What Have We Learned about Household Biomass Cooking in CENTRAL AMERICA?

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ESMAP
Energy Sector Management Assistance Program

THE WORLD BANK

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Preface

This report is the result of the work developed by the Energy Unit of the Latin America and Caribbean Region of the World Bank with financing from the Energy Sector Management Assistance Program (ESMAP). The team was led by Xiaoping Wang and consisted of Janina Franco (co-team leader), Omar Masera (Universidad Nacional Autónoma de México or UNAM), Marta Rivera (Fundacion Solar), and Karin Troncoso (Consultant). Alfredo Idiarte carried out the carbon finance analysis in Chapter 3 and Ainsley McPherson helped with editing and publishing the report.

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ESMAP Mission

The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance program administered by the World Bank. It provides analytical and advisory services to low- and middle-income countries to increase their know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth. ESMAP is funded by Australia, Austria, Denmark, Finland, France, Germany, Iceland, Lithuania, the Netherlands, Norway, Sweden, and the United Kingdom, as well as the World Bank.

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Acronyms

AHDESA	*Asociación Hondureña para el Desarrollo* (Honduras Development Association)
BEPE	Bureau of Environmental Protection and Energy under the Ministry of Agriculture (Government Agency Responsible for the Implementation of ICS Program in China in 1980)
CA	Central America
CCEM	*Centro de Certificación de Estufas Mejoradas* (Certification Centre for Improved Cookstoves under Zamorano University in Honduras)
CCT	Controlled Cooking Test
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CIF	Climate Investment Funds
CNE	National Energy Council (El Salvador)
CO	Carbon Monoxide
CPA	CDM Programme Activities
CRECER	Chronic Respiratory Effects of Early Childhood Exposure to Respirable Particulate Matter
ECLAC	Economic Commission for Latin America and the Caribbean
ERPA	Emission Reduction Purchase Agreements
ESMAP	Energy Sector Management Assistance Program
fNRB	Fraction of Non Renewable Biomass
GACC	Global Alliance for Clean Cookstoves
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HELPS	Helping Early Literacy with Practice Strategies
ICS	Improved Biomass Cookstoves
INEGI	*Instituto Nacional de Estadística y Geografía* (National Statistics and Geography Institute in Mexico)
KPT	Kitchen Performance Test

LPG	Liquefied Petroleum Gas
MEM	Ministry of Energy and Mines
NAMA	Nationally Appropriate Mitigation Options
NISP	Chinese National Improved Stove Program
NO2	Nitrogen Dioxide
PAHO	Pan American Health Organization
PCIA	Partnership for Clean Indoor Air
PECC	*Programa Especial de Cambio Climático* (Special Climate Change Program in Mexico)
PM	Particulate Matter
POA	Program of Activities
PREECA	*Perfil del Proyecto, Regional de Estufas Eficientes en Centroamérica* (Regional Efficient Cookstove Project Proposal for Central America)
RESPIRE	Randomized Exposure Study of Pollution Indoors and Respiratory Effects
SAGARPA	*Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Almintación* (Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food in Mexico)
SEDESOL	*Secretaría de Desarrollo Social* (Secretariat of Social Development in Mexico)
SERNA	*Secretaria de Recursos Naturales y Ambiente (*Secretariat of Natural Resources and Environment in Honduras)
SICA	*Sistema de la Integración Centroamericana* (Central American Integration System)
SREP	Scaling-up Renewable Energy in Low Income Countries
TECSA	*Tecnologías Ecológicas Centroamericanas*
UNDP/PNUD	United Nations Development Programme / *Programa de las Naciones Unidas para el Desarrollo*
USP	Urban Stoves Program in Sri Lanka
WBT	Water Boiling Test
WHO	World Health Organization

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Executive Summary

OBJECTIVES OF THE STUDY

Twenty million people in Central America cook with biomass using open fires or rudimentary stoves. The number of people using biomass for cooking in the region will remain significant for a long time due to high incidence of poverty, high LPG prices coupled with unsustainable LPG subsidies, as well as relatively easy access to fuelwood in the region. Providing these people with clean and efficient cooking solutions is not just an energy issue, but one related to poverty, gender inequality, public health, environmental sustainability, local employment, climate change, agriculture, and local employment.

A new generation of improved biomass cookstoves (ICS)[1] has recently become available in Central America. The economic benefits from improving public health, reducing deforestation, and mitigating greenhouse gas emissions well outweigh the costs of ICS dissemination. Efforts involving donor agencies, governments, non-governmental organizations, as well as local entrepreneurs have been made to disseminate ICS in the region in the last 10 years. Nonetheless, the penetration of ICS remains low—less than 10 percent of the affected population. A critical question to ask is how to

1. In this report, "improved biomass cookstoves" (ICS) refers to stoves that are mass-produced or built *in situ* that, with the benefit of laboratory research, perform better in fuel efficiency, emissions, durability, and safety than open fires or rudimentary cooking devices traditionally used. Reported or actual performance of the improved stoves covered in this report may vary markedly, but only ICS with reported or actual fuel savings of more than 50 percent over open fires are included. Annex VIII affords an overview of different definitions of cookstoves and the context where they are used.

grow ICS penetration from its less than 10 percent market share to 25 percent by 2020 to meet the regional goal of 1,000,000 ICS installed by then and, ultimately, to universal access? Assuming an average cost of US$150 per stove installed (including production, dissemination, training, certification, and promotional campaigns), universal access would require an investment of US$600 million.

The objective of this study is to better understand current developments in clean and efficient biomass cooking solutions, factors that have precluded a larger penetration of ICS within the region, and lessons learned from past programs—both in the region and in other countries—that may be relevant to Central America. The study recommends key actions that may help the region step up its current dissemination efforts and promote sustained use of ICS, a first step toward universal access to ICS by fuelwood users. Its intended audience includes different stakeholders, including government agencies, regional and international organizations, as well as various implementing entities who are thinking or rethinking appropriate technologies, policy interventions, financing, and delivery mechanisms for Central America to promote ICS.

BIOMASS USE AND ICS TECHNOLOGY DEVELOPMENT IN CENTRAL AMERICA

Biomass constituted 34 percent of total final energy consumption in Central America in 2008, second only to the use of oil. Biomass is used mostly in the form of fuelwood for household cooking, and to a lesser extent by a variety of small businesses. Of the 20 million fuelwood users in the region, approximately 86 percent, or 17 million, are concentrated in Guatemala, Honduras, and Nicaragua, including both urban and rural users. Surveys in Honduras show that a large percentage of households collect fuelwood themselves, while the purchase of fuelwood is limited largely to urban and salaried households.

Social and cultural characteristics figure prominently in biomass use for cooking in Central America. Collection of fuelwood and other agricultural residues for cooking is usually performed either by the whole family or exclusively by the head (usually the man) of the family. Women usually take charge of cooking. Men are estimated to spend on average 10 hours per week collecting fuel, while women (and small children sometimes) spend on average 4 hours per day cooking. Cuisine and cooking practices are similar among countries in the region; tortilla-making is the main and central cooking task, and the most intensive in terms of energy and time required. The prevalence of tortilla-making necessitates that a *plancha* (or griddle) be included in ICS design. Other typical regional dishes, such as frijoles (fried bean paste) and *guisados* (stew), are also energy—and time—consuming to make.

Cooking is done traditionally using open fires or with a rudimentary appliance, with or without a chimney, that is usually home-built. In addition to cooking, open fires serve other functions, including heating water for drinking or bathing, providing space heating, drying clothes and food, smoking food, keeping insects away, smoking roofs so that they become water-proof, serving as a social venue for families, and lighting in the absence of electricity. The use of multiple fuels and cooking appliances for cooking (so called "stacking") is common in the region. Surveys in Honduras show that more than 20 percent of the households use fuelwood and at least one other fuel.

Currently, a new generation of ICS with nearly 20 models is available in Central America with significant improvements in design and performance relative to the stoves disseminated before 2000. Rocket elbow[2] in the combustion chamber, *plancha*, and chimney have become standard elements of the design for most ICS available in the region. The costs of producing stoves with these elements range from US$60 to US$160. Both *in-situ* built and mass-produced (industrial) models are offered in the region.

COSTS AND BENEFITS OF ICS

Understanding what factors influence a family's decision in selecting a cooking fuel and appliance is crucial to ICS dissemination. To do so, we take Guatemala as an example and compare the costs and benefits of the three most common cooking technologies: open fires, ICS, and LPG. Given that many families use multiple fuels and cooking appliances to complement each other, such a comparison oversimplifies real life and yet is still illustrative. Costs to households include financial or out-of-pocket costs and economic costs such as labor and time to gather wood, cook, or transport LPG canisters. The financial costs of fuels and appliances are high for LPG users, and for ICS users if they only purchase fuelwood and don't collect it themselves, or if they purchase ICS without a subsidy. The economic costs are high for open fire users when they collect their own fuelwood.

2. A rocket stove, or rocket elbow stove, is an efficient cooking stove in which small-diameter wood logs are burned in a simple high-temperature combustion chamber containing an insulated vertical chimney that ensures complete combustion prior to the flames reaching the cooking surface.

Along with the high financial costs, the financial benefits for ICS users are high. We estimate that if people use ICS only and buy 40 percent of their fuelwood (collecting the rest), the payback time would be around 13 months. The more fuelwood is purchased, the faster payback from ICS occurs. In addition to the financial benefits, other benefits of acquiring ICS include reduced exposure to smoke and associated health benefits, increased comfort, preparing multiple dishes at once, time savings, as well as the aesthetic value associated with the cleanliness of the kitchen and with clean and shiny pots as a result of no direct contact with fire. So the case for acquiring an ICS by household is strong.

Had families using ICS stoves only purchased fuelwood and not collected it themselves, their monthly fuel expenditures would be surprisingly similar to families using LPG, even though the stoves they use are 66 percent more efficient than traditional stoves. Although many families in rural areas collect all or the majority of the fuelwood they need, this begs the question of why people in cities continue using fuelwood even when it is not cheap. It possibly has to do with the high start-up cost and lack of easy access to LPG in rural areas as well as cooking habits and food preferences of families.

It is important to note the significant societal benefits associated with ICS even though they may not directly affect household's purchase decision. Societal benefits associated with improved stoves are myriad, including avoided costs for the public health system, preservation of forest resources, reduced land use change, as well as greenhouse gas reductions resulting from decreased use of non-renewable biomass. There are many uncertainties associated with quantifying these benefits. Nonetheless, regardless of the intervention scenario, time period, or discount rate chosen, the economic returns from investing in ICS are substantial (the benefit-cost ratio is 9 to 1 or higher). Since the benefits represent both local and global public goods, the question really is: are the countries concerned and the global community ready to invest this much in ICS? One mechanism to pay for the global benefits of ICS is carbon finance. Revenues generated from emission reductions of ICS can help improve the viability of cookstove projects by overcoming financial or other barriers to investment.

LESSONS LEARNED FROM EXISTING COOKSTOVE PROGRAMS

It is useful to draw lessons from past successes and failures in order to develop future interventions. It should be noted, however, that while there is some positive experience with ICS programs around the world, we are far from having a complete understanding of the key aspects needed for successful scaling up and operation of large ICS programs in terms of the number of stoves installed and adopted; even less is known about the sustained use of stoves. Despite the many cookstove programs that have been implemented worldwide since the early 1980s, few of them are successful in terms of scale and sustainability.

To promote any change in cooking habits and appliances, social and cultural aspects as well as users' preferences need to be taken into consideration. In general, ICS imply major changes in the way people cook, and do not rank high on a user´s preference list, particularly for the very poor. Experience from pilot projects in Central America shows that fuelwood users respond well when ICS meet the needs of a specific circumstance, such as: when fuelwood is purchased and is becoming increasingly expensive (particularly in the case of former urban LPG users); when health issues are clearly understood by the whole family (as in the case of Honduras); when incentives are provided to lower the upfront costs of stoves (but are not seen as a gift); when ICS are tailored to local cooking practices, resulting in tangible fuel and time savings; and when they do not involve major changes in the dimensions of fuelwood and cooking habits and appeal to the "modernity" aspirations of users.

An enabling environment is needed for cookstove programs to take off. When an enabling environment has been provided by national governments (e.g., effective monitoring of program activities, providing financial incentives, and launching public awareness campaigns regarding wood smoke and other issues related to open fires), programs are more likely to succeed. Public health campaigns conducted in Honduras in the 1980s resulted in many households preferring chimneys installed on their traditional cooking devices. Also, designating a National Coordinating Authority for ICS with responsibility for integrating different dimensions of a cookstove program (energy, health, agriculture, environment and social development) was shown to be important in many countries. Such institution is not necessarily a new entity and can be an existing institution with the mandate to champion cookstove-related issues. In Central America, thus far only Nicaragua has a convening national authority, the Ministry of Energy and Mines, that has taken the lead in developing a national woodfuel strategy and supporting manufacturers in the development of efficient stoves.

Source: Authors

Another critical factor in developing a sustainable ICS initiative is to promulgate standards for stoves disseminated. This was shown in China in the 1990s and has been followed in the current Peruvian National Stove Campaign. Lack of standards and quality control on ICS discourages investment in high-quality ICS on a larger scale. This has been the case in Central America and Mexico, where most of the stoves disseminated have underperformed because of lack of minimum standards. Poor quality control affects users' preferences and trust in adopting new stoves. In the ECLAC (2011b) survey for Honduras, 77 percent of traditional stove users indicated a preference for acquiring ICS due to concerns about access to wood; only 46 percent of existing ICS users, however, indicated a preference for ICS due to problems with their existing ones, poor maintenance, or lack of use.

Different business models need to be selectively evaluated and promoted. There are three broad categories of business models: centralized mass-production and retailers, decentralized mass production, and decentralized *in situ* construction of ICS with user and community participation. In Central America, the first and third models have been used. Mass-produced stoves have been promoted mainly by stove manufacturers that operate with business orientation, as with the Onil and Ecofogón Stoves. External funding available to support mass production often covers only the cost of the stoves; as a result, only short-term monitoring and basic user training, if any, are conducted in these programs. The considerable upfront investments needed to launch and run mass production, assure good feedback and participation from users, and build up an extended supply chain represent key challenges for this approach. Also, the business orientation of this model is not suitable for reaching out to remote locations and the poorest segments of the population.

The decentralized *in situ* construction model has been used to disseminate Justa stoves in Honduras. Organizations promoting *in situ* stoves are interested not only in the number of stoves installed but in empowering local communities and organizations by strengthening their capacities. This model is more appropriate for rural areas, where there is not always a

Source: Authors

strong monetary market for fuelwood and where customers have very limited income. Two weak points of *in situ* stoves are the difficulty in building a supply chain and the problems in assuring quality control over the stoves installed.

A portfolio of financial mechanisms and incentives tailored to local circumstances is needed for large-scale programs. Financial support is needed to offset the high upfront cost of the users and defray the program management costs. Most common improved stoves in Central America are costly relative to the average family income of potential users. In addition, the indirect program costs represent a significant percentage of total costs, in some cases, more than 40 percent. None of the stove programs in Central America—with the exception perhaps of small family businesses—would be financially self-sustainable without external support.

Financing has also been a problem for many stove manufacturers hoping to maintain inventories, build a supply chain, and invest in basic R&D activities, and for end users to pay the high upfront costs. The most common financial mechanism benefiting end-users in Central America has been to reduce ICS upfront costs by applying large direct subsidies to stove prices or by giving away the stoves for free, which has shown mixed impacts in stove dissemination. Increasingly, stove manufacturers are exploring other sources of user financing, such as micro-credits or payments in installments. HELPS, for example, is working with the Rural Bank (Banco Rural) in Guatemala to sell stoves to bank customers using credits. However, experience with user financing in Central America and internationally is relatively new and it is too early to assess its replication potential. There remains much to learn from the experience of other household-level interventions that require behavioral changes: solar water disinfection, latrines, hand-washing, and solar panels for rural electrification.

RECOMMENDATIONS AND CONCLUSIONS

Based on the lessons learned in Central America and other countries with established experience with ICS, we recommend that in Central America it is necessary to provide an enabling institutional environment, to support the development of new and advanced products, and to increase efficiency and scale for ICS dissemination.

Governments should prioritize household biomass use on their agenda and designate a national coordinating authority (which can be an existing entity with a new/additional mandate) that has oversight of energy, health, environment, and gender issues related to household biomass use. Goals for ICS dissemination need to be clearly stated and national ICS plans launched and designed as part of the overall regional mandate. It is also important for the region to remove trade barriers related to ICS dissemination and to develop regional ICS standards together with testing and M&E protocols. A country-based regional campaign is necessary to make sure the general population knows why ICS are important, including fuel savings, health and quality of life for women and children, as well as environmental sustainability.

It is necessary to fund the development of more advanced biomass stoves with better performance than current ICS models. There is already good initial experience in the region with relatively advanced combustion stoves, such as the Turbococina. These efforts should be directed to improve critical components of stoves, such as the combustion chamber. In addition, solutions to replace open fires need to include not only an improved cooking appliance but also products with other functions provided by open fires. Unless the multiple functions of open fires (such as space heating and insect control) are addressed by a cookstove program, open fires will continue to be used in combination with ICS. At a minimum, open fire, if used, should be displaced from inside the kitchen.

Stepping up current ICS efforts in the region will require multiple entry points and business models. With a potential market of US$600 million to reach universal access and a diverse set of social, technical and environmental circumstances within the region, it is clear that no single party (public or private) will be able to shoulder the investment needs and that no single stove model or delivery mechanism will fit all. The business models needed to substantially scale up current cookstove activities may include: centralized mass-production of stoves with affiliated retail outlets or intermediaries; manufacturing using local builders, selling stoves through regular markets or NGOs; and finally decentralized *in situ* construction by stove builders, particularly for poor rural customers and remote locations where the logistics and costs of providing mass-produced stoves might be challenging. Each business model should be designed to avoid the mistakes or problems identified from past experience. In addition, it is necessary to better integrate socio-cultural and gender aspects related to biomass use in ICS Programs. Cookstove programs need to tailor the stove design, marketing and awareness campaigns to the interests and concerns of both men and women.

Financing both the production and purchase of ICS will be crucial to successful dissemination. At a likely market price of US$150 per ICS, only a fraction of potential users in Central America will be able to afford the stoves without some aid to reduce the upfront cost of stoves. Financial and other type of support should also be provided to cookstove manufacturers. This includes support for training and capacity building, soft-debt financing and loans for working capital to supply the ICS market; and, in the case of small manufacturers, financing to pay for the certification process and eventually for the transaction costs of the carbon market.

1

Introduction

Providing 2.7 billion people worldwide that cook with biomass in open fires with clean and efficient cooking solutions is not just an energy issue, but one related to poverty, gender inequality, public health, environmental sustainability, local employment, climate change, agriculture, and rural development. Most of the households that use biomass are poor and burn biomass in very inefficient appliances to meet their cooking needs. Furthermore, these open fires emit a significant amount of smoke due to incomplete combustion, which consists of commonly regulated air pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2), black carbon, and particulate matter (PM). Indoor air pollution has been estimated to be associated with 1.9 million premature deaths every year, constituting the 4th major cause of mortality globally, and has also been associated with a number of morbidity endpoints, the most serious of which are chronic and acute respiratory illnesses (WHO & UNDP 2009). The health effects are more acute among women, who are responsible for cooking in most countries, and among small children, who often stay near their mothers. When collecting or cutting fuelwood is not conducted sustainably, it contributes to forest degradation, soil erosion, and greenhouse gas (GHG) emissions.

