea, women are the main builders for the improved cookstoves. Technical staff teach women to build their own stoves.

TABLE 5. PRICE OF STOVES AND TYPE OF SUBSIDIES

	CHINA	INDIA		ERITREA	ETHIOPIA
Name of Program	Chinese Improved Cookstove Program	NPIC – Andhra Pradesh	NPIC-Maharashtra	Eritrea Dissemination of Improved Stoves Program	Mirt Improved Biomass Stoves Program
Price of Improved Cookstove without Subsidy	$10	$9	$9	$20	$5
Amount of Subsidy to End-Users	None to end-users	$4.5	$4.5	$10-20	None to end-users
as % of cookstove price	none	50%	50%	75%	none
Price of Improved Cookstove with Subsidy	$10	$2-$4.5	$2-$4.5	$10 in terms of non-cash inputs	$5
Price of Stove as % of Annual per Capita Rural Income	6.5%	2.4%	1.7%	10%	5%
Type of Subsidy	Producers Training, technical assistance	Direct cash subsidy to end-users.		Providing non-local materials Training, technical assistance	Producers Training, technical assistance

Source: Winrock 2001, RWEDP No. 40, RWEDP No.41, Smith et al 1993, Sustainable Energy in Eritrea, Dissemination of Improved Cookstoves.

C. Promotion Strategy

One of the most important aspects of an improved cookstove project is the promotion strategy. Much of the time, rural households are unaware of the benefits of the improved stoves, especially the health-related benefits. Venkata Ramana states that the presence of a well-thought-out promotion strategy that can target different segments of the population is crucial in improved cookstove programs (Personal Communication, March 27, 2003). Through a well-designed promotion strategy rural households can be informed of the benefits associated with the improved stoves. This will cause not only higher rates of adoption but cause households value their stoves more once they are adopted. This section will discuss the promotion strategies employed by the four case studies.

i. India.

In India, public awareness about the improved stoves is created through radio and television spots as well as local fairs (Meshram, 6). In Andhra Pradesh for example, the Non-Conventional Energy Development Corporation of Andhra Pradesh Ltd. (NEDCAP) "Dandora" (drum beating), a form of folk art, for announcing the implementation of the program in selected villages.

In Maharashtra, the state government developed 27 permanent demonstration sites, displaying the different models of improved chulhas. Training courses used screenings of a video film on improved stoves. Also, an innovative approach involved attempting to popularize the cookstoves through a people's program called Janambhoomi (Sinha, 26).

ii. China.

The Chinese program also makes use of demonstration in order to promote improved cookstoves. In addition, in some provinces, the Chinese Program requires building holders to have an improved stove in place in order to receive construction permits.

iii. Eritrea.

In Eritrea, much of the advertising for the stoves occurs through word of mouth, as households in villages nearby pilot villages hear about the benefits of the improved stoves. Demonstration can play an important role in the promotion of improved stoves as well.

> One method used by the Eritrean program is to first install the stoves in the houses of some early adopters so that the other villagers can see how the stove works. Or in a large town, they will do a first round of the project, where they take sign-ups. Installation is done for the first round signers, and then people can decide whether or not to adopt. In the town of Imbaderho, a small town of 5000 households, in the first round, about 420 households signed up for the new *mogogos*. On March 10, 2003, a follow-up visit was made by the ERTC to about 10 households that did not get the stoves in the first round. 'Almost all' indicated that they wanted the stoves but did not get them in the first round because they either did not know how good they are, or because they could not attend the original project sign-up meeting.[26]

Another promotion avenue employed by the Eritrean program is the use of mass media in the form of TV and radio spots. This may be more influential in semi-urban areas in Eritrea with wider access to electricity but it does not go a long way in rural areas where access is limited. However, it should be noted that there are close to 400,000 radios in Eritrea, which translates to one radio per every ten household. Even though only a small fraction of households own radios, they can be important tools in reaching the public, especially if we assume that several households may be sharing a radio.

iv. Ethiopia.

In Ethiopia, the GTZ project includes the promotion of the new stoves to households through awareness raising campaigns, distribution of promotional materials, and the use of mass media (HEPNR 15). In addition, the project helps promote the *Mirt* stoves by installing it in a market place and cooking injera with it. It is cited that many stoves have been sold through this promotion strategy (Winrock 2001, pp.23).