In the recent decade, there has been renewed global interest in biomass cooking. Modern energy services, including improved cookstoves and sustainable biomass production, as well as informed family decisions in acquiring modern energy services, are necessary to achieve the Millennium Development Goals (MDG), even though no MDG refers to energy services explicitly (WHO & UNDP 2009; IEA 2010). Biomass cooking is also closely

THE HEALTH EFFECTS ARE MORE ACUTE AMONG WOMEN, WHO ARE RESPONSIBLE FOR COOKING IN MOST COUNTRIES, AND AMONG SMALL CHILDREN, WHO OFTEN STAY NEAR THEIR MOTHERS.

related to two of the three pillars of the new United Nations Initiative "Sustainable Energy for All"—energy efficiency and universal access to modern energy services. The Global Alliance for Clean Cookstoves (GACC), which was launched in 2010 as a public-private partnership to mobilize support from a wide range of private, public, and non-profit stakeholders set a goal to foster the adoption of clean cookstoves and fuels in 100 million households by 2020.

Central America has a long tradition with cookstove interventions, having pioneered the development of the Lorena stoves in the 1970s. Currently, a new generation of improved cookstoves (ICS) is available with better stove designs, including industrial models[3] that have received international recognition and awards. At the regional level, the Central American Integration System (*Sistema de la Integracion Centroamericana* or SICA) set a target to install 1 million ICS and reduce the current consumption of woodfuels by 10 percent by the year 2020. Guatemala, El Salvador, as well as SICA, have joined the GACC as partners to take advantage of global knowledge and experience as part of their efforts in achieving the regional cookstove targets. Nicaragua has successfully developed its country targets to promote clean and efficient cooking solutions; other countries in the region are expected to follow suit (MEM Nicaragua 2010).

However, the penetration of ICS in Central America remains low, and the existing ICS initiatives have not been able to reach economies of scale. This study aims to better understand developments in clean and efficient biomass cooking solutions, factors that have precluded a larger penetration of ICS within the region, and lessons learned from past programs both in the region and in other countries that may be relevant to Central America. The study recommends key actions that may help scale up current dissemination efforts and promote sustained use of ICS in the region, a first step toward universal access to ICS by fuelwood users. Its intended audience includes government agencies, regional and international organizations, as well as various implementing entities who are thinking or rethinking appropriate technologies, policy interventions, financing and delivery mechanisms for Central America to promote ICS.

Different strategies are available to address the problems related to biomass use in cooking, including inter-fuel substitution and improved stoves. As will be seen later in this report, we argue that fuelwood will continue to

3. Industrial ICS are those that are built with standardized specifications and that are usually manufactured and then transported to their destinations.

be the primary cooking fuel for many rural and urban households in CA in the foreseeable future even though the general trend is to partially substitute LPG for fuelwood as household incomes rise. The report focuses on improved biomass stoves; inter-fuel substitution is beyond its scope.

For the purposes of the report, the Central American region is comprised of El Salvador, Guatemala, Honduras, Nicaragua, Costa Rica and Panamá. Since the biomass cooking population in the last two countries is very small, the report focuses on the first four countries.

In carrying out the study, the team conducted field trips and interviews with government officials, nongovernmental organizations (NGOs), the private sector, stove manufacturers, stove users, and development agencies with active ICS programs in CA. A virtual survey was carried out via email to target main cookstove stakeholders in Central America and Mexico (see the survey findings in Annex IX).

In this report, improved cookstoves refers to stoves that are mass-produced or built *in situ* based on certain levels of technical research and have better performance in terms of efficiency, emissions, durability and safety than either open fires or rudimentary cooking devices traditionally used in CA (see Annex VIII for different terms related to biomass cookstoves). The report focuses on biomass stoves and discusses LPG stoves only for comparison purposes. Reported or actual performance of the improved stoves covered in this report may vary markedly.

The present report is divided into four sections. We first examine the current patterns of household fuelwood use and trends and major technological developments for clean and efficient cooking in CA. We then look at the financial and non-financial factors that affect family decisions in acquiring and sustainably using ICS, as well as the societal costs and benefits associated with ICS. We also review the experience with ICS programs in the region and examine the lessons learned from successful programs in both CA and other countries. The report concludes with a set of concrete recommendations to increase the effectiveness and scale of future ICS interventions.

2

Current Fuelwood Use and Stove Technology Development in Central America

2.1 FUELWOOD USE

The Central American region had approximately 40 million inhabitants in 2010 and an area of almost 500,000 km^2. Fifty six percent of the total population in the region lives in urban areas. More than half of the population lives below the poverty line (55 percent) and almost a third lives in extreme poverty (32 percent). The low-income population is distributed in both urban and rural areas (Table 1).

There are large differences among the six countries in terms of their socioeconomic indicators, with Costa Rica and Panama the wealthiest, and Honduras and Nicaragua the poorest. Per capita income ranges from approximately US$11,000 in Costa Rica and Panama to US$3,000 in Nicaragua. In Nicaragua and Honduras, more than half the people live in extreme poverty (55 percent and 54 percent respectively).

Biomass constituted 34 percent of the total final energy consumption in 2008, second only to the use of oil. Biomass is used mostly in the form of fuelwood for household cooking and to a lesser extent by a variety of small businesses.[4] Reliance on biomass ranges from 13-48 percent of total energy use, and 56-92 percent of total residential energy use, depending on the country (Table 1) (Díaz 2010).

4. There is a wide range of small industries that consume fuelwood in CA. The most common ones include brick-making, pottery-making, tortilla and pupusa - making facilities, and bakeries.

Of the 20 million fuelwood users (51 percent of the total population) in the region, approximately 86 percent, or 17 million, are concentrated in three countries: Guatemala, Honduras and Nicaragua (Figure 1). While in Costa Rica, Panamá, and El Salvador, fuelwood users are predominantly rural, about 40 percent of the urban population in Guatemala, Honduras and Nicaragua also use fuelwood (DIECA et al. 2010; ASDI & PNUD 2008; MEM 2007). Approximately 10 percent of fuelwood-using households have efficient stoves; the rest use open fire or rudimentary cooking appliances.

In contrast, Sub-Saharan Africa has about 653 million people using traditional biomass for cooking. About 83 percent of the rural households and 60 percent of urban households are estimated to rely on solid fuels for cooking in Africa (IEA 2010). After Sub-Saharan Africa, India has most biomass users, as about 71 percent of its population relies on solid fuels. In China, about 423 million people rely on traditional biomass for cooking. In

TABLE 1. Socioeconomic Characteristics and Fuelwood Use in Central America

	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panamá	Centro -américa
Area (km²)	51,000	21,040	108,890	112,090	130,370	75,520	498,640
Population(millions)	4.40	6.76	13.03	6.97	5.67	3.29	39.89
GDP per capita (US$), 2010	6,580	3,360	2,740	1,880	1,080	6,990	
Population under the poverty line (%)	20	37.8	56.2	65	48	25.6	55
Population in extreme poverty(%)[a]		19	15	54	55[b]		32
Urban Population (as % of total)	62	60	47	35	59	71	54
Rural Population (% of total)	38	40	53	65	41	29	46
Fuelwood as percentage of final residential energy used	55.9	67.1	92.3	86.2	91.1	61.3	
Fuelwood population users (%)	9.3	27.1	71.7	69.2	67.2	16.0	51
Urban fuelwood population users (%)	0	11.6	46	37	46	0	
Exclusive fuelwood users (%)			25[c]	33[a]			
Population that purchases fuelwood (%)				65.8[a]			
Rural Population that uses fuelwood (%)	25	67	96	96	97	55	
Exclusive fuelwood users (%)			42[c]	59.2[a]			
Population that purchases fuelwood (%)				49.2[a]			
Sustainable fuelwood (%)*	n/a	42	58	n/a	64	n/a	n/a
Extractive fuelwood (%)[e]	n/a	58	42	n/a	36	n/a	n/a

Sources: Díaz (2010) unless specified otherwise. [a]Berrueta (2011b); [b]MEM (2010); [c]Berrueta (2011a); [d]OLADE (2008); ECLAC (2009); [i]interviews with local experts in each country.

*Sustainable fuelwood is defined as the wood harvested or collected that does not contribute to loss or degradation; Extractive fuelwood is the wood that contributes to loss and degradation of ecosystems or habitats of threatened species.

other East Asian countries, such as Cambodia, Lao PDR, Mongolia, Vietnam, and especially Indonesia and the Philippines, the amount of biomass users is also high (Ekouevi and Tuntivate 2011).

Regional fuelwood demand in Central America is expected to grow 15 percent between now and the year 2020 (Díaz 2010). This is the result of population growth and the slow-down or even reversal of the historic substitution of LPG for fuelwood. LPG was subsidized in countries such as Costa Rica, Panama, and El Salvador in the past, and switching from biomass to LPG occurred particularly in urban areas. However, since 2008, LPG subsidies have been adjusted in El Salvador to better reflect the cost of supply, and the price of LPG has escalated; currently, it reaches between US$15–17 per 25 lb. container compared to US$5 per cylinder previously (except for the first cylinder for households, which is sold at US$6 after the government subsidy). As a result, residential LPG consumption in El Salvador has decreased, and some households are believed to have switched back to fuelwood.

The potential impacts of fuelwood harvesting on environmental degradation and deforestation are not well documented but appear to be significant in specific areas. Between 36 percent and 58 percent of fuelwood demand is satisfied with wood extracted without proper management plans (Table 1). An ESMAP study (2004) estimated that in Guatemala approxi-

FIGURE 1. Fuelwood Users as Percent of the Population

mately 2,460 hectares of forests are lost each year due to fuelwood harvesting. In Honduras, at least 59 percent of the fuelwood used for cooking is considered nonrenewable (The Gold Standard, a third-party certifier of reductions of greenhouse gases, www.cdmgoldstandard.org) accepted a nonrenewable biomass factor (fNRB) of 0.59 to estimate carbon emission reductions from the cookstove project Proyecto Mirador in Honduras). High uncertainty is associated with this figure due to lack of data; however, in other regions of the world, the value for fNRB is much higher (75-90 percent) (Rob Bailis, personal communication, August 2012).

According to a recent survey in Honduras (ECLAC 2011b), approximately 56 percent of the households that cook with fuelwood purchase it. Most of these families are urban or have salary income. Fuelwood can be purchased at local convenience stores with home delivery by vending trucks, through neighbors, and at the market. Families buying fuelwood in the market represent a small percentage of all families covered in the survey, indicating that fuelwood transactions are highly localized, and that the main costs of fuelwood are transportation and labor for collection. Indeed, the survey found that families collecting fuelwood for their own consumption consider fuelwood free. Households in Honduras that collect fuelwood spend on average 10 hours per week collecting it.

2.2 GENDER AND CULTURAL ASPECTS OF HOUSEHOLD FUELWOOD USE

2.2.1 Gender

In Central America, collection of fuelwood and other agricultural residues for cooking is usually performed either by the whole family or exclusively by the head of the family (usually a male in CA) (ESMAP 2004; Troncoso et al. 2007; Cooke et al. 2008; stakeholders survey by the authors (see the Survey Analysis Annex)), unless there is not a man at home or in cases where fuelwood is widely available and easy to collect. Women are primarily in charge of cooking. The effects of cooking with fuelwood are therefore differentiated by gender: men spend on average 10 hours per week collecting fuel while women (and small children sometimes) spend on average 4 hours per day cooking, exposing themselves to indoor air pollution produced by the incomplete combustion of fuelwood. In this context, the introduction of an ICS that reduces time collecting fuel and eliminates smoke from the kitchen would allow both women and men to devote more time to productive economic activ-

WOMEN SPEND ON AVERAGE 4 HOURS PER DAY COOKING, EXPOSED TO INDOOR AIR POLLUTION PRODUCED BY THE INCOMPLETE COMBUSTION OF FUELWOOD

ities. It would also improve the health of women and children due to reduced exposure to smoke, which in turn will diminish the need for doctors and medicines and improve the overall quality of their lives.

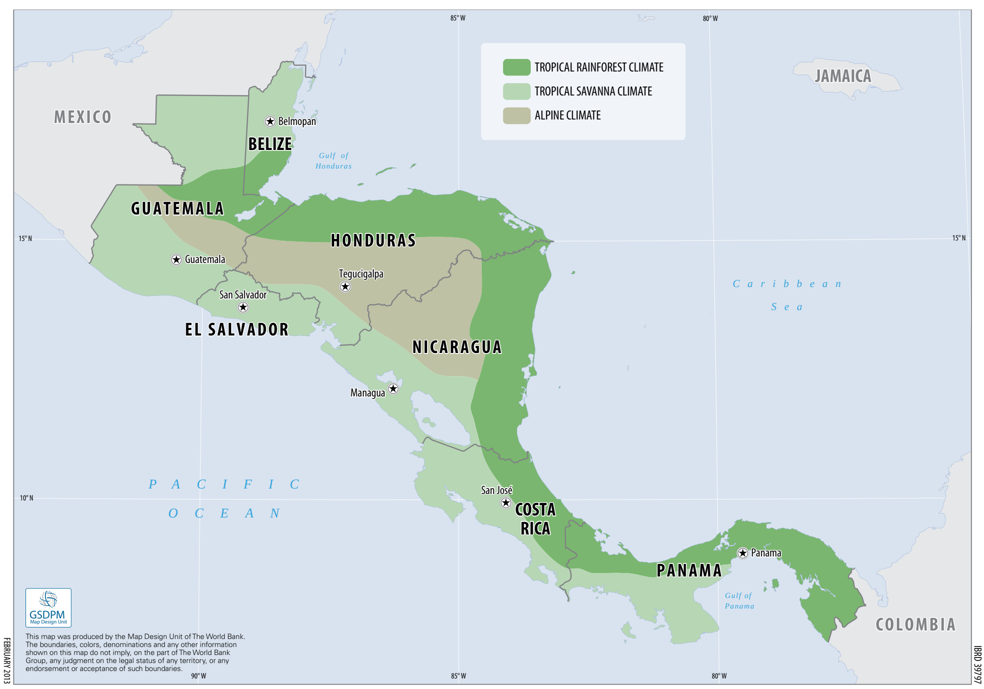
2.2.2 Traditional Cuisine

The six Central American countries share many cultural traits and culinary traditions. With the exception of Panama, these countries were part of the Capitanía de Guatemala until the beginning of the 19th Century and thus share the same cultural roots. The six nations have indigenous populations, with the most ethnic diversity found in Guatemala, which has more than 22 ethnic groups (including Maya, Garifuna, Mestizo, and groups from European descent).

There are, however, important differences related to cooking practices in different climatic zones (Figure 2). In the highlands, people cook in enclosed kitchens (i.e., with a roof and walls) and use fuelwood for space heating during winter. In the tropical dry areas, people usually cook outside the house. In tropical wet areas, fuelwood is used extensively to dry clothes in addition to cooking.

Tortilla making is the main and central cooking task in the region and the most intensive in terms of energy and time required (Masera & Navia 1997). Making tortillas is also the task that results in the highest exposure to smoke,

FIGURE 2. Climate Zones in Central America



as women need to stay continuously close to the fire (Armendáriz-Arnez et al. 2010). Making tortillas requires three main steps: first, *nixtamal* (corn that has been left in water with limestone) is cooked slowly for several hours over the fire, generally using large pots (5 liters or more). Second, the *nixtamal* is ground to get the dough. Finally, tortillas are prepared, either formed into flat circles by hand or with the help of a device, and are then placed on top of a flat pan or *comal*[5] for several minutes until they are cooked. The average family eats 3 kg. of tortillas per day, which requires high fuelwood consumption. In addition to tortillas, other dishes commonly prepared include beans and rice, and in tropical regions, fried bananas, as well as tubers. Other regional foods include vegetables, eggs, meat, pasta, and local *guisados* (stews). Traditional foods also include *atoles*[6] and a rich variety of tamales (Table 2).

2.2.3 Cooking Appliances

Cooking is done traditionally using open fires or on a rudimentary appliance, which is usually home built and with or without chimneys. The sim-

TABLE 2. Main Traditional Cooking Practices and Uses of Open Fires in Central America

Country	Dominant Cooking Practices	Other uses of open fires	Main Features
Guatemala	Tortillas, beans, rice, eggs, coffee, meat, chicken, potatoes, grains, bananas, corn, *atole*	Heat water, space heating (in highlands), dry fuelwood, dry clothes, keep insects away, illumination	To make tortillas a flat pan or *comal* is needed. To prepare *nixtamal* (corn dough to make tortillas), beans and other grains, direct fire is required in an extended simmering phase.
Honduras	Tortillas, beans, soups, meat, rice, spaghetti, corn, eggs, bananas, fried food	Heat water, space heating (sometimes), dry fuelwood, keep insects away (rare), toast coffee	Same as above
Nicaragua	Tortillas, beans, rice, nacatamales, atole, corn, bananas, fried food, chicken, meat.	Heat water, heat the environment (rare), keep insects away (often), dry fuelwood, heat the iron.	Same as above
El Salvador	Tortillas, pupusas (stuffed tortilla with meat or cheese), rice, beans, coffee, eggs, meat, corn, bananas, fried food, soup.	Heat water, heat environment (rare), dry smoke food, to make bread.	Same as above
Panama	Rice, beans, chicheme, guacho, tubers.	Heat water, keep insects away.	To prepare beans requires an extended simmering phase.

Source: authors' estimates based on information gathered through a survey of 28 people working on ICS implementation programs in Central America.

5. A *comal* is a large round flat clay dish on top of which tortillas are made. It is placed on direct flame. There are several sizes, but each is made so several tortillas can be cooked at the same time.
6. Atole is a hot thick beverage prepared with corn flour. It can be prepared with water or milk and it usually has a flavor (chocolate, cinnamon, coconut, rice), and is typically served with tamales.

plest arrangement consists of 3 stones, which can be adjusted to the size and shape of a pot or *comal* (Figure 3) (Díaz 2010). Other common appliances are U-shaped fires made by enclosing a fire with 3 walls of bricks or other local materials. In Honduras, many households adapt chimneys to these open fires, forming rudimentary stoves that channel smoke out of the kitchen. In Guatemala, 91 percent of fuelwood-using families use 3 stones, of which about 44 percent have chimneys. On the other hand, there is an increasing reliance on the so-called *"planchas,"* which are large square or rectangular flat iron griddles that are placed on the top of U-shaped fires and can accommodate several pots. Usually, *planchas* come with one set of removable discs so people can place pots of diverse sizes directly in contact with the fire. There is a large market for *planchas* all over Guatemala. The price of a *plancha* alone is not subsidized.

It is important to note that open fires serve not only for cooking, but also for many other functions. Some of their uses include: heating water for either drinking or bathing; providing space heating; drying clothes and food; smoking food; keeping away insects; and smoking roofs in order to waterproof them. When families lack electricity, fires provide light. Open fires also provide an opportunity for families to gather around, and they traditionally harbor deep cultural roots and symbolic meaning (e.g., the source of life) in indigenous communities. All these additional roles need to be taken into account when disseminating ICS (Table 2). Very rarely will new improved stoves be able to perform all the tasks that are performed by traditional open fires. Under these circumstances, unless

FIGURE 3. Traditional Open Fire Used in Central America

Source: Authors

alternatives are provided, people will continue using open fires side-by-side with new stoves.

The use of multiple fuels and appliances for cooking (so called "stacking") is common. In Honduras, the ECLAC (2011b) survey shows that more than 20 percent of households use fuelwood and at least one other fuel. 78 percent of the stoves in the survey have *planchas,* while 22.3 percent have ovens. Multiple fuels and cooking appliances are also observed in other countries outside of the region. In Mexico, for example, the national share of mixed-fuel users was 32 percent in 2000 (INEGI 2000).