A study done by Winrock International Ethiopian (WIE), the Women's Affairs Office of the Prime Minister's Office (WAO) and the Women's Affairs Department (WAD) of the Ministry of Agriculture (MOA) in Ethiopia found that a majority of women (77%) indicated that they had not heard about the improved stove technologies. The writers of the study suggest that this is partially due to lack of women's time for attending trainings by extension staff and partly to the lack of promotion for these technologies. The study finds that even though the Ethiopian Bureau of Agriculture has extension staff devoted to promotion activities, the number of staff when compared to the population is low. Other problems associated with the extension program are that it mostly focuses on men-related activities, and that it does

[26] Email correspondence with Robert VB, May 7, 2003.

not devote consistent effort to promote improved stove technology. The level and strength of promotion depends on the availability of funds from NGOs and international organization.

D. Technical Assistance and Monitoring

This section will discuss the role of technical assistance and program monitoring in each of the four case studies. The term "technical assistance" includes tasks performed by technical institutions in the designing of the improved stoves and the maintenance of the stoves. Monitoring involves the evaluation of the program objectives, ranging from the dissemination and use numbers for the stoves to their performance.

i. India.

The technical assistance for the NCIP is implemented through the thirteen state Technical Backup Units (TBUs). In Andhra Pradesh, the Regional Engineering College in Warangal provided technical support and training for stove builders and users. However, it was found that after-sales service and maintenance was lacking and user satisfaction was not monitored. The stove parts were not of high quality and users had a hard time finding new stove parts, especially for stove liners, which tended to crack after six months.

In Maharashtra, the TBU was the Appropriate Rural Technology Institute (ARTI), which provided training to traditional potters and self-employed workers to design build and sell improved stoves. [27] However, even though technical support was strong in the design and construction stages of the program, quality control was very poor. Barnes and Kumar believe that this is due to the "pressure by field implementation staff to meet sales targets." Furthermore, they state that untrained entrepreneurs sometimes built the stoves, with no mechanism to ensure the use of stove parts from approved vendors.

For monitoring, India uses a three-tier system. The first tier involves self-monitoring by the State Governments and nodal agencies. The second tier involves monitoring by TBUs and Regional offices. The last tier of monitoring is an evaluation by an independent organization.[28]

ii. China.

The CNISP program has strong mechanisms in place that provide technical assistance, monitoring, and maintenance services. In terms of R&D, there is a network of 25 institutions focusing on issues such as training and promotion of new stove designs. Another integral part of the program are the Rural Energy Companies, which work mainly at the county level alongside the County Offices of Rural Energy. These companies make and sell stoves and stove parts and provide installation and servicing of rural energy technologies.

One of the most important aspects of the Chinese program is the monitoring stage of the program where provincial energy offices evaluate the success of the dissemination efforts at the county level. This allows for an independent evaluation of the program. In China, the monitoring and evaluation of the improved cookstove program is conducted by province-level Rural Energy Offices (REOs), which visits each county to assess the fulfillment of its

[27] "The potters were provided extensive technical backup support in the form of testing new models developed by them and training programs and certification on new developments and technical designs." (Barnes and Kumar, 2003, pp.6)
[28] http://mnes.nic.in/html_folder/ch3_pg11.htm.

contract. Teams from the REOs perform on-the-spot examinations, offer help if necessary, and perform checks as specified by the BEPE.

iii. Eritrea.

In Eritrea, the technical assistance for the improved cookstove project is implemented by the Energy Research and Training Center (ERTC) which trains local artisans in the design and construction of the stoves, provides non-local supplies, as well as testing and monitoring stove performance. Eritrea Dissemination of Improved Stoves Program is closely monitored by the ERTC, with annual reports analyzing the progress of the program and monitoring program activity.

iv. Ethiopia.