2.3 TECHNOLOGICAL DEVELOPMENT IN CLEAN AND EFFICIENT COOKING

2.3.1 Historical Background

Central America has a long history of stove innovation. In the 1970s, the development of the Lorena stove reached popularity both within the region and in many developing countries. The stove was created in Guatemala, made out of sand and clay, built *in situ,* had an opening for a large *comal,* and set the standard for many Lorena-type models to come. The current Lorena-type stoves built are called *plancha* stoves, which have a base made of block or bricks to create a flat surface. Three walls are then built up around the sides of the base. The iron top, or *plancha,* is then placed on top, and a chimney is installed at one end (Figure 4). It is estimated that up to the year 2000, about 150,000 *plancha* stoves had been built, mostly in Guatemala. There are no standard dimensions for *plancha* stoves, and most of them do not have a combustion chamber. The main improvement of *plancha*

FIGURE 4. Various Types of Plancha Stoves with a Plancha and Chimney

Source: Díaz (2010)

stoves over open fires is the chimney. As a result, these stoves help reduce indoor air pollution, if properly used, as the smoke is sent outside the house via chimney. However, these stoves contribute to ambient air pollution and do not necessarily result in fuelwood savings (Granderson et al. 2009). The *plancha* stoves made before 2000 were built by heavily subsidized programs, with very poor quality control and no program monitoring and evaluation (Figure 4).[7] Almost all of them have disappeared. Consequently, they are not considered an ICS for the purposes of this study.

2.3.2 Main ICS models distributed in El Salvador, Guatemala, Honduras and Nicaragua

Currently, a new generation of industrially made ICS is available with improved designs and performance (see Annex II for details). Much innovation is occurring among manufacturers exploring different models to increase acceptance and sustained use, including *in situ* built and industrial models. The advantages and disadvantages of *in situ* and industrial stoves are described in Table 3.

Most of the ICS models disseminated in the region have an iron top plancha for tortilla making and a chimney and incorporate rocket elbow design in the combustion chamber. The popular models accommodate the

TABLE 3. Advantages and Disadvantages of in situ Built & Industrial Stove Models

	Advantages	Disadvantages
In Situ Models	• Design can be flexible to take into consideration regional customs and needs • Users can take part in the construction of the stoves • Users can pay part of the stove cost with their own labor and local materials • Promotes local employment	• Difficult to ensure quality and stove performance • Training builders, stove construction, and drying the stove take time • Training can be expensive and have limited effect on improving stove maintenance • Usually requires materials that are not locally available, making needed repairs and replication difficult after the external promoters are gone • Very difficult or impossible to move
Industrial Models	• Standardized quality and performance • Easy and relatively fast to install • Portable • Does not require training of local builders • Can be mass-produced and distributed	• Centralized production makes transportation to end users in remote areas difficult and expensive • Transport costs need to be considered in the final cost • Taxes can make it less affordable • Stove price cannot be reduced through local participation (labor and materials) • Cannot be adapted to local customs and needs

7. Despite these problems, some NGOs continue building similar *Plancha* stoves nowadays.

use of multiple pots and have a large combustion chamber in which large pieces of wood can be used. Full retail prices of these stoves are not available for all stoves, as some of them are not marketed, and the price provided for others does not include the indirect costs for running the programs. The popular models are estimated to cost around US$150, including both stove production and dissemination costs. The thermal efficiency of these ICS is generally above 50 percent over open fires; in addition, there is substantial reduction in particulate and carbon monoxide emissions. The Zamorano Agricultural University in Honduras is the only agency in the region that provides the services of testing stove performance. It has been carrying out tests for some ICS models voluntarily or upon manufacturer's request. The details of major ICS models are presented in Tables 4 and 5.[8]

TABLE 4. Prices and Characteristics of Industrial Stove Models

Stove	Sales Price or Cost[b] (US$)	Production Capacity[a] (per year)	Fuel Savings	Testing and results certified by Zamorano
Ecocina	60	5,000	Above 50%	Being tested by Zamorano
Ecocina Tortilleras/ oven	250		Above 50%	To be tested by Zamorano
Mimosa	70		Above 80%	No
Turbococina	150		Above 95%	No
Onil	125	60,000	65%	Yes
Noya	160	5,000	Above 50%	To be tested by Zamorano
Justa 22x22 (square)	150			
Justa 22x30 (rectangular)	140			
Justa with oven 16x30	160			
Copan 16x24	120			
Ecofogón	115	10,000	Above 50%	No
Ecofogón Tortilleras	122			No
Ecofogón Oven	880			No
Mifogón	70	10,000		No
Rapidita 1-plate (charcoal)	20	2,400		No

[a] Note that some figures correspond to actual annual production, while others (Ecocina, Onil, Ecofogón and Mifogón) are estimates made by the producers of their potential production capacity.

[b] Note that although these are sales cost, many stoves have been highly subsidized and the user only pays a fraction of its cost.

8. The information presented in this section has been obtained directly from the implementing organizations, is self -reported, and has not been independently evaluated.

TABLE 5. Prices and Characteristics of Main *in situ* Stoves

Stove	Sales Price[b] (US$)	Production Capacity[a] (per year)	Fuel savings	Testing and results Certified by Zamorano
La Chapina	115	1,440	60%	Being tested by Zamorano
Justa 16x24	140	12,000	48%	Yes
Justa 2x3	85	30,000	57%	Yes
Justa Fundeih	100–120			No
Ecofogón	115		50%	No

[a] Note that figures are estimates made by the producers of their potential production capacity.

[b] Note that although these are sales cost, many stoves have been highly subsidized and the user only pays a fraction of its cost. For instance, the Justa 2x3 the user provides only the local material, and the Justa Fundeih is usually given for free.

3

Economic Considerations and Regional Experience in Dissemination of Improved Stoves

In this section, we review the costs of fuels and stoves, actual and perceived monetary and non-monetary benefits to families, and the costs and benefits to society at large of improved stoves and of alternative fuels and appliances. The ultimate purpose is to create an economic framework to help us understand the factors influencing families' decisions in selecting cooking fuels and appliances. We will also examine the extent to which carbon finance can provide financial incentives for the dissemination of improved cookstoves by monetizing the global environmental externalities.

In Central America, rather than a strict fuel ladder, we see a trend towards diversification in fuels and technologies, as well as frequent stacking. This analysis will focus on three of the most common technologies found in countries with high biomass use, including Guatemala, Honduras, Nicaragua, and El Salvador: open fire, ICS, and LPG stoves. Also, the switching process is not strictly linear. A large number of households using fuelwood as their primary cooking fuel also use LPG and electricity as complementary fuels (Redman 2011, ECLAC 2011a and 2011b). The pros and cons of the three technologies were documented by Troncoso et al. (2007) (see Table 6) for the highland areas in southwestern Mexico, which to a large extent, applies to CA due to its geographical proximity and similarity in cuisine and social and cultural practices.

TABLE 6. Comparison of Three Cooking Technologies

Technology	Reasons for using it	Benefits	Drawbacks
Open fire	• Is faster to start • Provides space heating • Supports heavy pots • Accepts large logs • Is customary	• Is cheap • Is versatile • Does not require learning new skills	• Smoke is a nuisance • Dirty kitchen • Smoke causes health problems • Smokes the food
Improved Biomass Cookstove (ICS)	• Little or no smoke • Is aesthetically pleasing • Saves fuelwood • Is better for health	• Saves fuelwood • Reclaims the kitchen as a place for family gathering • Cook does not get too hot	• Chamber opening is small • Is difficult and slow to start • Needs maintenance • May need special fuelwood • Requires learning new skills
LPG	• Cooks faster • Is easy to use • Is suitable when there is no fuelwood • Is convenient and clean • Does not smoke food	• Is available any time	• high start-up costs and recurrent fuel costs • requires cash payment • Unsuitable for making tortillas • Does not heat the kitchen • May not be available locally

*adapted from Troncoso et al. (2007). The second column refers to reasons given by women why they decided to acquire ICS. The third column refers to the benefits reported by women once they have tried the new stoves.

3.1 COSTS OF FUELS AND APPLIANCES

3.1.1 Costs of LPG

There are a variety of different costs: private, financial, or out-of-pocket costs; private economic costs (such as labor to gather wood or transport LPG canisters); and public costs to society (deforestation, outdoor air pollution, GHG emissions, costs to the fiscal authorities of subsidizing fuels or stoves, etc.). Some of these costs are not well understood or documented. Furthermore, these costs vary by country and local circumstance. Among four of the Central American countries of interest, Guatemala has the best available relevant data and is thus used as an example in this analysis.

The LPG retail market in Guatemala is highly concentrated, with only 3 distributors: Zeta Gas, TOMSA and DAGAS. The price of LPG is deregulated. The retail price in the capital city as of June 2012 is Quetzals 94 (US$ 12.3) for a 25-lb. (11.4kg.) cylinder, the container with the largest market share (MEM Guatemala 2012). The current retail prices outside of the capital city are not available. However, Ahmed et al. (2005) reported that the retail prices in other regions of Guatemala could be as much as 50 percent higher than in the capital city, reflecting a combination of logistics costs; different unit costs of storage, bottling, and distribution operations; and lack of competition.

The average LPG consumption in Guatemala is 12 kg. per household per month with only 1 kg. difference between urban and rural households (Kojima, Bacon and Zhou 2011).[9] Monthly expenditures on LPG are US$12, representing 2.4 percent of the average household's income and 20 percent of the poor's. LPG prices (before subsidies) in other Central American countries vary, but not by much, showing that it is a relatively mature market (Table 7).

Using LPG involves a large start-up cost in addition to significant ongoing fuel costs. The cost of purchasing a LPG cylinder, accessories, and stovetop with two burners is Q600 (US$77.90). In Guatemala, LPG dealers offered installment plans for the cylinder deposit fee and stove purchase. While an installment plan actually increases the total payment for start-up by 20-30 percent, it helps some households overcome the high upfront costs of adopting LPG. Still, some families can't afford it even with financing options from distributors. In addition, purchase of LPG fuel requires regular cash outlays, which many rural families do not have.

Another issue to consider is distance from LPG distribution centers to rural areas. The household surveys suggested that there are LPG users in almost all communities (ESMAP 2003). However, many rural areas do not have a store or outlet where LPG is easily available, and some do not have year-round accessible roads in order to get to the nearest distribution centers. Lack of easy and convenient access to LPG may prevent some families from adopting it or affect their consumption. What is not monetized in the LPG retail price is the labor and time of transporting the bottle back and forth from the house to the exchange point for refilling. From a private economic cost perspective, this may be prohibitive in many rural areas of CA, explains why LPG use may become feasible only in peri-urban and urban areas with relatively easy access to LPG distribution centers. From a

TABLE 7. Central America LPG Prices and Subsidies, for a Cylinder of 25 lb. or 11.4 kg.

	GUA	ES*	HDS	NIC	CR	PAN
Import parity price	13.1	14.0	11.9	12.2	17.4	n/a
Subsidy	0.0	0.0*	–2.1	0.0	0.0	n/a
Taxes	1.6	0.6	0.7	0.0	1.5	0
Retail price	14.6	14.6	10.6	12.2	18.9	4.37

*In El Salvador, the retail price for the first cylinder/month/per family is US$6 as of 2012.

Source: MEM Guatemala, Estadísticas petroleras week Oct 24-28, 2008 (except Panama and Nicaragua), as quoted in Lecaros et al (2010). For Nicaragua: http://www.mem.gob.ni/media/file/HIDROCARBUROS/ESTADISTICAS/INFORME%20ESTADISTICO%20FEBRERO%202012.pdf

9. The authors noted that there was possibly a bias in the original household survey (ENCOVI 2006) caused by some households not having a refill during the survey period or on a monthly basis. As a result, they were not captured by the survey or equate the amount purchased to the amount consumed.

public policy perspective, it is a question of how much infrastructure investment is needed to make LPG a viable fuel for the entire population, as well as how to design a pricing policy that makes it affordable.

3.1.2 Costs of Fuelwood

Household expenditures on fuelwood are not easy to quantify for several reasons. First, very few families in rural areas rely on purchasing it. Most rural families collect their own fuelwood, while some complement self-collection by purchasing it. For most rural families, fuelwood is a subsistence fuel, since its collection is largely free except for time and, in some cases, transportation costs. Families can obtain it without having to have cash in hand. For families that rely on purchasing fuelwood wholly or partially, prices vary greatly, depending on locale, type of species, size of logs, dryness, type of vending outlets, and other factors, which are not systematically documented in the literature. Indeed, even the measuring units vary greatly based on local customs, and could be *tarea,* load, pickup, *manojo,* etc., which are not always convertible from one to the other, making across-the-board comparisons even more difficult (ECLAC 2011a and 2011b).

Due to these constraints, we use data collected from four rural communities in Guatemala: Alta Verapaz, San Antonio Seja, Baja Verapaz, and San Marcos, where Onil stoves are disseminated by Fundación Solar and HELPS International. It should be mentioned that these data are used for illustrative purposes, and that there is insufficient information to extrapolate them to other regions of Guatemala or other countries in the region.

FOR MOST RURAL FAMILIES, FUELWOOD IS A SUBSISTENCE FUEL . . . FAMILIES CAN OBTAIN IT WITHOUT HAVING TO HAVE CASH IN HAND.

Even in these four communities, prices vary by type of wood and distance for transportation (Table 8). The average consumption by households surveyed for this project is 1.5 *tareas*[10] of fuelwood per month using open fires. With the use of an efficient stove, first reports of fuelwood consumption were of 0.50 *tarea* per month, resulting in savings of around 66 percent. For families using traditional stoves, the lowest prices of fuelwood among the four communities surveyed are found in San Marcos. Monthly expenditures on fuelwood there are US$36.90/month for traditional stove users and US$12.30/month for ICS users.[11] Fuelwood savings from adopting ICS is therefore US$24.50/month.

Contrary to the common belief that fuelwood is cheaper than LPG, had the families using ICS only bought fuelwood and not collected it themselves, their monthly fuel expenditures would be close to those cited earlier for

10. A *tarea* is a standard unit of measurement for firewood used throughout CA.
11. Considering Q7.70 per dollar and a cost of Q190 per *tarea*.

TABLE 8. Fuelwood Prices in Four Selected Communities in Guatemala

Community	Average dimensions tarea* of fuelwood (mts).	Consumption with open fire (*tarea*/ month)	Consumption with ICS (*tarea*/ month)	# of hours per day with lit fire	Average value Q/ *tarea*/ month	Average value transportation *tarea*/home/ month
Alta Verapaz	3.20 long 0.50 wide 0.84 high	1.12	0.50	12	Q230	Q48.80
San Antonio Sejá	3.35 long 0.40 wide 0.84 high	1.50	0.50	15	Q270	Q60
Baja Verapaz	2.00 long 0.50 wide 1.00 high	1.54	0.63	12	Q250	Q22.50
San Marcos	3.00 long 0.50 wide 0.84 high	1.50	0.50	10	Q150	Q40

Source: M. Rivera, Fundacion Solar, May 2012.
* 1 tarea = 3.35m X 0.40m X 0.84m X 0.784 (coefficient) = 0.882 m^3 (ECLAC 2011b).

LPG, even though the stoves they use are 66 percent more efficient than traditional stoves. Indeed, an analysis of the household survey in Guatemala found that many households using commercial fuelwood apparently spend more purchasing it than they would spend if they bought LPG to substitute for wood, and that LPG and wood-users have the highest fuel expenditures in urban areas (ESMAP 2003). This coincides with the fact that many families in rural areas collect all or the majority of the fuelwood they need. Still, it begs the question of why people in cities continue using fuelwood even when it is not cheap. One reason could be that when people give up making tortillas at home after adopting LPG, they must begin to purchase tortillas outside, which would imply a private financial outlay. Another possible explanation is that one can buy fuelwood on a daily basis, but one needs to have more money upfront for the full price of an LPG cylinder, which can be challenging for poor families. Other reasons for continued urban fuelwood use are not necessarily economic but cultural, having to do with cooking habits and taste preferences. Since many of these families use multiple fuels at home, they may use wood for making particular dishes.

It is reasonable to expect that the opportunity costs for the time that families spend on fuelwood collection are much lower than what market fuelwood prices would suggest; otherwise, families using traditional stoves would switch to LPG and save significant additional income (US$ 26.9–13.3 = US$23.6/month, based on the above calculations). In this regard, using fuelwood prices as a proxy for the time saved in fuel collection would overestimate the fuel savings benefits by a large margin.

3.1.3 Costs of Improved Stoves

The direct financial cost of building a traditional open fire or a similar system is low, involving mainly the costs of *comal/plancha* for as little as US$3 and if applicable, a chimney for US$8-12. The rest is labor. In addition, an open fire offers families the flexibility of locating it anywhere they like.

As most of the ICS are disseminated with donor support, direct sales at full price are very few. One example of direct sales is the Noya stove in Guatemala, which is sold directly to users at market price. The Onil stove has been sold directly to users, too, but given its small retail volume (15 percent of total sales, or around 2,000 stoves per year, are without any subsidy; personal communication, Helps-Guatemala, August 16, 2012) and localized market (mainly in certain parts of Guatemala), it is not representative of the broader market in CA. By and large, market prices for improved stoves in CA are nonexistent. As an alternative, we resort to using the costs of stove dissemination as a proxy. The costs of dissemination include marketing, materials, construction, user training, follow-up visits, program administration, monitoring and evaluation, and public awareness campaigns.

Partly because of its size and the metal materials required, improved biomass stoves acceptable in the Central American context are much more expensive than common models acceptable in Asia or Africa (see Tables 4 and 5 in Chapter 2), which are reported in the range of a few to less than US$20 (Yabei Zhang, personal communications; Habermehl 2007; Shrimali et al 2011). Table 9 provides a breakdown of the costs of the Justa 2x3 stoves disseminated by Project Mirador in Honduras.

3.2 BENEFITS OF LPG AND ICS

We will first examine the benefits of improved stoves through the lens of the family, considering how any benefits would figure into a family's decision of whether to acquire an improved stove or not. In interviews with rural communities in Guatemala and El Salvador, wood savings was the most cited advantage, even for people who do not purchase wood or think it is worth trying to sell. Other benefits include reduced exposure to smoke, increased comfort, cooking more food at once, and time savings (Redman 2011, von Ritter Figueres 2010). Troncoso et al. 2007 also cited the aesthetic value associated with the cleanliness of the kitchen and clean and shiny pots as a result of no direct contact with fire.

For those who do not purchase it, fuelwood is perceived as free, whether it is collected on one's own land or not; the value, instead, is located in the time and labor consumed in collecting and transporting it. Improved efficiency of fuelwood collection would reduce the financial cost when people have to buy it, and the non-financial costs (time and labor) associated with biomass harvesting and transportation. Several factors could complicate estimates of fuelwood savings. First, the savings measured at home are sometimes lower than laboratory tests or self-reported values (Zamorano, internal report, 2009). Second, improved stoves do not completely replace the multiple functions that open fires or traditional stoves provide, such as heating, cooking certain types of food, lighting, or insect control, hence different types of stoves co-exist.

Reduced indoor smoke resulting from improved stoves implies avoided costs for sickness in families (but smoke emitted to the atmosphere through chimneys would still cause ambient air pollution). Furthermore, lower incidence of sickness would allow people to devote more time to productive activities.

Quantifying the time and labor saved in fuelwood collection and the avoided household health costs associated with improved stoves is a daunting task due to lack of data. We use the Justa 2x3 stoves produced and disseminated by Proyecto Mirador (PM) in Honduras as an example. Proyecto Mirador is by far one of the largest improved stove programs in CA, having disseminated approximately 10,000 stoves in 2011. Its dissemination costs are also relatively low compared to similar stoves disseminated in Honduras (for details, see Carneiro 2012).