In Ethiopia nine Rural Technology Promotion Centers (RTPCs) are responsible for technology development and promotion. Even though the technology produced in these centers are similar due to the training in prototype and batch manufacturing they received, each center also produces technologies that are specific to the communities they serve. In terms of monitoring, a study done by Winrock International Ethiopia found that the RTPCs engaged in very limited follow-up with the beneficiaries of the technologies. Also, the Centers did not have a formal feedback mechanism in place. Another finding was that the Centers lack professional and skilled employees, a strong budget, and experience a high turnover. Overall the study states that there is "an urgent need to strengthen the capacity of the centers if they are to achieve their objectives" (Winrock, 2001, pp.18-19). The GTZ Project has designed a system which will monitor performance and evaluate the impacts of the program. It plans to "build the capacity of regional counterparts and to delegate the monitoring to the implementing agencies at regional/zonal level" (HEPNR, 8).

Elements for Success in Program Characteristics: Recommendations for Eritrea.

Program Coordination

Program coordination is important for all the phases of improved cookstove programs. In China, the straightforward implementation mechanism that minimized bureaucracy and established direct contact between the implementing agency at the national level and the local agencies contributed to the success of the program. In the state of Maharashtra in India, on the other hand, lack of communication between the state and local TBUs translated to a disconnect between the expectations of the MNES and the reality that the state TBU faced in the field. As a result, even though the number of stoves that the MNES directed TBU to disseminate were handed out at the state level, the actual adoption and use of these stoves have been predicted to be much lower than the figures released by the authorities. The Ethiopian improved stove program seems to be suffering a similar fate with the NPIC program in Maharashtra, as coordination between extension staff, rural technology experts, and the local agencies, which represent the end-users, has been reported to be weak. In addition, the Ethiopian program lacks a national body that could facilitate greater interaction between these organizations.

In Eritrea, the implementation of the improved cookstove program is structured along the lines of the Chinese program. The government is well organized and maintains strong connections with the ERTC. Also, similar to the Chinese program, the Eritrean government allows for competition between villages to determine who will be eligible to receive the improved cookstoves. This allows those villages that are organized and ready for the

implementation of the program to go first. Eritrea should maintain the coordination mechanism that is in place as it is well positioned to face challenges coming from this direction.

Subsidies

When improved cookstove programs shy away from using subsidies, especially in rural areas, they are overlooking the possibility that it might be "precisely those areas that require heavy subsidization which might be the most important to reach." (Barnes et al, 1994) As Halpern and Barnes also acknowledge " under some circumstances it is reasonable to use subsidies to promote access to energy for the poorest households, which now must get by with such fuels as dung and straw for cooking, and candles and kerosene for lighting.[…]Energy subsidies have become unpopular among policy advisers. But subsidies should not be rejected out of hand. Instead, they should be more carefully designed to maximize their impact on the poor" (Barnes and Halpern, 2000, pp.65).

The author believes that subsidies should focus on achieving affordability for households. Subsidies (to end-users) have greater influence on success, especially in the second phase of improved cookstove programs as it is at this stage when stoves are the most expensive and thus least affordable for low-income rural households like those in Eritrea. In China, the end-users did not need subsidies because they had relatively high rural incomes. The price of the improved cookstoves was on average seven percent of annual rural household income in China. The percentage was approximately one to two percent for Andhra Pradesh and Maharashtra without the subsidies. A study of the NPIC program in these states shows that many of the households in Andhra Pradesh and Maharashtra also had adequate incomes to afford the improved Chulhas, even if the government did not subsidize them or subsidized them to a lesser extent (Barnes and Kumar, 2003). Subsidies, coupled with a quota system, which determined the number of cookstoves to be disseminated on an annual basis, caused local agencies to hand out Chulhas to households regardless of their needs, which led to high dissemination numbers but low use. It might indeed make sense for the NPIC to scale down on the subsidies and move to a more commercial system in the distribution of improved Chulhas.

The situation in Ethiopia and Eritrea may be different as rural incomes are much lower in these countries. In Eritrea, the improved stove makes up about twelve percent of the rural household income whereas this figure is five percent for Ethiopia. In Ethiopia, the lack of subsidies to the end-users is one of the factors found to cause low dissemination rates for the Mirt stoves in rural areas (Winrock, 2001).

The Eritrean program should continue its subsidy approach if it wants to sustain the high dissemination and use rates in rural areas of the country, especially at this phase of the project. Learning from NPIC's mistakes, the Eritrean program should avoid using quotas to set goals for stove dissemination. Furthermore, the program should be closely monitored to make sure that subsidies are not leading to the distribution of unused stoves and stove parts.

As the Eritrea Dissemination of Improved Stoves Program moves on to national scale, efforts should be directed towards commercialization and mass production of the stoves, which will allow producers to benefit from economies of scale and lead to lower stove prices. As the improved stove prices goes down, the government can reduce subsidies and decrease its spending on the program.

Promotion Strategy

A strong promotion strategy is important across all phases of improved cookstove programs. However, promotion is clearly essential at the second phase (Growth and Scale-Up) of cookstove projects when the program starts to increase in scale and becomes implemented at the national level. Since, Eritrea's improved stove program is currently at this stage, educating the public about the benefits of the improved stoves is important if the program is going to be successfully scaled up to the national level.

The Eritrean improved stove program could benefit greatly from a project promotion survey, which could direct the program administrators to the most effective avenues for promoting the improved cookstoves. Also, the program could benefit from an evaluation of the effectiveness of current promotion strategies.

While demonstration schemes are widely used as a promotion strategy in all cases studied, most programs also use media resources such as TV and radio spots to inform the public. Eritrea should continue with its media promotion efforts, primarily focusing on radio spots since approximately one in every ten households own a radio and more might have access to one through sharing or borrowing from households that have radios.

Currently, most of the promotion of improved cookstoves happens through word of mouth but this might not prove adequate as the program seeks to expand to the whole country. Eritrea should continue its demonstration projects Eritrea might want to investigate ways in which it could further promote the cookstoves such as increased demonstration events or training village level administrators so that they can inform/educate villagers about the improved cookstoves.

Technical Assistance

The NPIC experienced strong technical support in the design and construction stages of the program in Andhra Pradesh and Maharashtra. However, the same success cannot be attributed to the "quality control" aspect of the program, mostly due to the pressure (from the national government) to disseminate as many stoves as possible in a given time. This led to a high percentage of stoves be set aside at the household level because of poor quality and malfunctioning.[29] On the other hand, much of the success of China's technical assistance has been attributed to the Rural Energy Companies, which are the primary producers of the stoves and stove parts. Since they are responsible for both the sale and maintenance of the stoves, they have an incentive to provide the best service to the improved stove users. Since the Eritrean program does not rely on a commercial dissemination approach, it is not possible for it to emulate the Chinese approach. However, Eritrea has to make sure that quality control remains an important aspect of the improved cookstove program as the program moves on to the next phase.

Monitoring

The Chinese program is very successful at monitoring the dissemination efforts of the program since it employs the help of an independent party at the provincial level to take responsibility for this function. The Indian program uses different stages of monitoring, also

[29] In the two districts (16 villages, 800 chulhas) that were selected in Andhra Pradesh, it was found that 65.4 percent of the improved chulhas were working and in use. 34.6 percent of the chulhas were either not in use or had been dismantled. The numbers were similar in Maharashtra where 65.2 percent of the chulhas were working and in use and 35.8 percent were not used or had been dismantled. (Ministry of Non-Conventional Energy Sources, Annual Report 2001-2002, http://mnes.nic.in)

relying on an independent party for the evaluation of the program. The Ethiopian program on the other hand, does not have a strong monitoring strategy in place, a component of the program that should be improved as the GTZ project progresses.

The improved stove program is being frequently and closely monitored by the ERTC in Eritrea. ERTC should sustain its efforts in the next phases of implementation and continue to perform annual evaluations as the project moves on to the national level.

VIII. COMPARISON OF COOKSTOVE CHARACTERISTICS.

This study focuses on the dissemination of "biomass" cookstoves in the developing world. Even among biomass stoves though, there is much heterogeneity and much of the success for improved cookstove programs depends on the characteristics of these stoves. This section will discuss cookstove characteristics in terms of:

- Durability;
- User involvement in design and production; and
- Perceived benefits by rural households.

A. Durability.

Durability of improved cookstoves is an important factor determining household choice on whether to adopt the stove or buy a new one to replace the old one. The durability depends on such characteristics as the quality of materials used in the construction of the stove, provision of proper technical knowledge to stove builders, and the availability of technical assistance for stove repairs. Among the improved stove programs analyzed, the Indian Chulha had the shortest life span with an estimated 30 months whereas the its Chinese counterpart came out to be the most durable. Although the NPIC program requires that the stoves be constructed by self-employed workers who are certified by the Technical Backup Units, that this was not the case at all times. The stoves built by uncertified self-employed workers were usually of lower quality. Furthermore, even though stove manufacturers were required to buy their inputs for the construction of the stoves from approved suppliers, this requirement was frequently overlooked and inferior stove materials were purchased from the market.