The reported cost for PM's stoves falls between US$75 and US$115, depending on a user's contribution to the stove base. In addition, PM's

TABLE 9. Overview of Justa 2x3 Cost Structure and Jobs Created

Stove part	Cost per stove (Lp.)*	Paid by	Made by	Permanent jobs created
Chimney	170	PM	contractor	6
Plancha + cinco + grate	580	PM	contractor	8
Combustion chamber	50	PM	contractor	6
Stove frame (arms)	265 to 475	Beneficiary	Stove maker	
Technical assistance (contractor + transport of PM's donated parts + stove maker)*	280 *(94,47+ 30,00+155,53)	PM		33
Stove base	50 to 600	beneficiary	beneficiary	?
Administration (including supervision)	121	PM		11
Total contribution by PM	1,201 (US$ 61.0) (it does not include the beneficiary contributions; based on Lp$ 19.41/US$)	PM		64

* US$1 = 19.69 Lp. as of October 8, 2012.

cost structure doesn't incorporate any marketing or public awareness campaigns, which we assume would add 10 percent to the overall cost. The resulting cost of the stove would be between US$82 and US$126. We examine three scenarios: families purchase fuel only; families collect 60 percent of the fuel and buy the rest from the market; and families collect fuel only. Families are assumed to use wood fuel only and to consider only the out-of-pocket savings from fuel. The payback time for an ICS is shown in Table 10. With collection only, the payback time of an improved stove is difficult to define since there is no financial benefit to the family. When involving purchase of fuel, the payback time for an improved stove is a matter of several months to a year. The more fuel is purchased, the faster the payback will be.

The benefits associated with improved stoves are myriad from a societal perspective, including avoided costs for the public health system, preservation of forest resources, reduced land use change, as well as greenhouse gas reductions resulting from decreased use of non-renewable biomass (Table 11). Garcia-Frapolli et al (2010) estimated that for the *Patsari* stove

TABLE 10. Illustrative Analysis of Payback Time for Acquiring Justa 2x3 Stoves in Honduras (months)

Stove cost	100% collection	60% collection and 40% purchase	100% purchase
$82	—	8.4	3.3
$126	—	12.9	5.1

TABLE 11. Comparison of Costs and Benefits of Three Cooking Technologies

Costs/Benefits	Open Fires	Improved Stoves	LPG Stoves
Out of pocket expenditures of households			
Fuel	None to high*	None to high*	High
Stove	Low or none	Medium	High
Others	None	None	High**
Non-financial costs to households			
Time and labor for fuel collection	High to none*	Medium to none*	None
Time and labor for fuel transportation	High to none*	Medium to none*	Low to medium
Time to cook	Medium to high	Medium	Low
Health costs and lost productivity due to smoke exposure	High	Medium	Very low
Costs to the society (externalities)			
Costs to public health care system	High	Medium	Very low
Loss of forest resources	high	medium	None
Land use change	high	medium	none
Emissions of greenhouse gases	High***	Medium***	Low to Medium

*It depends on whether the families purchase fuelwood, how much and at what price.
**Other costs for LPG include canister deposits, stoves, accessories, etc.
*** Only GHG emissions resulting from burning of non-renewable biomass are considered.

program in the highlands of Mexico, the benefit-cost ratios are between 11.4:1 and 9:1. Regardless of the intervention scenario, time span, and the discount rate chosen, economic returns from investing in ICS are substantial in all other studies carried out in Zimbabwe, Uganda, Malawi and China. Since the benefits represent local and global public goods, the question really is: are the countries concerned and society at large ready (willing) to invest this much in improved stoves? The next section will present an analysis of how carbon finance can help society pay for one of the public goods: reduced impacts from climate change.

3.3 POTENTIAL CONTRIBUTION OF CARBON FINANCE TO ICS DISSEMINATION

Improved cookstoves have the potential to generate additional revenues from carbon credits (see Annex IV for a general description of the carbon finance mechanisms). Such revenues can, in turn, help to improve the viability of cookstove projects by helping to overcome financial or other barriers to investment. In order to earn the carbon credits, consistent follow-up on stove use has to be performed, whichsupports the monitoring of the cookstoves as well as systematization of results. A number of cookstove projects in Central America have registered with the Clean Development Mechanism (CDM) or Gold Standard for the voluntary carbon market, including Project Mirador in Honduras and Turbococina in El Salvador (see Box 1 for a case in Peru). The objective of this exercise is to determine to what extent carbon finance can contribute to the implementation of a regional ICS program in CA. For illustrative purposes, the analysis assumes a Program of Activities (POA) for the entire region and makes simplistic and conservative assumptions about several factors.

The analysis first compares the potential carbon revenues from a regional POA to the preparation and implementation costs of such POA to see if the program is self-sustainable. It then explores to what extent the remaining carbon revenues can be used to offset the cost of implementing a regional cookstove program, including production, monitoring, certification, information campaign, etc. Finally, we also carried out a sensitivity analysis, taking into account the uncertainty or variability associated with the following parameters: carbon price, emission reduction potential per ICS, annual ICS installations, cost of ICS program (on a per ICS basis), cost of set-up and operation of carbon program, and the discount rate.

Basic assumptions include:

- A CDM Program of Activities to accommodate various ICS technologies, projects, and implementing agencies in all countries in CA. It assumes two CDM Program Activities (CPAs[12]) per country; hence a total of 12 CPAs.
- The size of the program is 1 million cookstoves by 2020, the regional target set by SICA for CA. Each CPA is assumed to ramp up its annual production and installations to 20,000 by the end of the fourth year, and maintains it at this level thereafter.
- Initial adoption rate is 90 percent, declining by 5 percent per year until the end of the stove life.
- The average lifetime of cookstoves is assumed to be 5 years.
- The baseline carbon prices are assumed to stay constant at US$5/ton certified emission reduction (CER).
- The crediting period is a minimum of 10 years.
- The discount rate is 12 percent per year.
- Initial set up and registration cost of the carbon program (including studies and documentation for 12 CPAs) was estimated at US$910,000 (in net present value). Annual operation cost is US$150,000 for the POA and US$50,000 for each CPA (including verification costs). Additional variable costs (for supervision, for example) were included.
- ICS dissemination program costs were estimated at US$150/ICS for the first year (including the cost of the stoves, installation, distribution, training, management, and related program costs), with annual reductions of 3 percent expected from economies of scale.
- Annual CERs generated per ICS were assumed to be 2 tons of CO_2e per stove.
- CDM methodology AMS-II.G[13] was used as a reference for the modeling exercise. Only CO_2 emissions were considered.

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12. Activities under a Program of Activities are executed by various CPAs (CDM Program Activities). Each CPA is an individual project, with its own management structure, area of work, technology, etc. Each CPA must meet however the eligibility conditions specific to a certain POA and get registered under it to be able to participate and claim carbon revenue.

13. Under this methodology, the following formula is used to calculate ERs:

$$ER_y = B_{y,savings} * f_{NRB,y} * NCV_{biomass} * EF_{projected\_fossilfuel}$$

Where:

ER_y	Emission reductions during the year y in the tCO_2e
$B_{y,savings}$	Quantity of woody biomass that is saved in tonnes
$f_{NRB,y}$	Fraction of woody biomass saved by the project activity in year y that can be established as non-renewable biomass
$NCV_{biomass}$	Net calorific value of the non-renewable woody biomass that is substituted
$EF_{projected\_fossilfuel}$	Emission factor for the substitution of non-renewable woody biomass by similar consumers

The main costs of preparing and implementing a POA include (a) POA preparation cost, such as the studies and documentation needed for the CDM registration for both the POA and individual CPAs; and (b) operating costs, including monitoring and verification of ERs.

We find that expected carbon revenue far exceeds the costs of setting up and managing a carbon finance program for cookstoves in CA, allowing a full recovery of the preparation and implementation costs of the hypothetical POA. This result holds even with significant deviations from the initial assumptions; it would require extreme changes in the values assumed for the carbon program not to make sense. Among other possibilities, carbon prices would have to decline 72 percent (to a hurdle value of about US$1.4/CER), carbon program costs (initial investment, management, monitoring) would have to increase between 7 and 22 times, or annual new installations of ICS per CPA would have to decline by 80 percent (from 20,000 to a hurdle value of about 4,000 stoves). In addition to recovering the initial investment in POA preparation, a carbon program would help recover a portion of the costs of the ICS dissemination program. The cost recovery level varies according to a number of factors (including all those listed in the assumptions section), and can range from marginal contributions to full cost recovery (or even exceed the full program cost). In the base case, 17 percent of the ICS program costs could be recovered. In the high case in which carbon prices were to increase to US$10–US$20/CER, the cost recovery would increase to 40–85 percent. In the low case in which carbon prices or emissions reduced by ICS were to halve, cost recovery would decline to 6 percent (Table 12).

Carbon revenues are most sensitive to carbon prices, emission reductions and baseline deforestation pressure (Figure 5). Carbon prices are externally determined by the carbon market and independent of the project. Unless a long-term contract for CERs sale at a pre-determined price is secured, the prices are expected to vary throughout the lifetime of the POA.

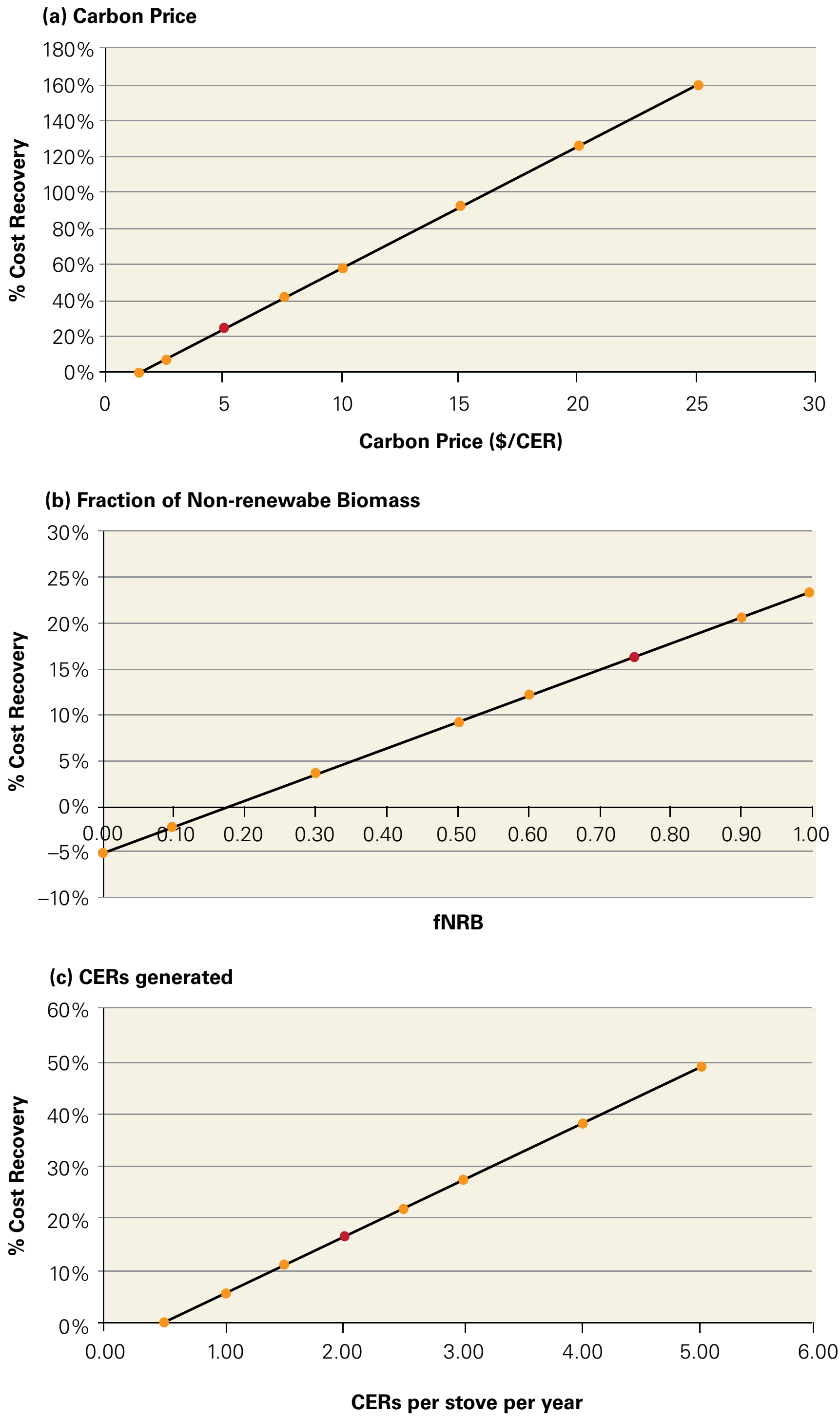
Emission reductions are achieved based on three main factors: a) the cookstove's thermal efficiency and actual fuelwood savings, b) the level of adoption and sustained use by the user, and c) the lifetime of the cookstoves.

Under the CDM methodology adopted, reductions in fuelwood consumption can accrue CO_2-related carbon credits only if they occur in areas where excessive biomass extraction is causing deforestation (credits related to non-CO_2 greenhouse gases that are saved by ICS—such as CH_4—do not depend on the renewability of fuelwood use). This factor is called the fraction of non-renewable biomass (fNRB) in the formula for calculating ERs. fNRB has a scale from 0 to 1 and measures the extent to which woody biomass saved actually results in reduced CO_2 emissions.

TABLE 12. Estimated Costs and Revenues of a Hypothetical Carbon Program for Central America

	Year	0	1	2	3	4	5	6	7	8	9	10
	Units	Mar-12	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cumulative Operating ABS under PoA	# ABS		**18,000**	**69,300**	**162,300**	**329,400**	**532,800**	**714,300**	**874,620**	**1,001,940**	**1,081,140**	**1,116,660**
CERs accrued	# CERs		36,000	138,600	324,600	658,800	1,065,600	1,428,600	1,749,240	2,003,880	2,162,280	2,233,320
Carbon Program's Cash Flow												
Initial CDM preparation/ registration cost	$ M	$(0.64)	$(0.30)	0	0	0	0	0	0	0	0	0
CER Revenue	$ M	0	$0.18	$0.68	$1.59	$3.23	$5.01	$6.71	$8.22	$9.42	$10.16	$10.50
Carbon Program Operation Cost	$ M	0	$(0.46)	$(0.78)	$(0.82)	$(0.89)	$(0.97)	$(1.05)	$(1.11)	$(1.17)	$(1.20)	$(1.22)
Carbon Program's Net Income		$(0.64)	$(0.58)	$(0.10)	$0.77	$2.34	$4.04	$5.67	$7.11	$8.25	$8.96	$9.28
NPV		$18.7	=> Development of Carbon Program financially viable									
IRR		80%										
Carbon Program's Net Income as % of Cookstove Program Cost												
NPV of Carbon Program's Net Income		$18.7										
Coosktoves costs			$2.70	$7.86	$14.40	$25.46	$31.87	$30.91	$29.99	$29.09	$28.21	$27.37
NPV of Coosktoves Costs		$113.1										
% Carbon Program's Net Income / Cookstove Program Cost		17%	=> carbon revenue can recover a significant % of the cookstove cost									

FIGURE 5. Sensitivity of Percent Cost Recovery of Cookstove Program

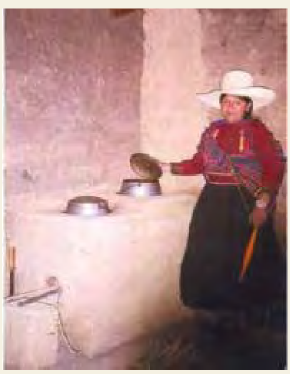


BOX 1.
QoriQ'oncha Program: A Peruvian Experience with Carbon Finance

The QoriQ'oncha (Gold Stove in quechua) is a voluntary country-wide carbon project in Peru registered with the Gold Standard, which enables the dissemination of efficient cookstoves through carbon finance. It has a Program of Activity structure, which allows more projects to be included in the future under the program. The project is overseen by the Switzerland-based NGO Myclimate and the French social enterprise Microsol based in Peru.

The project services three districts, each with its own local project participant and unique stove model and dissemination strategy. Most stoves are made out of adobe, emphasize efficient fuel combustion for cooking and heating, and use chimneys to remove smoke from the cooking environment. Nearly 30,000 improved stoves were distributed during the period 2008–2010 resulting in emissions reductions of 33,000 tCO_2e/yr. The scaling up phase is expected to deliver approximately 260,000 stoves by project completion in 2017. Based on the number of stoves disseminated between 2008 and 2010, 168,291 tCO_2e are projected to be mitigated by the project over the next 7 years.

Inclusion of carbon finance has made scaling up stove distribution considerably easier, thus generating greater development impacts within the project area. Stove improvements and market advancements typically proceed incrementally. Anticipated revenues stemming from carbon financing help to sustain both market growth and cooking technology improvements. Because cookstoves and stove user services are developed using a trial and error approach, progressive technology advancements, spare parts diffusion schemes and post-sale services have profited from sustained carbon financing. However, the challenges faced by the cookstove carbon finance projects include lack of reliable data for estimating emission reductions and monitoring of the stoves in use.



Source: Myclimate and Microsol, 2010; Microsol, 2011, Simon et al, 2012

Given their potential impact on the level of cost recovery of the ICS program, the factors that deserve close attention for planning a carbon program are carbon prices and ICS delivery models. It is manifest that a favorable carbon price benefits the ICS program greatly. Emission reduction purchase agreements (ERPAs) can help secure steady carbon prices and manage risks associated with carbon market fluctuations. Selection of ICS models with optimal cost and fuel savings potential would also help maximize cost recovery of cookstove programs.

Business models chosen for delivering the installations under each CPA also matter. Different business models may involve varying unit cost of installation since the installation costs account for a sizable portion of the products. They also determine the scale-up potential under a given CPA, which is critical to achieving SICA's one million ICS target.

3.4 REGIONAL EXPERIENCE WITH DISSEMINATION OF IMPROVED COOKSTOVES

The review of the regional experience with dissemination of ICS presented below is based on self-reported data by and interviews with implementing agencies and stove manufacturers. A detailed and comprehensive analysis of the main cookstove programs in CA is difficult given the large information gaps on the subject. There is a large uncertainty regarding the number of ICS actually disseminated in CA and in particular, how many of these stoves are in use. There are also large gaps in the information available in terms of the different stove programs or companies in place, the detailed cost structure, actual adoption and use of the stoves disseminated, and other variables related to both the program structure as well as the stove itself. No independent evaluation has been carried out on most of the regional cookstove programs.

In December 2009, all CA countries endorsed the SICA's goal to reduce fuelwood consumption and install one million efficient stoves by 2020 as part of the Matrix of Actions for the Integration and Energy Development in Central America (SICA 2009). The action plan to achieve this goal was recently being developed. In November 2011, SICA joined the Global Alliance for Clean Cookstoves as a regional partner which represents a very significant first step. ECLAC is also helping develop a regional plan for installing efficient stoves in CA, including country breakdown of the 1 million stove target and resources required. It is estimated that a total investment of US$17 million would be needed and there is need to engage both public and private sector (ECLAC, personal communications on *Perfil Del Proyecto Regional De Estufas Eficientes En Centroamérica* (PREECA), December 2011).

A DETAILED AND COMPREHENSIVE ANALYSIS OF THE MAIN COOKSTOVE PROGRAMS IN CENTRAL AMERICA IS DIFFICULT GIVEN THE LARGE INFORMATION GAPS ON THE SUBJECT.

Up to date, actual experience in promoting clean and efficient stoves in the region are limited to individual, stand-alone development and dissemination programs with the participation of the governments, bilateral and multilateral organizations, local engineers and entrepreneurs, NGOs and other civil organizations, including churches. These efforts have been mostly made without centralized information or evaluations on stove performance. There is lack of inter-institutional coordination and different ministries are doing separate efforts in ICS implementation. In general, each country has its own ICS models partly due to the adaption to the local cultural and social preferences and partly due to the commercial barriers and lack of economies of scale. The latter refers to the hefty tariffs applicable to imported stoves. Indeed even the stoves sent to Zamorano for performance testing are subject to customs tariff. Also, there is rarely quality control or guarantees to the products offered.