Barnes and Kumar contend that most of these quality problems in India arise from the nature of the program where users do not have a choice in picking stoves that were suitable for their households. The authors also believe that "a greater number of standard parts in the stove also can be important for lower costs and improving quality control" (Barnes and Kumar 2003).

One problem associated with programs where the improved cookstoves are built into the houses of users (such as in India, Ethiopia, and Eritrea) is the fact that these stoves require custom installation. Alterations to the original design of the stoves lead to lower efficiencies. This problem is avoided in the Chinese program where all the critical components of the stoves are produced in small factories and then assembled in the home.

In Eritrea and Ethiopia, the durability of the improved stoves is a function of the materials used and their design. For instance, in Eritrea, the life span of a *mogogo* with a metal chimney is approximately 5 years whereas the life span of a *mogogo* without a metal chimney can be as long as 20 years.[30] Similarly, in Ethiopia, the Mirt stoves that used a scoria-cement mix were found to be more durable but since this mix was not available in most rural areas, stoves had to be built with other materials, which made them less durable.

B. User Involvement in the Construction of the Stove.

[30] Mogogos with metal chimneys were more prone to corrosion and developed holes.

All of the four programs involved users in the construction phase of the stove, with varying degrees of participation. The situation in China is slightly different than the cases in Eritrea, and Ethiopia because women were involved at the design and field-testing stages of the program rather than in the actual construction phase. The household involvement in these initial stages enabled the stove designers and builders to incorporate "convenience to household" as an important element in the program. In Eritrea, women were involved in all phases of the program, including the construction of the stoves. Technical personnel from the Eritrean Energy Research and Training Center visited villages to train the women how to build the stoves themselves. This enabled them to take advantage of the local skills and capabilities, as rural women had considerable expertise in pottery making, clay furniture making, etc.

Women were active participants in the production, sale, and installation phases of the stoves in Ethiopia as well. GTZ notes that almost half of the stove producers in Ethiopia are women (HEPNR, 2000). However, there is evidence that the RTPCs in Ethiopia did not have direct contact with the beneficiaries. Even though the extension staff acted as an intermediary between the technical staff and farmers, this did not lead to enough linkage between the end-users and developers.

> Since there is no linkage between technology developers and end users, technology development does not take account of the indigenous knowledge of farmers and as such the role of innovative farmers is neglected. Moreover, there is lack of participation of women in technology development.
>
> Technology development is also gender neutral and biased towards the ones who can afford it. Even though RTPCs are operated with government budget, they have to produce technologies that they can sell and their potential targets are those who can buy. On the other hand private enterprises are profit oriented and are interested in making technologies that can fetch them money. Special focus is not made to address the needs of women. The aims set for the technology development is to alleviate the workload of the farmer without consideration to the specific needs and concerns of women. Even though women are implicitly assumed to benefit from the technologies to be developed/multiplied, no special reference is made to the needs and priority concerns of women (Winrock, 2001, pp.18-19).

Much of China's success in the CNISP can be attributed to women's involvement in the program. Women were involved both at the field-testing stage and in discussions centering on their needs from the stoves. In one region, the stove included a shelf to place spices, at the request of women.

C. Perceived Benefits and Drawbacks.

This section will talk about how and whether the rural households perceive the benefits of the stoves in each of the programs. The most common benefits associated with improved cookstoves are better health and fuel savings.

In India, it was found that "users of the improved stoves actually rank the removal of cooking smoke from the household as a higher priority than energy saving, with the exception of Andra Pradesh, where users picked "smoke removal" as a less beneficial aspect compared to "fuel savings" (Barnes and Kumar 2003).