UP TO DATE, ACTUAL EXPERIENCE IN PROMOTING CLEAN AND EFFICIENT STOVES IN THE REGION ARE LIMITED TO INDIVIDUAL, STAND-ALONE DEVELOPMENT AND DISSEMINATION PROGRAMS WITH THE PARTICIPATION OF THE GOVERNMENTS, BILATERAL AND MULTILATERAL ORGANIZATIONS, LOCAL ENGINEERS AND ENTREPRENEURS, NGOS AND OTHER CIVIL ORGANIZATIONS, INCLUDING CHURCHES.

About 200,000 stoves have been disseminated by the 8 largest ICS programs within the Region, as outlined in the previous section since the year 2000, most of which were industrial or mass-produced models. The newer generation of ICS installed in CA since the late 1990s and 2000s, such as the Justa, Onil, and Ecofogón, represent substantial progress in terms of users acceptance levels, stove performance, product diversification and innovation, and business development strategies compared to previous programs in the region.

While some of the most successful programs measured by user satisfaction and stove adoption involve stoves installed *in situ* (like the Justas in Honduras), there is an increasing trend to disseminate stoves that are portable, or semi-portable and mass-produced. Several new stove models involve innovative ideas, a salient example being the Turbococinas, which is to date the only model of advanced biomass combustion stoves currently available within the Region. As the dissemination of Turbococinas only began recently, it is too early to gauge its acceptance and sustained use.

Even within a relatively homogeneous region, there is great diversity among countries in user stove preferences, the size and type of programs and stove models disseminated, households targeted, and business strategies. Guatemala and Honduras have the most experience with ICS. In both countries, the stoves disseminated are large by weight and volume and are aimed mostly at rural customers. El Salvador disseminates more mass-produced industrial stoves with target users representing a mix of peri-urban and rural customers, with peri-urban users having increased as a result of a reduction in LPG subsidies. In Nicaragua, the market for stoves is still small, aimed at portable stoves and mainly located in urban areas. Nicaragua and El Salvador are the only countries to date that are developing charcoal stoves. Panama and Costa Rica have minimal ICS activity to date. The detailed description of ICS activities in each country is seen in Annex I.

A critical question to ask, then, is: what actions would be needed for a substantial scale-up of ICS dissemination within the region? In particular, how to grow from the current less than 10 percent share of total market potential, to capturing a 25 percent market share by 2020 to meet SICA's goal of 1,000,000 cookstoves installed by then and, ultimately, to universal access? Assuming an integrated cost of US$150 per stove installed (including production, dissemination, training, certification and promotional campaigns), universal access would require US$600 million of investment. In the next section, we will distill some lessons learned in both Central America and internationally in a hope to help the region achieve the SICA 2020 goal.

4

Lessons Learned from Cookstove Programs

While there is already positive experience with ICS programs around the world, a clear understanding of the key aspects needed to operate successful large-scale ICS programs is still lacking, particularly if the focus is on sustained stove use instead of the number of stoves installed or adopted. There are few detailed and integrated assessments of large-scale ICS programs that have been implemented worldwide since the early 1980's, and even fewer take into account field measurements of actual impacts. Among the earlier programs implemented in the 1980's, only China was able to successfully scale up their efforts, with more than 180 million ICS disseminated by the mid-1990's. Currently, there are ongoing national programs in Peru, Mexico, Nigeria, Sri Lanka, Uganda and Ethiopia (Boxes 2 and 3), and India is in the beginning stages of introducing a new program. There are also programs currently implemented at local levels in these countries, but it is too early to assess their actual impact and whether they will be able to create a market for ICS. Below is a general account of factors that have affected the success of ICS programs in Central America and internationally, based on information available.

BOX 2.
The Mexican National Improved Cookstove Program

Biomass is used extensively for cooking in central and southern areas of Mexico. Approximately 28 million people or 5 million households use fuelwood for cooking or water heating, of which 19 million use wood as the only cooking fuel and 9 million use both wood and LPG. About 90 percent of biomass-using households are located in low-income communities in rural areas.

Under the *Programa Especial de Cambio Climático* (PECC), Mexico established a national biomass cookstove program (*Programa Nacional de Estufas de Leña*) to disseminate 600,000 ICS between 2006 and 2012. Two government agencies were responsible for implementing the Program: Secretariat of Social Development (Secretaria de Desarrollo Social or SEDESOL) and the Secretariat of Agriculture, Livestock, Rural Development, Fishery and Food (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación or SAGARPA). SEDESOL was responsible for disseminating 500,000 ICS and also created the program Instalación de Estufas Ahorradoras de Leña, together with the National Forestry Commission and the Indigenous Communities Development Commission. SAGARPA was responsible for disseminating the other 100,000 ICS. Most ICS are disseminated through the state delegations of the abovementioned agencies. According to SEDESOL, between 2007 and 2010 their program installed approximately 280,000 ICS in marginalized communities.

The National Program is ambitious and an important first attempt to promote ICS. However, assessment of the Program's effectiveness has been difficult due to lack of information on the percentage of households using ICS and effective adoption levels.

Source: Diaz, R., Berrueta, V., Masera, O. 2011. Cuadernos Tematicos No.3 sobre BioEnergia: Estufas de Lena. Mexico D.F.

4.1 ICS DO NOT ENTIRELY REPLACE OPEN FIRES, BUT ARE GENERALLY INTEGRATED INTO A MENU OF FUELS AND APPLIANCES.

ICS programs need to acknowledge that *local cooking needs* are comprised of many practices with very diverse technical, cultural, and gender implications and demands. Traditional stoves, such as open fires, usually serve other purposes besides cooking (such as space and water heating, food drying, lighting). For these reasons, ICS rarely serve *all* household cooking needs and also rarely replace *all* additional end-uses performed by open fires. In fact, more and more literature documents the combined use of ICS and open fires (or the combined use of ICS, open fires, and LPG/

BOX 3.
The Peruvian National Improved Cookstove Campaign: Por Un Perú sin Humo (for a smoke-free Peru)

In June 2009, Peru launched its national cookstove program *Medio Millón de Cocinas Mejoradas Por un Perú sin Humo* (Half a Million Improved Cookstoves for a smoke-free Peru). Improving the health of children under 5 years of age was a key driver for the campaign. The Program employed an integral approach to improve household conditions by focusing on health, nutrition, and economic development. It aimed to: (i) provide a framework to facilitate the inclusion and strengthening of initiatives, PPPs, and international support for scaling up certified stoves; (ii) facilitate knowledge sharing on certified stoves; and (iii) ensure quality, use and adoption levels of certified stoves.

The Program involved seven ministries, GIZ, Sencico, Pan American Health Organization (PAHO), Juntos Program, Sembrando program,and other non-governmental organizations (NGOs). It provided a platform that enabled coordination, planning, management and implementation at the national, regional, and local level and was critical for issuing various government decrees to ensure the Program's economic, political, and technical sustainability.

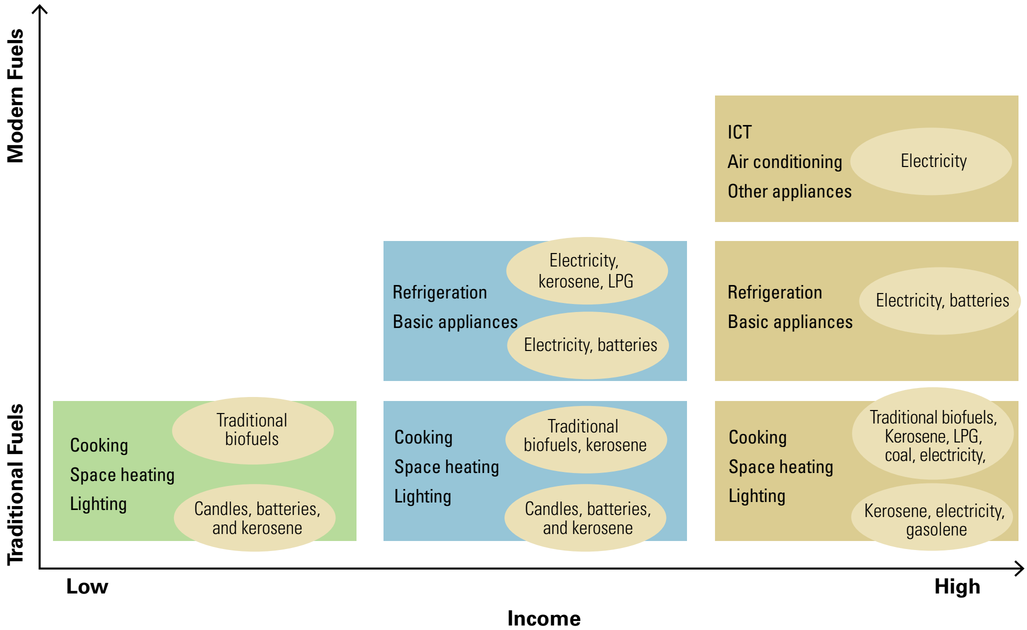
As of February 2012, the Campaign installed about 224,000 certified stoves throughout the country, of which 44 and 29 percent were done through NGOs and public programs and social responsibility projects implemented by the private sector. The rest of the stoves were installed through local governments (20 percent), and regional governments

The Campaign was successful due to the development of norms and regulations certifying stove technology. The National Training Institute for the Construction Industry (SENCICO) issues certification validation to stoves that meet the predefined technical specifications. It also keeps record of locations where stoves will be installed in order to monitor their on-site efficiency. SENCICO has certified 23 different stove models at their laboratory, and the results are published on the Program's website.

Source: PCIA, 2011. World Forum on Clean Indoor Air—Executive Document. Lima. http://www.cocinasmejoradasperu.org.pe

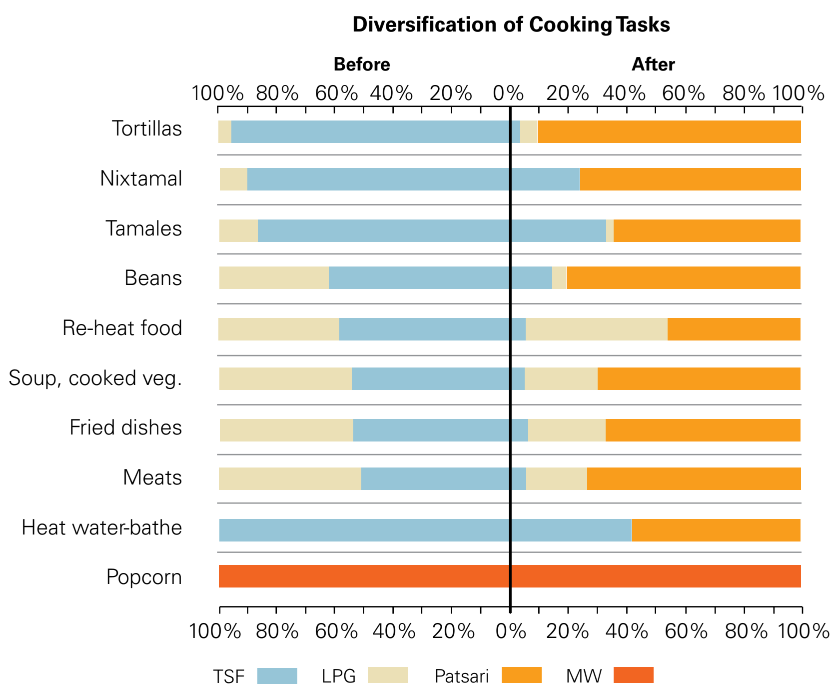
electric stoves if the three fuels are available to households). Rather than switching completely to new fuels and devices, households prefer to "stack" them to increase flexibility (Figure 6). This is seen in Mexico both before and after rural households adopted *Patsari* (Figure 7). LPG is preferred for reheating food and cooking meals that require little time, ICS are preferred for tortilla making and other cooking tasks, and open fires continue to be used for water heating (Ruiz-Mercado et al. 2011; Redman 2010; Troncoso et al. 2007; von Ritter Figueres 2010; Heltberg et al. 2003).

FIGURE 6. Stacking of Fuels and Appliances with Increasing Income



Source: Kowsari & Zerriffi, 2011

FIGURE 7. Fuels and Appliances Used Before and After Adopting *Patsari* Stoves in Mexico



LPG = liquefied petroleum gas, TSF = three-stone fire, MW = microwave (MW).
Source: (Ruiz-Mercado et al. 2011).

4.2 THE SUCCESS OF A PROGRAM NEEDS TO BE MEASURED BY THE NUMBER OF STOVES THAT HAVE BEEN ADOPTED AND USED RATHER THAN BY THE NUMBER OF STOVES SOLD OR INSTALLED.

There should be a shift in the indicators of project success from documenting the number of stoves "installed" or "sold" (currently the main indicator used by a large number of cookstove projects in CA and elsewhere) to the number of stoves adopted and in sustained use (Ruiz-Mercado et al. 2011). Only a handful of stove programs in CA offer follow-up visits after installation. Field evaluations documenting lifetime stove performance are sorely lacking in CA and elsewhere. This shift in emphasis will make project follow-up and monitoring an integral component of project design and will also push governments and donors to act with longer time spans. Cost-effective monitoring tools to assess actual stove performance are already entering the market in some areas (Ruiz-Mercado et al. 2011). For example, Project Mirador in Honduras introduced Salesforce software to its operations in the Santa Barbara region of the country.

4.3 TO PROMOTE ANY CHANGE IN COOKING HABITS AND DEVICES, SOCIAL AND CULTURAL ASPECTS AND USER PREFERENCES NEED TO BE TAKEN INTO CONSIDERATION.

ICS imply major changes in the way people cook that do not rank very high within users' preference lists, particularly for the very poor. This has to do with many factors, including:

- the availability of free or low-cost fuel, discouraging investments in fuel efficiency;
- low purchasing power of many fuelwood users combined with their lack of time to learn how to use new stoves and aversion to taking risks, which disproportionately affect the poorest populations;[14]
- the need to change well-established cooking habits. Cooking is a deeply rooted social activity in the Central American culture, which makes people conservative when changes are proposed that would drastically alter

14. In this regard it should be noted that fuelwood users have traditionally been considered beneficiaries of cooking programs, rather than customers. As a result, stove promoters have often not needed to offer proper warranties related to the quality and durability of the devices disseminated.

traditional cooking practices (or if people perceive changes in food taste with new stoves);

- less convenient attributes of the ICS or inability of the stoves to fulfill some of the uses covered by traditional open fires. In CA women generally prefer fires with: (i) fuel that lasts, and (ii) larger pieces of wood that take time to burn so they can do other chores without being tied to feeding fuelwood to the stove constantly.[15] Second, in CA women cook several things at a time, preferring a larger area for cooking and keeping food warm, rather than one hot plate. The use of *comal* or *plancha* is indeed needed for any type of stove to be disseminated in the region. Third, oftentimes users do not see ICS as providing a real improvement in living conditions because they cannot fulfill key services provided by open fires, such as space heating, hot water for bathing, lighting, insect control, a gathering place, etc.;
- high front-costs of the more efficient ICS. Many of the improved stoves available in CA are more than US$100, which are expensive compared to the traditional open fires and the population's purchasing power;
- general lack of awareness regarding acute and chronic health problems derived from wood smoke. While fuelwood savings are more tangible once ICS is adopted, improvements in health may not be, as it is often harder for women to see the link between smoke and poor health before having a smokeless stove. This clearly needs to be addressed if a behavioral change is to follow, particularly if women do not see a benefit from modifying their cooking habits. Once the health issues are understood, women are more apt to make changes. For example, Honduras implemented a national information campaign in the 1980s where the negative effects of smoke were portrayed. As a result of this campaign, the dangers of smoke are common knowledge among woodfuel users. Therefore, many cookstoves in Honduras have a chimney to take the smoke out, and women are well aware of the health benefits of having a chimney. Unfortunately, no national awareness campaigns on the detrimental effects of wood smoke have been conducted recently in CA. Strikingly, the most comprehensive health studies ever conducted worldwide on the negative impacts of wood smoke were carried out in Guatemala (see, for example, the CRECER and RESPIRE Projects[16]), but

15. For these reasons, it will be important that existing industrialized models that require small pieces of firewood to be constantly fed undergo field tests to ensure acceptance among women users.
16. RESPIRE- Randomized Exposure Study of Pollution Indoors and Respiratory Effects and CRECER-Chronic Respiratory Effects of Early Childhood Exposure to Respirable Particulate Matter. The two projects were coordinated by the University of California, Berkeley in collaboration with Universidad del Valle in Guatemala. See http://ehs.sph.berkeley.edu/guat/

their findings have not been adequately disseminated to the Guatemalan Ministry of Health or the general public;

- lack of involvement and lack of information/market campaigns directed to men and women. Limited campaigns conducted in the past were directed only to women even though men traditionally control cash flows and does most of the fuelwood collection in CA. ICS directly benefit women and small children because they are no longer exposed to smoke, and indirectly benefit men because fuelwood savings imply less time devoted to fuelwood collection or less fuel expenditures. This highlights the importance of considering the whole family in awareness campaigns and training processes for ICS diffusion. Men often make decisions at home, particularly if monetary payment is required. Men can also influence the adoption (or rejection) of ICS through their perception of food state or food preparation times. (Tucker 1999; Lazos & Paré 2000).[17] It is important, then, that ICS awareness campaigns take into account social context and understands the roles of all family members in CA (Ekouevi & Tuntivate 2011).

Pilot projects in CA have shown that fuelwood users respond well when the barriers presented above are removed. For example, positive results are recorded when fuel becomes increasingly expensive (particularly in the case of former urban LPG users); when health issues are clearly understood by the whole family (as demonstrated in Honduras); when incentives are present to reduce the stove front costs (but not seen as a gift, as the Guatemala Noya case demonstrates); when ICS are adapted to local cooking practices; when tangible fuel and time savings are proven; when ICS implementation do not involve major changes in cooking habits; and finally, when ICS appeal to the users' desire for "modernity" .

Specifically, savings from ICS are very attractive for women and men who traditionally purchase fuelwood, a factor which can be used to promote ICS sales. In urban and rural areas where fuelwood is no longer readily accessible for collection and must be purchased, it is easier for women to adapt to new stoves, since fuel must also be purchased. Also, women in small cooking businesses, such as tortilleras, see the advantage of efficiently burning fuelwood and have no problem adapting to improved stoves. The same applies to women who used LPG as fuel to make tortillas for sale: once the LPG subsidies were removed, they switched to ICS to continue their commercial

17. In a study carried out in Mexico, 40 percent of the women did not acquire an ICS because their husband had not agreed to do so (Troncoso et al. 2007). Some ICS use wood cut into very small pieces, which requires extra work and can be a problem for stove appropriation in some circumstances. In a study carried out in Guatemala, it was found that 22 percent of the families had enlarged the stove entrance to accommodate larger pieces of wood (von Ritter Figueres 2010).

business. Having an ICS that is convenient and easy to cook with, and having access to spare parts, improves stove adoption. On the other hand, ICS are complicated to use; once these programs are gone, and if there is nobody to provide support if something goes wrong with the improved stoves, women will go back to open fire cooking methods, especially in rural areas where fuelwood is often available to gather at no monetary cost.

Another factor important for women to adopt ICS is the esthetic values associated with nice and modern-looking stoves and a clean kitchen. These attributes have been critical for the acceptance of new industrialized metal stoves among women. These modern metal stoves are portable and attractive, women like them, the stove occupies less space, and women feel proud to own one. Therefore, understanding users' preferences and needs, gender issues, and the decision-making process within households is essential for successfully scaling up cookstove efforts.

4.4 AN ENABLING ENVIRONMENT IS NEEDED FOR COOKSTOVE PROGRAMS TO TAKE OFF

Providing an adequate institutional framework has been essential for the success of cookstove programs. When National Governments provided enabling environments such as program activity monitoring, financial incentives, and public awareness campaigns regarding wood smoke and other issues related to open fires, programs have been highly successful (See Annex III Cases 1 and 3 for the cases of Sri Lanka and China, respectively). National Cookstove Programs based on delivering stoves for free to final users have precluded the formation of sustained cookstove markets, even years after programs have finished, as customers do not get used to purchasing cookstoves. This issue has been witnessed in Mexico and India (see Box 2 and Annex III).