In Eritrea, interviews conducted in 22 households across 8 villages indicated that the primary benefit for the new *mogogos* is reduced smoke. Villagers stated that they experienced significant decreases in stinging eye problems.[31] Fuel savings followed reduced smoke. Other benefits cited were decreased cooking time and increased productivity, improved safety, and better quality bread. Drawbacks of the stoves include the larger size, the labor, effort and cost for installation/ construction, and the inability to move stoves with change of residence. [32]

In a survey completed in 150 of 600 households using the improved stoves in Ethiopia, 94 percent of the respondents indicated that they bought the stove for its fuel saving quality (Winrock, 2001). Other reasons cited by Ethiopian users include reduced smoke, faster cooking, durability, and safety (PRASIHSP, 2000). In addition, a study done by Wudnesh showed that women in the study areas spent five hours a day on average collecting firewood. In most regions where the Winrock study was based on, women identified wood collection as their most difficult task (Winrock, 2001).

The Ethiopia study also found that the technology developed by the RTPCs depended not on the farmers' needs but on the past experience of the technology developer. The surveys designed to assess the needs of the beneficiaries were very limited. "For the most part, technology development in RTPC has been from prototypes imported from abroad or from designs borrowed from other Rural Technology Centers" (Winrock, 2001) This is partly due to the lack of contact between the technology developers and the end-users.

[31] Van Buskirk, Robert., Eritrea Design, Promotion, and Dissemination of Energy-Efficient Stoves Project Evaluation Report August 2001.

[32] Ibid. Additional benefits might include better quality injera, labor savings from fuel collection, keeping up with neighbors who have the better stoves, and better ash for fertilizer or more dung for fertilizer. The fuel savings goes to increased dung for fertilizer, reduced labor for collection, increased dung supplies for sharing, increased fuel for other household uses, or reduced fuel costs. Labor saved goes into other household activities or better visiting time and guest hosting conditions (e.g. elimination of smoke allows one to entertain guests and cook at the same time).

TABLE 6. OVERVIEW OF COOKSTOVE CHARACTERISTICS

	CHINA	INDIA		ERITREA	ETHIOPIA
Name of Program	Chinese Improved Cookstove Program	NPIC - Andhra Pradesh	NPIC- Maharashtra	Eritrea Dissemination of Improved Stoves Program	Mirt Improved Biomass Stoves Program
Materials Used	Prefabricated cast iron, ceramic, concrete slabs	Mud with cement or pottery liners	Two-pot chimney model with pottery liners	Mud, ceramic, metal	Pumice (volcanic ash) and cement. Scoria (red ash) and sand/cement
Variability of Design	High – 20 different types	Moderate - Several models depending on regional requirements	Moderate – two basic types	Low	Moderate – depends on availability of materials
User Involvement in Design	Yes. Women involved in design and field testing stages.	NA	NA	Village women.	Women very active in the production, sale, and installation of the stoves
Efficiency Improvement	10-12% to 20-25%	24-28%	20-28%	6-8% to 20%	10% to 19-21%
Durability	High – close to ten years	Low – estimated as 30 months		Moderate	Low – 5-8 years under optimal conditions
Commercial Marketing	Yes.	Yes	Yes	No	Yes

Source: Winrock 2001, RWEDP No. 40, RWEDP No.41, Smith et al 1993, Sustainable Energy in Eritrea, Dissemination of Improved Cookstoves.

Elements for Success in Cookstove Characteristics: Recommendations for Eritrea.

User Involvement in the Design and Construction of the Stove

It is very important for an improved cookstove program to include the users of the stoves in the design and construction stages of the project. This is partly because the users, mostly women, will be the primary beneficiaries of the programs and they should naturally have a say about an intervention that will bring change to their lives. More importantly, however, the end-users will be more knowledgeable than the scientists in terms of what the improved cookstoves will need to accommodate in terms of local cooking practices, additional benefits (such as insect removal or heating), and aesthetic requirements. Chikkatur believes that "a bulk of the engineering of energy technology should be carried out in the village itself, with villagers as partners. The villagers need to be an integral part of the entire technology design process and not just in the implementation stage" (Chikkatur, 2002).

The Eritrea Dissemination of Improved Stoves Program involves the users of the stove in the design and construction phase of the stove. This is made possible since the builders of the stoves are usually drawn from among the users. As the Eritrean program moves to national scale and the stoves start to be produced commercially, the ERTC should make sure that the users are kept as an integral part of the design and construction of the stoves by keeping easy communication channels between the producers and the end-users.

Perceived Benefits and Drawbacks

The perceived benefits and drawbacks of the stove will differ from region to region. Successful stove programs will take heterogeneity into account when designing their

programs. A survey of the characteristics of the traditional stoves should be performed prior to designing the improved cookstoves since those stoves that do not possess similar characteristics are not likely to be adopted by households. This was the case when a program failed to understand the different uses of the stove in a certain region and constructed the stove so that it was "smokeless" without knowing that the rural households used the smoke emitted by the old stove to repel insects. What happened was the households reverted back to using the traditional stove, putting the new one aside (Chikkatur 2000).

The Eritrean program does a good job in soliciting the views of improved stove users through occasional surveys and village visits. Eritrea should keep taking feedback from the users of the improved stoves and make sure that the stoves continue to adequately address the needs of the rural households. This is possible through conducting more user surveys or visiting villages to talk to stove users. In addition, there should be a feedback mechanism put in place as the program branches out to more villages in the country. Since, some degree of heterogeneity in user needs among different regions should be expected, the Eritrean program should make sure these are not overlooked by building a strong channel of communication between program administrators, technical staff, and local communities.

IX. RECOMMENDATIONS

This paper tackled the problem of low adoption rates of improved cookstoves in rural settings in the developing world in an effort to provide recommendations to the Eritrea Dissemination of Improved Stoves Program. To identify key determinants of successful improved cookstove programs, four programs that target rural settings were examined. The analysis of improved cookstove programs in India, China, Eritrea, and Ethiopia enables the author to come up with the following recommendations for the Eritrea Dissemination of Improved Stoves Program:

9. The Eritrea Dissemination for Improved Stoves Program should **continue the subsidy approach** to make the stoves affordable to low-income rural communities. However, the program should **avoid setting quotas** for improved stove dissemination, as was done in India. In addition, the program should be closely monitored to ensure that subsidies are not leading to the distribution of unused stoves or stove parts.

10. As the program moves on to national scale, Eritrea should **promote commercialization and mass production** of the stoves. This will allow stove producers to benefit from economies of scale and bring improved stove prices down. As the stoves become more affordable, subsidies can be phased out. As mass production of stove parts becomes a reality, the ERTC should **encourage competition between stove producers** and ensure that the parts are of high quality.

11. Eritrea should **encourage competition between villages** that can prove to the government that they are ready and organized for a village-level switch to improved cookstoves. This approach helps identify those villages that represent households that have greater use for the stoves.

12. The Eritrean program should **rely on a stronger promotional strategy** as the project moves to national scale. The program might want to investigate ways in which it could further promote the improved cookstoves. The author believes that the program could greatly benefit from a project promotion survey, which could direct the program administrators to the most effective avenues for promoting the improved cookstoves. Finally, Eritrea should **evaluate the effectiveness of the current promotion strategies.** This will be useful in ensuring that funds for promotion are being spent on the right strategies.

13. Eritrea should continue to **solicit feedback from the users** of the improved stoves and make sure that the stoves continue to adequately address the needs of the rural households. This can be possible through conducting more user surveys or visiting villages to talk to stove users. There should be a feedback mechanism put in place as the program branches out to more villages in the country. Since, some degree of heterogeneity in user needs among different regions should be expected, the Eritrean program should make sure these are not overlooked by building a strong channel of communication between program administrators, technical staff, and local communities.

14. The Eritrean Energy Research and Training Center (ERTC) should **monitor the results of the improved cookstove program** and aim to **complete annual evaluations** on the progress of the program.

15. The enlargement of the scale of the program to the national level will require increased levels of funding, especially if the subsidies are to be sustained. Eritrea should find ways to **inform international donors and NGOs about the program's success** in the initial two phases. The Eritrean Technical Exchange can be instrumental in these efforts.

16. The survey of the four improved cookstove programs has shown that the maximum rate of adoption ranges between four to five percent, as realized by the Chinese National Improved Cookstove Program. The Eritrean program should view this number as a target while monitoring the dissemination efforts closely to make sure that the adoption of cookstoves results in the use of cookstoves. Eritrea has to **significantly increase the dissemination of improved stoves** as it moves to the Sustained National Promotion Phase. Currently, an average of 2900 stoves are being installed annually. This number has to increase to approximately 25,000 stoves to achieve a dissemination rate similar to that of the Chinese program, which is the most successful program surveyed in this study.

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