Many countries have found it effective to designate an ICS National Coordinating Authority responsible for integrating the different elements and dimensions (energy, health, agriculture, environment, etc.) of a cookstove program (See for example the cases of Sri-Lanka and several countries in Africa in Annex III, and the Peru case in Box 3). Such institution is not necessarily a new entity but an existing one with the mandate to champion cookstove-related issues and program. For instance, in Nicaragua, through its Ministry of Energy and Mines, the country has been able to develop national targets to promote clean and efficient cooking solutions. Including well-established, locally trusted groups that act as mediators for community interests at the sub-regional level (NGOs) has also facilitated ICS program implementation.

Integrated, coordinated, and sustained efforts (10 years or more) in cookstove dissemination work better, as documented in China and Sri Lanka (Annex III), among other examples. Programs need to have clear targets, time frames, and performance indicators as well as a monitoring and evaluation system in place.

Conducting national awareness campaigns (which so far have been carried out largely at the project level and only in a small number of ICS projects in CA) to ensure that both policymakers and users understand the negative health effects of smoke is also needed before disseminating the stoves. A continuous message from health agents within a broader campaign (e.g., "healthy households," which may involve nutrition, water, and hygiene) is more effective than one-time visits from non-health agents with a narrow indoor-air-pollution message.

4.5 SETTING STANDARDS IS CRUCIAL FOR CREATING MARKETS FOR ICS

Another critical factor when developing a sizable ICS market is to establish standards for the disseminated stoves. This was shown in China in the 1990s (Smith et al. 1993) and was also demonstrated in the Peruvian National Stove Campaign. In fact, lack of standards and quality control discourages investment in high-quality ICS at a larger scale. This has been the case in CA (von Ritter Figueres 2010) and in Mexico, where most of the stoves disseminated by the National Cookstove Program severely underperformed because of lack of minimum standards. Also, Mexican manufacturers interested in producing more efficient and durable stoves have found it difficult to compete with technically deficient but cheaper models. It also affects users' preference and trust in adopting new stoves. In the ECLAC (2011b) survey for Honduras, 77 percent of traditional stove users indicated a preference for a better model due to concerns about access to wood; only 46 percent of existing users of improved stoves, however, indicated a preference for still newer improved stoves due to problems with their existing stoves, poor maintenance or lack of use.

The first—and so far only—certification center for wood-burning cookstoves in CA was established in 2009 at Zamorano University in Honduras. The Tree Water and People (TPW) Energy Collaborative and the Aprovecho Institute supported the creation of the Certification Center for Improved Cookstoves (*Centro de Certificacion de Estufas Mejoradas or CCEM*). The CCEM has the basic infrastructure to test thermal efficiency, levels of emissions, and pollution produced by the most commonly used ICS in the region, using standard protocols such as the Water Boiling Test (WBT) and the Controlled Cooking Test (CCT). They have also conducted some field evaluations of cookstoves using the Kitchen Performance Test (KPT). Thirteen different ICS models have been tested in the center so far, upon the request of donors or through Zamorano's own initiative. CCEM then certifies the results of the tested stoves. However, there is no legal framework anywhere in CA that makes ICS certification mandatory; therefore, the results are not legally binding. The Zamorano Certification Center provides an initial step in the right direction, but needs to be strengthened. In particular, Governments or SICA need to establish and implement mandatory or voluntary standards, so the results from stove certification actually serve as a catalyst to increase the marketing of efficient, durable, and clean stoves.

4.6 DIFFERENT BUSINESS MODELS HAVE PROVEN TO BE SUCCESSFUL IN INCREASING ICS PENETRATION

Currently, many different cookstove business models are operating worldwide (See, for example, World Bank (2011) for a review of selected international programs and Annex III Cases 1–3 for examples in Sri Lanka, India, and China). More specifically, there are diverse organizations, business orientations, and dissemination strategies within CA. In general, we can group the existing business models into three broad categories. The first category includes a group of manufacturers relying on centralized mass-production facilities and retailers (same company or third party)—as with the Oorja, Envirofit and Stove Tec cookstoves in India and other countries. This business model allows manufacturers to quickly ramp up stove production in order to lower stove costs and to assure standard product quality. This is the business model preferred by private investors, and so far, has been associated with many of the advanced combustion cookstoves requiring state-of-the-art manufacturing technology. In this model, stoves are usually sold at market price, and the companies develop diverse sales strategies to attract consumers: from promotional campaigns that can capture customers who can pay full cost to microfinance (payments in installments or microcredits) to carbon financing for those customers that need a reduced upfront cost to be able to purchase a stove (World Bank 2011).

In Central America, mass-produced stoves have been promoted mainly by stove manufacturers that operate with a business orientation, as with the Onil and Ecofogón Stoves. Such manufacturers obtain funding from international organizations, religious groups, and other in-country associations, including the Rotary Club, local NGOs, and municipal and national governments. Because funding only covers the cost of the stoves, only short-term monitoring and basic user training, if any, are conducted in these programs.[18] The considerable upfront investments needed to launch and run the business, assure good feedback and participation from users, and build an extended supply chain represent key challenges for this approach (See Annex III, Case 2 for the case of India). Also, this business model is not suitable for reaching remote locations and the poorest segments of the population.

IN CENTRAL AMERICA, MASS-PRODUCED STOVES HAVE BEEN PROMOTED MAINLY BY STOVE MANUFACTURERS THAT OPERATE WITH A BUSINESS ORIENTATION

A second model for stove dissemination may be called decentralized mass-production. It basically consists of manufacturing stoves through a network of regional stove production centers. These centers are run by local artisans or local associations formally trained in the manufacture of a particular set of stoves adapted to local conditions. The stoves are then sold using regular markets, as usually these types of programs are performed in countries where there is already a market for traditional stoves. Stoves are then marketed at a subsidized price to be able to compete with traditional models. The most salient examples of this business model worldwide are the New Lao Stove Program managed by GERES in Cambodia, with 800,000 stoves sold so far, and the Anagi Stove in Sri Lanka, with 3,000,000 stoves sold and a production capacity of 300,000 per year (Annex III Case 1). Many programs in Africa also use decentralized mass production. This model usually involves a large donor, like GIZ or the European Commission, in partnership with a local NGO (such as GERES), and targets small towns and rural areas. In CA, this model has not been explored given the small size of programs in the region, the lack of a traditional stove market, and the problems in selling stoves to end-users at market prices.

The third model for stove dissemination is decentralized *in situ* construction of cookstoves by stove builders. In this case, an organization with technical expertise in cookstoves—usually a trustworthy NGO—trains local groups and other organizations to construct particular stove models adapted to local circumstances. Rather than purchasing the stoves, users often participate by providing labor and local materials. This is the case with the *Justa 2x3* stoves in Honduras, for which the host organization, Proyecto Mirador, maintains a roster of local certified installers and subcontractors for stove parts.

18. Comparative studies carried out in Mexico and Guatemala with the Onil stove showed that adding users training and follow-up activities substantially increase stove acceptance and use rates (von Ritter, 2010; Troncoso *et al.,* 2011)

In Central America, organizations promoting *in situ* stoves are interested not only in the number of stoves installed, but also in empowering local communities and organizations by strengthening their capacities. AHDESA and Proyecto Mirador are good examples of this approach. Programs aimed at *"in situ"* installation commonly provide the manufactured stove parts (such as *planchas* and chimneys), user training, as well as some sort of monitoring, while final users provide local materials and labor. In some cases, people from the same village are trained in stove building, while in other cases, stove builders are brought in by the organization in charge of the program (ESMAP 2004). This model has been championed by NGOs with external and government funding. It is more appropriate for rural areas, where there is not always a strong monetary market for fuelwood and where customers have very limited income. Two weak points of the *in situ* model are difficulty in building a supply chain and problems in assuring quality control once the stoves are installed. The Patsari Cookstove Project in Mexico is expected to address the last problem by creating a national network of Certified Patsari Stove Builder Organizations. To earn certification—which is required for receiving funding from the National Cookstove Program *in situ*—interested parties need to comply with a set of criteria including adherence to Patsari technical specifications, quality of stoves built, extent and quality of user training, and stove monitoring.

4.7 A PORTFOLIO OF FINANCIAL MECHANISMS AND INCENTIVES TAILORED TO LOCAL CIRCUMSTANCES IS NEEDED FOR PROGRAM SCALE-UP.

Most stove programs in CA have depended on donor—many times foreign—funding and large direct subsidies for stove development, program administration, and/or to reduce upfront costs to final users (with the exception of Noya stoves in Guatemala). Since external funding has a time limit, this has led to problems of lack of continuity—i.e., dissemination ends when the funding finishes—and lack of resources to provide monitoring and evaluation once the stoves are installed.

Financing has also been a problem for many stove manufacturers in order to maintain inventories, build a supply chain, and invest in basic R&D activities. PROLEÑA in Nicaragua indicated that a lack of working capital is a major problem for scaling up its stove sales. No specific financial or tax incentives exist for stove manufacturers, and many trade barriers among CA countries discourage selling stoves out of country borders, thus limiting the potential size of the market.

None of the programs in CA—with the exception perhaps of small family businesses—would be financially viable if the costs of stove development, users awareness and monitoring were to be added to the costs of selling stoves, or if the organizations were to rely solely on direct sales. Also, the costs of building a reliable supply chain have not been included in most programs; many times, spare parts are simply not available to users when the stoves installed start to wear out, which affects the long-term sustainability of the program.

There is no detailed information available on the costs of stove programs for most of the cases reviewed in this study. However, for two cases where such information was available, we may conclude that the production costs of ICS represent only 50 percent or less of total program cost. In the case of AHDESA, for example, 44 percent of the total stove cost comes from actually building the stove *in situ* (54 percent including the stove base), 15 percent from user training, and about 31 percent from other costs. It should be noted that these costs do not include any user awareness campaigns or AHDESA's R&D expenditures to develop the stoves. A recent pilot study conducted in Guatemala by Fundación Solar of Onil stoves showed that stove costs represent 55 percent of the total program costs of US$223 per stove (Fundación Solar 2011). The high program costs result from a series of 4 to 5 after-installation visits per customer and a hotline to answer questions and solve problems. As stove programs grow in size, it is expected that these indirect program costs as a percentage of total costs will decrease. Nonetheless, it is important to recognize that indirect program costs will continue to be significant for large-scale interventions.

As shown by a comprehensive review of GIZ cookstove programs in Africa and Latin America, a mix of donor, government, and private sector funding seems essential for a successful scaling up of cookstove programs (Rai & McDonald 2009). At start-up, neither purely market strategies based on fully recovering program costs through sales nor purely government-subsidized approaches work. The questions, then, are what levels of direct and indirect subsidies and incentives are needed, and how can one apply them in an intelligent, non-permanent, and coordinated fashion? All major cookstove programs have applied some sort of price subsidies, either to customers (in China, the average subsidy applied to stoves was 26 percent), or to producers (30 percent in the case of GERES in Cambodia) (Ekouevi & Tuntivate 2011). Rai & McDonald (2009) note, for example, that donor subsidies in the form of product development and promotion, training of stove manufacturers, and awareness creation have been essential for products to take off. Reaching the poorest users in rural areas, in particular, may require direct subsidies and grants to NGOs rather than a commercial approach.

Most commonly, stove manufacturers in CA, which usually disseminate own stoves, reduce ICS upfront costs to costumers by applying large direct subsidies to stove prices or by simply giving away the stoves for free. However, increasingly, stove manufacturers are exploring other forms of user financing, such as microcredits or payments in installments. HELPS, for example, is working with the Rural Bank (*Banco Rural*) in Guatemala to sell stoves to bank customers that qualify for a credit line. A recent pilot project by Fundación Solar used financing mostly for indirect subsidies, giving users options to pay for stoves in installments, rather than selling stoves at a highly reduced cost. This approach seems to be working in the pilot phase, as 246 stoves—37 percent more than expected—have been sold. Most stoves were sold in cash (167, or 68 percent) and those that were purchased using micro-financing have been repaid according to schedule. Also, users have reported a high degree of satisfaction with the new stove and fuelwood savings, which have reached 66 percent when measured in the field (Fundación Solar 2011).

Different types of financial mechanisms for reducing upfront stove costs to users are increasingly being tested and explored in other regions (See Annex III Case 1 for Sri Lanka and Case 2 for India). These mechanisms include payments in installments, micro-credits, and government grants for the poorest segments of the population. Vouchers or some form of rebate that provides increasing subsidies based on the smoke removal or energy efficiency of stove products has also been proposed (World Bank 2011). However, as many of the large international programs involved in the new generation of cookstoves are new, there is little information available on the successes and challenges associated with each option. There is much to learn from the experience of other household-level interventions that seek to encourage behavioral changes: solar water disinfection, latrines, and hand washing, and also from the installation of solar panels for lighting.

Specific incentives and support needs to be provided to stove manufacturers as well if a rapid scale-up of program activities is to be achieved. This has traditionally been a void in CA. Support can be in the form of training and capacity building related to stove marketing and business administration, as carried out by GIZ and the European Commissions for projects in Africa and Asia (World Bank 2011; Kees & Feldmann 2011a). Also, financial support is needed in the form of soft loans, tax reductions, or other types of mechanisms to allow manufacturers to build a capital and operate at larger production scales (GACC 2011).

4.8 FINANCING PROJECTS THROUGH CARBON MARKETS HELPS SUSTAINING THE DISSEMINATION EFFORTS AND FOCUS PROGRAM EFFORTS ON STOVE ADOPTION AND USE

A novel approach increasingly used for projects to help scale up activities consists of entering carbon markets, including M&E activities within the program design, and providing long-term financing to stove dissemination. Two main carbon funding mechanisms are available for cookstove projects and programs: the Clean Development Mechanism (with four approved methodologies) and the Gold Standard (with one approved methodology). As of March 2011, the CDM had 3 registered cookstove projects with 16 in the pipeline, plus another 11 under its program of activities; the Gold Standard program had 7 registered improved cookstove projects, 4 validated ones, and 19 in the pipeline (World Bank 2011).

Two organizations in CA have ongoing carbon finance projects: Proyecto Mirador (Justa 2 x 3 stove) through the Gold Standard, and TECSA (Turbococina) through the CDM. In both cases, carbon finance revenues could potentially represent a significant fraction of total program costs, depending on the carbon prices (see Chapter 3 of this report). In the case of the Ugastove Project in Uganda, carbon financing has also been key to enable ICS to compete with traditional stoves, and in the case of the QoriQ'oncha Project in Peru, carbon financing has been crucial when building a supply chain for ICS (Box 3 and Annex III Case 4).

A series of barriers have precluded the introduction of carbon financing into more cookstove projects. These barriers include the lengthy and costly process of getting projects validated and registered, as well as technical problems with the methodology. For example, the estimation of the fraction of non-renewable biomass and fluctuations in carbon prices and uncertainties associated with the carbon market make it difficult to accurately predict prices. Programmatic Projects for both the Voluntary Market and CDM offer interesting avenues to greatly reduce transaction costs, as many stove projects can be bundled together. HELPS uses this approach for its Onil Stove Project in Mexico and Guatemala, which is in its final approval phase (PCIA 2010). Project cost-effectiveness could also be improved by refining and improving current methodologies used to estimate carbon mitigation associated with both Gold Standard and CDM projects. This, in turn, could increase the flow of funding to these projects, as outlined by Johnson et al. (2010).

5

Recommendations and Conclusions

Stepping up ICS dissemination in CA will require a concerted, sustained, and coordinated effort among the different stakeholders, including international donors, regional bodies, national governments, stove manufacturers, and implementing agencies. As stated by GACC (2011), successful ICS programs will need to create a "virtuous circle" by which demand for ICS is enhanced, supply is strengthened and an enabling environment is fostered; this last point being a key task for regional and national governments. To reach these goals in the context of CA, we recommend the following actions.

5.1 PROVIDE AN ENABLING ENVIRONMENT FOR IMPROVED STOVES

Governments should prioritize household biomass use on their agenda and designate a national coordinating authority that has oversight of energy, health, environment, and gender issues related to household biomass use. Targets and goals need to be clearly outlined, and a national ICS plan must be launched and designed as part of the overall SICA mandate regarding ICS and reduction in fuelwood use. The national authority should have the capacity to operate and effectively coordinate the national ICS programs and should be governed by a mandate that is not linked to political agendas or elective terms. Such is the case of Nicaragua, where the Ministry of Energy and Mines has led the development of country targets to

Source: Authors

promote clean and efficient woodfuel use and stove manufacturing. To reach SICA's goal, the market for ICS needs to grow from the current 5 percent of the potential 4 million households to 25 percent in 8 years. This requires a regional effort to disseminate 125,000 additional stoves each year or approximately 4 times the present ICS dissemination rate. ECLAC has already outlined a Central America Cookstove Dissemination Strategy with suggestions for yearly and total targets by country, according to demographic, economic, cultural, and environmental criteria (Sánchez 2011). This proposal could represent a starting point for developing national targets and specific programs by Governments in the region.

It is also important for the region to remove trade barriers related to ICS dissemination. Currently, regional stove manufacturers face several barriers to sell their stoves in neighboring countries. These trade barriers could be eliminated to help increase the ICS market size for stove manufacturers and to improve the opportunities for technology transfer and dissemination across the region.

Develop Regional ICS Standards together with Testing and M&E Protocols. National and regional ICS programs could be certified to ensure quality control. This process may include the following aspects:

- Setting quality standards for cookstove performance and guarantees from manufacturers.
- Adapting standard stove performance tests (such as WBT see Annex V) to better reflect the reality of CA cooking. Specifically, the tests should be adapted to cookstoves using *planchas* or *comales* (for example multipot cooking or tortilla making) and actual field performance.
- At the project level, minimum specifications need to be established that ICS programs should comply with, such as the following: a) user awareness campaigns and training on ICS use; b) provision of a maintenance program, spare parts guarantee, and provide training material; c) for stoves that are built in situ, a certified mason must be required; and d) to incorporate monitoring and evaluation activities to assess the actual impact of the ICS installed.

Currently, there is active international discussion of the three aspects mentioned above: standards for ICS performance, testing protocols, and M&E tools and protocols. For example, under the auspices of the Partnership for Clean Indoor Air (PCIA), an ISO International Workshop Agreement has been approved for rating stove performance. CA should actively engage in the international standard-setting processes to benefit from the discussions and agreements and also to ensure that international standards reflect CA cooking and user realities. The Zamorano Center should be strengthened, assuring full regional coverage of stove models and appropriate funding for up-to-date measuring equipment and trained personnel.

Conduct a regional awareness campaign about ICS benefits, cost-effectiveness, and health problems due to smoke exposure. A country-based regional campaign focusing on fuel savings, health and quality of life improvements for women and children, and environmental sustainability is necessary to guarantee that the general population knows why ICS are important. The effort to educate populations on the harmful effects of smoke can be coordinated with related international institutions, such as the World Health Organization (WHO). In fact, WHO is about to publish a series of guidelines for indoor air pollution related to wood smoke, which can be used in the proposed campaign. Through the campaign, the concept of saving fuel can be tied to environmental preservation and the monetary savings to people that purchase fuelwood. This campaign can support information dissemination in burgeoning CA ICS markets. In particular, this campaign should initially target government officials.

5.2 SUPPORT DEVELOPMENT OF NEW AND ADVANCED PRODUCTS

Fund the development of advanced biomass stoves, which can comply with stricter standards in terms of cleanliness, combustion efficiency, and affordability. Initially, there have been positive experiences in the region with advanced combustion stoves, such as the Turbococina. Funding should support regional efforts to improve critical stove components, such as the combustion chamber, which, according to state-of-the-art-standards, can be mass-produced. The chambers may then be adapted to different models such as those that feature planchas or multi-pot cooking capabilities. The invention of rocket elbow, originally created for stoves in CA and Africa, typifies regional innovation. Today, the rocket elbow has become a standard component of most stove models in Central America. International donors, local and regional universities, and other regional and international actors can support additional regional innovations. Collaboration with research institutions from Mexico working on ICS may engender attractive and cost-effective results, as the cooking patterns and practices of Mexico and CA are very similar.

In addition, solutions to replace open fires need to include not only an improved cooking appliance but also products with other functions traditionally provided by open fires. For example, in cold regions, cookstoves must provide alternatives to space heating needs, and in tropical regions, they must provide alternatives to insect control (which is traditionally achieved through smoked roofs). Also, alternative uses of open fires that ICS do not properly addressed (such as heating water for baths, etc.) should be considered. This may involve redesigning cookstoves or providing other measures to solve the problem (e.g. spraying roofs with insecticides). Unless the cookstove program effectively covers benefits or needs satisfied by open fires, open fires will continue to be used in combination with ICS. Through effective ICS implementation, ICS should at least replace open fires in the kitchen.

5.3 INCREASE EFFICIENCY AND SCALE FOR ICS DISSEMINATION

Stepping up ICS efforts will require multiple entry points, types of cookstoves, and business models. With a potential market of US$600 million (assuming a market price of US$150 per stove) and a diverse set of social, technical, and environmental characteristics within the region, no single party (public or private) has the capacity to shoulder regional investment needs. Additionally, no single stove model or delivery mechanism will fit all populations within the region. Various business models could be implemented, depending on regional demographics. Following are examples of business models needed to substantially scale up current cookstove activities. The first model may include centralized stove mass-production with affiliated retail outlets or intermediaries. Companies with strong working capital are more likely to apply this model, which will be more effective in urban and rural regions with higher concentrations of mid- to high-income customers. Areas with lower income populations may choose to implement another model, concentrating on manufacturing using local builders and selling stoves through regular markets or NGOs to help lower the costs and streamline logistics associated with sustaining a large supply chain. And finally, for rural and remote low income populations where the logistics of providing mass-produced stoves might be challenging and the costs of said stoves might by high, public and/or private institutions should implement a business model focusing on decentralized *in situ* construction by stove builders. Each model should be designed to avoid mistakes or problems identified from past experience. For example, *in situ* models need to ensure proper quality control over stoves.

In addition, it is necessary to better integrate socio-cultural and gender aspects of biomass use into ICS Programs. Cookstove programs need to explicitly include a component focused on user training and feedback, including both women's and men's perspectives and priorities. Also, an effective program should analyze gender impacts at various stages of dissemination (design, implementation, monitoring and evaluation), and it is important to tailor the awareness campaigns to different interests of and benefits for men and women that are discussed in Section 4.3.

Finance the production and purchase of ICS. With a potential ICS market of 4 million customers in CA, there are niches for all certifiable stove models. However, at a likely market price of US$150 per ICS, only a fraction of potential customers can afford to buy the stoves, unless financial mechanisms are provided to reduce their upfront costs. A detailed study needs to be conducted to establish the best financial strategies in the Central American context, as financial mechanisms should be adjusted to different customer segments within each country (for example, according to urban, rural, and income class). However, reviewing the Central American experience as well as international case studies provides some guiding principles: a) that programs should focus their initial efforts in places with the highest adoption potential—either because of the presence of intermediating organizations, a fuelwood scarcity and correspondingly higher wood prices, or other factors; b) that direct subsidies to stove prices are needed, but care should be taken to avoid creating perverse incentives (such as giving stoves for free on a massive scale) that later on hinder market creation; c) much more emphasis should be given to indirect price subsidies, for example, to stove producers or manufacturers, so they can introduce ICS into markets at lower prices; and d) other types of financing should also be explored to increase the affordability of ICS to customers. The latter financing mechanism includes payments in installments, micro-credits, and other innovative models such as free trial periods, rent to own, and consigning. These financing mechanisms have not been researched or implemented in a cookstove context, but important lessons may be learned from other sectors, such as the sale of solar panels for lighting, water disinfection, and others.

Financial and other support should also be provided for stove manufacturers. This includes support for training and capacity building; soft-debt financing, and loans for working capital to supply the ICS market; and, in the case of small-manufacturers, financing to pay for the certification process, and eventually, for the transaction costs to get ready to enter the carbon market.

Explore Carbon Financing for Cookstove Projects. Carbon finance for ICS is already a reality for two projects in CA, and there are a few more in the pipeline. Access to carbon markets provides fresh financial resources that are proving critical to support continuous cookstove monitoring and follow-up, (as in the case of Proyecto Mirador) and to financing widespread dissemination of advanced cookstoves (as with the Turbococinas Project). Supporting other ICS projects that qualify for CDM or voluntary markets could be a natural way for ICS programs to evolve towards certified performance and documenting actual stove use. International donors and national governments may help facilitate carbon cookstove project development in Central America by reducing the currently high transaction costs through capacity building, promoting programmatic projects, and helping finance the initial studies. Financing the development of improved methodologies for carbon offset projects, which would allow for fully capturing the benefits of GHG reductions through cookstove implementation, is another avenue that would catalyze project activity. Programs and donors should also explore other compensation mechanisms for carbon offsetting projects, programs, and policies, such as Nationally Appropriate Mitigation Options (NAMAs).

5.4 CONCLUSIONS

This report carries out its analysis and reaches its conclusions with a limitation in time and information available. It represent initial inquiries that aim to fully understand the issues and problems related to cookstove dissemination in the region and charts proper actions needed to mitigate these issues and problems. Much has been learned from past experience both in Central America and other regions in the world about promoting improved stoves, including user preference, cultural and social customs, delivery mechanisms, product quality control, and program monitoring and evaluation. Local Central American entrepreneurs have been the pioneering force in stove development and dissemination, oftentimes with external support. However, the past decade of efforts in the region has not transcended into a scale economy or self-sustaining market for improved stoves; indeed, the region is far from forming a commercial stove market because of the deficiency in cookstove demand and supply. In the short to medium term, regional actions should focus on improving the enabling environment, developing new and advanced products to replace both cooking and other functions of open fires, and increasing the efficiency and scale for stove dissemination.

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ANNEX I

Country Specific Experience with ICS in Central America

EL SALVADOR

In El Salvador, 30 percent of households use fuelwood for cooking, largely concentrated in rural areas. The low percentage of fuelwood users relative to the regional average is partly explained by the historic direct subsidies to LPG, which have been retargeted since 2008. Currently, only one bottle per family is subsidized—at a price of US$6 per bottle—while the market price for LPG is around US$15 per bottle. As a result of the recent subsidy retargeting, the number of people using fuelwood is believed to be increasing (*La Prensa Grafica* (El Salvador), 2012/1/18).

In El Salvador, wood-burning cookstoves have been handled by different institutions without specific coordination, mostly by the Forestry Department of the Ministry of the Environment, the Ministry of Agriculture, and recently, the National Energy Council (CNE) (in terms of quantifying consumption).

El Salvador is the most innovative country in terms of ICS programs and models. There are two main innovators: Mr. Gustavo Peña, who has developed 5 different ICS models, and Mr. René Nuñez, developer of the Turbococina stove. Mr. Oscar Figueroa, another Salvadorian innovator, is developing two stainless steel ICS models: the Mimosa, which works with charcoal, and the Consentida, which works with mini fuelwood logs. Both models are expected to be introduced into the market in late 2012.

Several ICS programs are in place in El Salvador. These programs center on specific stove models; the manufacturers are responsible for marketing, installation, training, and quality control with or without partnership with other institutions. The most salient stove models are the "Ecocina," produced by the "Stove Team" Group, and the "Turbococina," manufactured by "Tecnologías Ecológicas Centroamericanas."

Dissemination of the Ecocina is supported with subsidies from the Rotary Club. The stoves have been either sold at half of the US$60 list price or given away for free. About 10,000 units have been distributed since 2006. The newer Ecocina models are bigger and more sophisticated than the original version, and they are marketed using word of mouth. These newer models are sold at full market price, from US$113 to US$250. There are two models made specifically to target tortilla makers, as well as an oven to cook bread or pizzas. Almost 500 new ICS models have been sold. Women in the tortilla and *pupusa* making businesses like these stoves, particularly after the government reduced the LPG subsidy.

Tecnologías Ecológicas Centroamericanas (TECSA) currently distributes the Turbococina. The retail price of the stove is not available, as the stove has not been marketed to final users. Its mass production cost is estimated at US$140. As a primary measure, 1,200 Turbococinas were donated to public schools, where wood is used for cooking through a joint initiative with the Ministry of Education. 12,000 women (mostly mothers of the children attending the schools) have used these stoves to prepare school lunch. TECSA plans to use carbon financing to scale up the dissemination and reach 3,500 schools and 120,000 households. TECSA believes that women with prior experience using Turbococinas will be more willing to use one at home. A program of activities for Turbococinas was registered with CDM in 2011, and its first phase covers the 2010–2014 period. The stoves are expected to mitigate 4.66 tons of CO_2e/stove/year for household stoves and 6.05 tons of CO_2e/stove/year for institutional stoves (i.e., those installed in schools). The maximum annual emission reduction that the project may achieve through full-scale operation is estimated to be 580,000 tons of CO_2e/yr. TECSA will give the stoves away for free to customers, using the revenues generated by selling carbon credits to pay for the stove and program costs.

TECSA implemented a pilot project which installed 15 Turbococinas in a community, and a high acceptance level was reported. However, the stove needs electricity for running the fan, and small pieces of fuelwood need to be inserted into the stove every two to two-and-a-half minutes while cooking. In addition, the metal surface on top is small and allows for cooking only one dish at a time. These design limitations require significant deviation from traditional cooking practices and could potentially affect adoption and sustained use of the stoves.

GUATEMALA

Guatemala uses large quanities of fuelwood and has the most experience with improved cookstoves in CA. However, at the moment there is no integrated government strategy or legislation to promote sustainable fuelwood production or to ensure its clean and efficient use. Issues related to biomass cookstoves have been addressed by different institutions, including the Ministry of Energy and Mines, the Ministry of Environment, the Ministry of Health, and the Ministry of Agriculture. The Ministry of Agriculture, through the National Forestry Institute (Zanotti, 2008), has been concerned with the use of fuelwood for cooking. The Ministry of Environment carried out an ICS program with Rotary International to support poor communities and to lower greenhouse emissions. Unfortunately, there is no focal point for the related government or local initiatives, and individual efforts have been made without coordination.

Since the Lorena stoves that were developed in the mid-1970s, stove preferences have favored *in situ* constructed ICS with a *plancha* and a chimney, but these preferences are changing. Industrial models are penetrating the market due to their mobility, smaller size, and efficiency. There are two main industrial, or mass-produced, ICS models in Guatemala: Noya and Onil.

The Noya stove was designed by Mr. Manuel Tay with the idea to create an easy-to-use ICS that is also attractive to women. Mr. Tay sells the stove for US$160. The company is essentially a family business with a current production capacity of 600 stoves per month. Noya stoves are sold at retail price. Credit is available under some circumstances and is provided by Mr. Tay himself, but most people choose to pay cash. The company relies on mouth-to-mouth diffusion and sells the stoves by order. Since 2000, approximately 6,000 Noya stoves have been sold directly to clients *without subsidies.*

Mr. Tay works with rural and peri-urban users who are capable of paying for stoves. As most of Mr. Tay's clients purchase fuelwood, the ICS has a direct benefit. Mr. Tay emphasizes simplicity and sells a product that looks modern to the user in addition to its high-quality technical performance. Women like the stove because it is made out of metal—like a gas stove—and because it looks modern. The stove has a large combustion chamber, and it is easy to use and maintain.

The Onil stove is a semi-portable cement stove that is manufactured centrally and is assembled in situ. The stoves are marketed by the non-profit organization HELPS International with support from Shell Foundation. HELPS is the largest ICS manufacturer/supplier in CA, with about 100,000 Onil stoves and 20,000 nixtamal stoves (for large pots) installed since 2001.

It has expanded its operations to Mexico, Honduras, and Nicaragua. The retail price of Onil stoves is US$125.

Onil stoves are sold through a variety of channels. Fifty percent of HELPS sales are through NGOs, foundations, and local governments; 20 percent through businesses with social responsibility; 15 percent through government; 5 percent direct purchases and 10 percent with micro-credits provided by the Guatemalan Rural Bank to its clients, mostly in small towns. HELPS uses various outlets for marketing its products, including radio, newspapers, billboards, rural schools, urban buses, stands at events, and market day events involving rural communities and community distributors. Onil stoves are well accepted in general as they have both the *plancha* and the capability to cook over a direct fire. However, the stove is perceived as small. It can serve a family of 5 members. In addition, the stove is very heavy and weighs over 100 kg., making transportation a challenge. The Onil stove program has being certified and seeks carbon-credit funds via CDM.

It should be noted that the designs of both Onil and Noya stoves have improved over time in response to users' feedback. HELPs has also developed other products to meet household needs that were satisfied by open fires. For example, a small hanging board surrounding the *plancha* is provided for keeping pots; additionally, the Nixtamal stove was developed to fit large pots and the Onil Cooker as a retained heat cooker; basic solar PV lighting has been introduced to replace light from the open fire; and a water filter has been installed with Onil stoves (in some regions of Guatemala, 40 percent of fuelwood is used to boil water).

HONDURAS

Similar to Guatemala, fuelwood is extensively used for cooking in Honduras, and the country has had experience with improved cookstoves since the 1980s. Several institutions govern woodfuel issues in Honduras including the Institute of Forest Conservation and Development, Protected Areas and Wildlife, State Forest Administration, and the Ministry of Natural Resources and Environment (SERNA). There is no direct coordination among the different institutions. In November 2011 US$30 million in grants were approved for Honduras in addition to concessional financing from the Program of Scaling-up Renewable Energy in Low Income Countries (SREP), one of the Climate Investment Funds (CIF). The Government of Honduras decided to allocate US$2 million of the SREP resources to help scale up dissemination of improved cookstoves.

In Honduras, ICS projects are well established. As a result of a health campaign conducted by the Health Ministry in the 1980s, many Hondurans have stoves with functioning chimneys. Stoves with *planchas* are clearly preferred in the Honduran cooking context, as pots are not in direct contact open flames, and as a result, do not accumulate black soot. For these reasons, the Justa stove model is the most popular improved cookstove in Honduras. The Justa stove has multiple variations, but it fulfills the cultural needs of Honduras: (i) a continuous *plancha,* so pots and pans are clean and not exposed to fire; (ii) an area for making tortillas; (iii) an area large enough to cook other meals over the *plancha,* and; (iv) a chimney to eliminate smoke from the kitchen. The combustion chamber has a rocket elbow, and the chamber entrance is large enough to fit sizable pieces of fuelwood, which is attractive to rural populations and women in general. The Justa has been well received in Honduras, and introduction of other stoves has proven difficult. There are two main organizations working with Justa stoves in Honduras: ADHESA and Proyecto Mirador.

ADHESA is a local NGO that began working with ICS in late 1990s. It has developed with several models of Justa stoves. The most popular models to date are the in situ models, such as Justa 16x24, which are made of cement or bricks. ADHESA also works with various portable ICS models made of metal. Recently, AHDESA developed a new metal stove named COPAN that has been well accepted by users. These stoves cost US$120-165, depending on the technical specifications. ADHESA has manufacturing capabilities, but their main dissemination strategy has been to provide training on the construction of Justa stoves to other NGOs and individuals. AHDESA also works closely with several international NGOs and donors, including Tree, Water and People. As of now, they have trained 22 NGOs and individuals, with an estimated 11,500 stoves disseminated. The stoves were previously given for free, but other business models have been increasingly explored, particularly as a result of a collaborative project with GIZ. Currently, it is expected that users pay at least 40 percent of the stove cost.

In particular, ADHESA has trained NGO Proyecto Mirador to construct Justa stoves. Proyecto Mirador developed a new Justa model, Justa 2x3, and started their operations in the Santa Barbara region. The Justa 2x3 is built *in situ,* reduces fuelwood use by 55 percent, and has a production cost estimated at US$77 (i.e., the direct cost of building the stove without accounting for indirect project costs). They have built 32,000 stoves since 2004, and are aiming to construct 100,000 stoves by 2015. Stove users provide local materials (with an average estimated cost of US$17) and host the installers as needed. The stove is installed for free, implying a direct subsidy of US$60 from the project developer. Proyecto Mirador provides training to users and closely monitors and evaluates each stove installed. Each sale is well documented and three follow-up visits are made one, seven, and fourteen months after installation. Stoves come with a 5-year warranty and are installed by qualified contractors, with an aggregate annual production capacity to build between 30,000 and 35,000 stoves. Proyecto Mirador centralizes production of *planchas,* combustion chambers, and chimneys. The organization also disseminates these stoves on a community-by-community basis, concentrating on meetings with local leaders and word-of-mouth advertisement.

Proyecto Mirador achieved Gold Standard Registration in June 2010. With an estimated reduction of 2.7 tons of CO_2e/year per stove and a lifetime of 5 years, carbon prices of US$10-20/ton should cover a significant part of the program's costs. The project is estimated to generate 270,000 tons CO_2e/yr when it reaches full-scale operation. As required by the Gold Standard, Proyeto Mirador stoves are subject to verification every two years.

NICARAGUA

In Nigaragua, 70 percent of the population relies on fuelwood for cooking. However, this country has little experience with improved cookstoves when compared to Guatemala and Honduras. Government agencies in Nicaragua have addressed issues related to fuelwood and cookstoves, although dissemination of improved cookstoves remains limited. Currently, Nicaragua is the only country in CA that has prepared a National Strategy for Fuelwood and Charcoal. The proposed strategy would be effective during the 2011–2021 period and is currently pending the President's Office approval. The strategy is a multi-sector effort that involves the Ministry of Energy and Mines, Ministry of Environment and Natural Resources, Ministry of Agriculture and Forestry, the National Forestry Institute, and the Nicaraguan Foundation for Sustainable Development. A fuel map is being prepared based on the National Fuelwood Survey. The National Strategy includes a clear action plan with financial resources and an appointed person to implement the strategy.

In Nicaragua, women like to cook over a direct fire, so *planchas* need to have an opening to place the pot. There are two main ICS models disseminated in Nicaragua: *Ecofogón and Mifogón.*

The *Ecofogón* stove is trademarked by Proleña, a Nicaraguan NGO. Proleña has actively constructed and implemented ICS throughout Nicaragua and has trained other NGOs and individuals to construct and implement cookstoves since 2001. *Ecofogón* comes in different models, both metal and portable, and all are built *in situ.* All models include a rocket elbow in the combustion chamber. To date, Proleña has distributed 13,000 stoves, mostly in urban areas. The *Ecofogón* costs US$125, and are primarily made upon request. Proleña collaborates with international organizations, such as the Rotary Club and JP Morgan, and with local organizations, such as the National Government. Proleña has the capacity to manufacture up to 200 metal stoves per week.

Proleña stoves have been promoted in local newspapers and TV shows with positive results. The financing mechanism for Proleña stoves has been mixed, including stoves given for free (those contracted by the Government), others subsidized by 40-50 percent (those contracted by the Rotary Club), and stoves that are 94 percent paid for by the user (those contracted by JP Morgan). The stoves come with a 6 month guarantee and are expected to last from 3-5 years, except for the chimney that must be replaced more frequently. Recently, Proleña trained local artisans to produce an inexpensive charcoal stove called "Rapidita", based on a Kenyan model. They have sold approximately 700 Rapidita stoves without advertising. The chimneys last 2 years, and the *planchas* have iron *parches* that last 6 to 12 months.

Proleña also trained local entrepreneur Mr. Bonilla, who then went on to develop another stove model: the *Mifogón*. In 2002, 1,300 *"Mifogón"* stoves were installed with the support of ESMAP. Since then, Mr. Bonilla promotes his stoves directly to clients, but sales have declined significantly in recent years, reaching only 300 stoves in 2011. The stoves cost US$70 and are produced in a factory with capacity to manufacture 40–50 stoves per day. Coffee growers and private agribusinesses have purchased Mifogón stoves for their workers in rural areas.

COSTA RICA

Costa Rica has the lowest levels of fuelwood consumption in the region. Open fires are rarely used for cooking, whereas modern fuels such as electricity and LPG are used more frequently. Nonetheless, fuelwood use represents 55.9 percent of total residential energy use because of its low efficiency (Consumo de Energía del Sector Residencial, Gobierno de Costa Rica 2011). The current National Energy Plan promotes the use and development of new alternative energy sources such as biomass, but the focus is on electricity generation and productive uses rather than on residential energy use for cooking. Historically, residential sector energy policies have been more focused on supporting the use of LPG and electricity for cooking rather than encouraging more efficient fuelwood use. The Costa Rican Ministry of Environment, Energy and Telecommunications (MINAET) is the focal point for biomass-related matters.

There is little experience with ICS in Costa Rica. In rural areas, populations tend to use *in situ* stoves with chimneys or iron stoves. The "Farm Stove Project" started in 2011 and has disseminated 100 *Finca* stoves as part of a larger development project financed by a grant from National Geographic and the Embassy of Finland. The plan is to distribute 1,200 stoves during the first phase. The Farm Stove Project aims at training local women to run and market the stove business. The project works with a local women's group to develop women-owned stove building networks. The project's main challenge has been women's lack of familiarity with the improved cookstove model, since it is very different from the traditional stoves the women are used to. The project is still in its pilot phase, and stoves have been given out for free.

PANAMA

In Panama, fuelwood has been traditionally used for cooking in rural areas and as fuel in small industries, such as bakeries, pottery kilns, restaurants, and salt extraction. Half of the rural population in Panama uses fuelwood for cooking. However, ICS have received scant attention from the Panamanian Government. Currently, there are no Government plans or activities related to ICS in the country. The Panamanian Ministry of Energy and Mines is the focal point for biomass-related matters.

There is very little experience with ICS in Panama. Starting in 2009, Proverde, a local NGO supported by the Embassy of Finland and the organization *Manos Amigas,* started the dissemination of *"Ecojusta"* stoves. *Ecojustas* are similar to the Honduran *Justa* model and were developed after local organizations received training from AHDESA. So far, approximately 230 stoves have been disseminated in rural areas at a price of US$250 per unit. The user pays 30 percent of the cost, and *Proverde* subsidizes the rest. Resistance to change and lack of trust in the new stoves by potential users have led to slow progress of the project.

Proverde works with indigenous communities and rural people to educate them about health problems related to indoor air pollution. ICS are introduced as a way to save fuelwood and reduce health problems. *Proverde* conducts meetings with the communities to explain the benefits of ICS. Once installed, stoves are monitored every month. The project reports that 30 percent of ICS users still use open fire.

ANNEX II

Main ICS Models in Central America

Ecocina—Inversiones Falcón, El Salvador

The Ecocina (Figure 8) is an ICS developed by Salvadorian manufacturer Inversiones Falcón with the support of the Rotary Club, Stove Team (a US-based Foundation), and Aprovecho Research Center (ARC, located in Oregon, US). It is a simple and compact industrial stove with a prefabricated concrete body, a rocket elbow,[19] and, without a chimney, a *plancha* or with a pot can be used directly over the fire. Since 2006, Inversiones Falcón has disseminated over 10,000 Ecocina stoves. The cost of each Ecocina is US$60, and they are sold with a 50 percent subsidy.

Besides the Ecocina, Inversiones Falcón has development five additional industrial ICS models as a response to local cooking practices. Two of these models were designed specifically for *tortilleras* (women that sell tortillas), and one, the Escolar stove, for schools. According to field interviews conducted for this study, the industrial Ecocina *tortillera* stove can save seven times the amount of money previously spent on LPG.[20] The Eco3 stove has the capacity to cook several dishes at the same time, either on top of a plancha or in direct contact with the fire through removable discs. Inversiones Falcón also manufactures an efficient biomass oven for small and medium enterprises. The costs of these stoves range from US$250 for the commercial industrial *tortillera* stoves, US$150 for the Escolar stove, to US$113 for the Eco3 stove.

19. A rocket stove, or rocket elbow stove, is an efficient cooking stove using small diameter fuelwood, which is burned in a simple high-temperature combustion chamber containing an insulated vertical chimney that ensures complete combustion prior to the flames reaching the cooking surface.

20. LPG price without subsidy.

FIGURE 8. Ecocina (left) and Turbococina Stoves (right)

Source: Authors

Turbococina—Tecnología Ecológicas Centroamericanas, El Salvador

The Turbococina (Figure 8) was developed by Tecnologías Ecológicas Centroamericanas (TECSA), based in El Salvador. It is an important combustion technology innovation, as it eliminates black carbon as a secondary fuelwood combustion product. Turbococina is estimated to reduce CO_2 by 4.7 tons per year. According to the testing, the Turbococina stove may be able to last for more than 40 years if properly used and maintained. The stove can fit a *plancha* where one can cook 12 tortillas simultaneously, or it can hold a pot with up to 30 liters of water. It needs to be fed small pieces of fuelwood continuously and uses an electric fan.[21] The household model costs US$140 and the industrial model costs US$160 when mass-produced.

Mimosa, Consentida, and Cuadrada—Salva Bosque Stoves, El Salvador

Mimosa charcoal stoves and the Consentida and Cuadrada fuelwood stoves are being developed by Salva Bosque Stoves in El Salvador and are expected to be ready to enter the market in late 2012. The stainless steel Mimosa charcoal stove has a charcoal deposit and a griddle where pots can be placed. It needs only 150 grams of charcoal to work for over two hours and can cook 1 kg. of beans in two hours. This stove costs around US$60–US$75. Consentida and Cuadrada fuelwood stoves need to be constantly fed small pieces of fuelwood, and they both employ electric fans. In one hour these stoves can use up to 0.5 kg. of small pieces of fuelwood and can cook food for 2 to 8 people. These stoves are estimated to cost about US$400 and US$500 respectively, which could be lowered if mass-produced. Efficiency data was unavailable for these stoves.

21. The manufacturer is designing fans that will use the thermal energy from fuelwood combustion instead of electricity.

Onil—HELPS International, Guatemala

The Onil stove (Figure 9) is the most common industrialized model in Guatemala with around 100,000 stoves distributed in the last 10 years. This stove was designed in 2001 and is distributed by HELPS International. The Onil stove has a prefabricated concrete base, a rocket elbow in the combustion chamber, and a metal *plancha* with detachable rings that enable direct contact with fire. It weighs around 300 lbs. and can last up to ten years if properly maintained. The Onil stove's factory price is US$115, and it is manufactured in Guatemala City.

Noya Stove—Inversiones Tay, Guatemala

The Noya stove was developed by Inversiones Tay.[22] The stove was designed with a modern and streamlined appearance which appeals to women in local communities. The Noya (Figure 9) is a metal box with a chimney that has a *plancha* for tortillas and 2 detachable rings to allow pots to be in direct contact with the fire. The Noya stove weighs 48 lbs.; however, the metal box needs to be filled with 100 lbs. of brick and sand which is provided by the users. The stove sells for US$160. A 5-year guarantee is included in the total price. The stove has been on the market for 3 years, and 6,000 units have been sold. There is a smaller model with one burner that sells for US$100 that has not been as well accepted as the larger model.

Justa Metal and Copan Stoves—ADHESA, Honduras

The Justa Metal Stove is one variation of the Honduran Justa stove, which was originally developed by the NGO ADHESA with the objective to support small and medium enterprises. The Justa Metal Stove is a standalone metal portable stove with a combustion chamber that fits larger fuelwood

FIGURE 9. Onil (left) and Noya Stoves (right)

Source: Authors

22. Inversiones Tay is headed by Manuel Tay, the original designer and implementer of the Lorena stove.

sizes, and it has a solid metal *plancha* with no detachable rings (in Honduras, stoves that allow cooking through direct flame have not been well accepted by users). The Justa Metal stove comes in two models: one with a square *plancha*, and the other with a rectangular *plancha*. These stoves cost US$150 and US$140, respectively. Additionally, ADHESA created another variation of the Justa Metal Stove that includes an oven below the combustion chamber. This model was created in response to users' requests for an oven to bake pizzas or bread. The stove with an added oven component sells for US$165. ADHESA reports that supplying spare parts for industrialized stoves to users in remote regions of Honduras remains an issue for the non-profit, due to logistical and infrastructural difficulties.

The Copan portable industrial stove was also developed by ADHESA and has been well received by local women due to its clean appearance and fuelwood savings. The stove was recently developed to be installed quickly and with minimal effort in one day. It is a metal box that includes a rocket combustion chamber, a metal *plancha,* and a chimney. Efficiency tests are still ongoing. The Copan stove sells for US$120. It has been given away for free to low-income communities as part of private companies' social responsibility initiatives. Supplying spare parts is an ongoing challenge.

Ecofogón, Mifogón, and Rapidita Stoves—Proleña, Nicaragua

The Ecofogón stove (figure 10) was developed by Proleña, a Nicaraguan NGO that has worked with ICS for more than a decade. The non-profit has also provided training to NGOs and other individuals on ICS construction. The Ecofogón is a metal stove that weighs about 100 pounds and has a combustion chamber, a metal *plancha,* and a chimney. To date, Proleña has distributed about 13,000 stoves throughout urban and peri-urban areas of Nicaragua where there is high demand. It has different industrial variations, including the Industrial Ecofogón stove with a cost of US$115, and the Tortilleras Eco-

FIGURE 10. Industrial Ecofogón (left), Mifogón (center), and Rapidita Stoves (right)

Source: Authors

fogón which costs US$122. The stoves have a 6 month guarantee period and have a lifetime of 2 to 4 years, while the chimney has a 2-year lifetime. Proleña also designed the EcoOven for bread baking, which costs US$880.

The Mifogón stove (figure 10) is a metal stove with a *plancha* and one circular opening for cooking pots over direct fire. About 1,300 Mifogón stoves were sold in 2001, mostly to agribusinesses that buy them for their workers in rural areas. The stove costs US$70, and has not yet been tested by the Zamorano Center.

The Rapidita stove (figure 10) is a one plate charcoal stove similar to Kenyan stoves produced by manufacturers trained by Proleña. It is a fairly inexpensive stove with a ceramic combustion chamber. It is usually used by people cooking food that can be made on one burner, like beans, and mostly by low-income people living in peri-urban and urban areas. The stove costs US$20. Its production is constrained by limited manufacturers of the ceramic combustion chamber, as artisans can earn higher incomes from fashioning handcrafts than from selling combustion chambers. A *comal* can be placed on top of the stove to make tortillas. In Managua, around 700 Rapiditas have been sold by word of mouth alone.

Chapina Stove—Hombres y Mujeres en Acción, Guatemala

The NGO *Hombres y Mujeres en Acción* developed Chapina, an industrial ICS model inspired by the Onil model. This donor-driven program uses an integrated participatory approach that involves local communities to raise awareness and promote stove construction and maintenance. *Hombres y Mujeres en Acción* has provided around 2,000 *Chapina* stoves in 2 years. The *Chapina* stove weighs approximately 200 lbs., is installed over a block table, and can be used to cook for families of 7 to 10 people. *Hombres y Mujeres en Acción* has a production capacity of 120 Chapinas per month. The stove costs approximately US$115, which is partially subsidized with donations (with 25 percent of the cost borne by final users through labor and local materials). The Zamorano Center is currently testing the *Chapina*. Thanks to technical inputs from Zamorano, small technical adjustments are being made to achieve higher efficiencies.

Justa 16x24 In situ Stove—Adhesa, Honduras

Justa was developed by the NGO ADHESA and has multiple variations. It is very popular in Honduras and fulfills the cultural needs of Hondurans by having: (i) a *plancha,* so pots and pans are clean and not exposed to fire, (ii) an area for making tortillas, and (iii) an area large enough to cook other meals over the *plancha.* The combustion chamber opening can take large pieces of fuelwood, which is attractive to rural populations and women in

FIGURE 11. Justa 16x24 Adhesa (left) and Justa 2x3 Proyecto Mirador (right)

Source: Authors

general, because its burning process does not require full-time attention. The Justa *in situ* stove has a life span of 3 to 10 years, depending on maintenance (Figure 10). It costs US$150, 55 percent of the cost comprising the stove itself, 15 percent for follow up activities, 15 percent for administration costs, 8 percent for research, and 7 percent for supervision costs from their partners (Trees, Water and People; GIZ).

Justa 2x3—Proyecto Mirador, Honduras

Proyecto Mirador, an NGO founded in 2004 and serving the Santa Barbara region of Honduras, developed Justa 2x3[23] (Figure 7), a variation on the original Justa. Proyecto Mirador has built more than 32,000 stoves in 7 years, and their capacity has increased from 100 stoves in the first year to 10,000 in 2011. They expect to build 30,000 stoves in 2012. Proyecto Mirador provides the chimney, *plancha,* combustion chamber, grate, and the service of the stove builder; each user contributes the base for the stove, the stove frame, which can be made either of bricks and cement or adobe, as well as additional wood for insulation. It is designed to last 5 years. Proyecto Mirador reports a cost of about US$85 per stove, plus the additional co-investment from users, with a maximum final cost of about US$117.

Justa Fundeih Stove—FUNDEIH, Honduras

Another variation of the in situ Justa stove in Honduras is Justa FUNDEIH (Fundación para el Desarrollo Integral de Honduras). Key modifications relate to lowering total cost through in-house manufacturing of metal stove parts. FUNDEIH's Justa stove costs between US$100 and US$120. The stoves are given away for free in collaboration with government and donor-driven programs. Thus far, FUNDEIH has not tested or certified their stoves.

23. 2x3 (*dos por tres*) means "in an instant" in Spanish.

Ecofogón In situ Stove—Proleña, Nicaragua

The Ecofogón Stove has an *in situ* model developed by Proleña in Nicaragua. It has the same components as the industrial model, except that the combustion chamber and *plancha* are placed over a brick or cinderblock table. The dissemination program includes an awareness campaign, training, and follow-up. Four trained people can build 10 *in situ* Ecofogón stoves in one day.

ANNEX III

Selected International Cookstove Programs

CASE 1. THE ANAGI COOKSTOVE PROGRAM IN SRI LANKA

The Anagistove, with approximately 3,000,000 stoves sold and a 17 percent market share, is the product of three decades of efforts to introduce improved cookstoves into the Sri Lankan market. This stove was introduced into the commericial market after addressing capacity building needs of urban and rural markets, distributors, and manufacturers. The cookstove itself evolved from a heavy mass pottery piece to the current streamlined, lightweight, fast cooking, off-the-shelf Anagi stove sold in the market. In the first project phase, project officials were in charge of the cookstove dissemination process as well as delivering the stoves free of charge to users. Through this method, the project was unable to create long-term, self-sustaining markets after the project's end. In the second phase, a commercial approach targeting urban users was designed: the Urban Stoves Program (USP). Practical Action (formerly ITDG) initiated the USP in collaboration with Ceylon Electricity Board and with support from donor agencies and the Sri Lankan government. As the Anagi is an off-the-shelf product, the project used well-established manufacturing and distribution channels for selling similar products in the formal sector (tile factories). Through the project, participating organizations built up the capacity of existing local urban infrastructure in 4 key areas: production, marketing and promotion, training and quality control, and monitoring. A loan to cover capital investments and the risks associated with a new product was provided to stove producers. In the third phase, the Rural Stove Marketing Project, which targeted the informal sector, a larger number of potters, unskilled persons, and other low-income users were created. A local NGO provided technical training for potters and stove installers while trying to create awareness and develop market channels at the national level. Mass media, public displays, television, radio, and school competitions are examples of some of the promotion channels employed to advertise the Anagi. The RSMP objectives were reformulated to encompass job opportunity gender equality, as well as inclusion of the poorest households through community based organizations with existing links to the poorest households. In addition, the objectives incorporated Anagi stove promotion and training in ongoing activities. The CBOs were provided with funding to establish a revolving fund to facilitate purchasing stoves on credit that are then paid back in installments. Currently, 65 percent of stoves are paid at the time of purchase, 31 percent are bought on credit, and 3 percent are paid for in advance. There is sustained capacity to produce 300,000 stoves annually by 185 potters nationwide. Approximately 22 percent of the producers are women.

Critical Factors for success were:

1. Flexibility of strategies: The success of the Urban Stoves Program is partly attributed to the application of modern marketing strategies while accommodating for a variety of socio-economic, cultural, and equity factors and aspirations of a traditional society.

2. Program continuity: Despite the involvement of different organizations led by different objectives and strategies, each development phase picked up from where the previous one left off without much duplication of effort. This, coupled with the program's focus lessons learned, ensured program continuity.

3. Exposure to international experience and networks: Through collaboration with international organizations such as ITDG, the program benefitted from funding and the international experience of its partners regarding successful product commercialization.

4. Involvement of both governmental and non-governmental organizations: The government organization CEB initiated the first attempt to disseminate ICS. Although continued post-project dissemination failed, the project's wide reach through district offices coupled with the project's subsidization scheme raised crucial awareness of the ICS movement. Non-governmental organizations' increased involvement, and

finally, ownership of the stove program ensured continued interest and effort in promoting ICS even after government and private sector priorities changed.

5. Appropriate product design and product flexibility. Diverse stove models were offered to users.
6. Generally speaking, low-income users should not be the primary target of a commercialization scheme.
7. Emergence of large-scale producers: Efforts were made to support the emergence of larger scale production by training clusters of potters.

Source: Konaris, T, Commercialization of Anagi Stoves: Lessons from the Improved Cookstoves Program in Sri Lanka. www.impactalliance.org,

Amerasekera, R. M. 2011. Quest for Sustainability Profiles of ICS Programmes in Asia: Sri Lankan ICS Case Study Baseline and Monitoring Methodology: Improved Cookstoves, Technologies and Practices to Displace Decentralized Thermal Energy Consumption. Gold Standard Foundation.

CASE 2. CURRENT BUSINESS MODELS FOR COOKSTOVE DISSEMINATION IN INDIA

Through a comparative analysis of 10 different cookstove programs currently implemented in India, Shrimarli et al. (2011) conclude that, while commercial cookstove efforts in India remain too immature and too sparse to allow a definitive assessment of whether such businesses are sustainable at scale over the long term, a preliminary series of successful strategies to scale up stove dissemination may be identified. The key success factor for the companies examined was secure upfront capital with low expectations for return coupled with urgency in developing and managing the supply chain. Also, the relative success of these different organizations in getting a stove business off the ground was directly related to the ability to get enterprise financing for the initial development of the stove business. All of the companies that distributed large numbers of stoves needed significant enterprise financing to support the upfront time and money spent on customer research, stove design, and establishment of a supply channel. The magnitude and stability of enterprise funding seemed more important to achieving scale than whether its source was private or charitable in nature.

Indian government subsidy programs have caused significant problems for ICS businesses by distorting or destroying markets. On the one hand, even though the National ICS program was discontinued in 2003, it has created an enduring expectation among potential stove customers that they should receive stoves essentially for free. On the other hand, ongoing government subsidies for LPG make ICS that are potentially in competition with LPG less competitive.

Successful companies have managed to create a legitimate value proposition for consumers through well-designed, commercial cookstoves distributed through well-conceived supply networks. Instead of blaming consumers for failing to recognize the health or other benefits of a new stove, these companies have respected the priorities of their potential customers and provided them with something they value on their own terms. However, no company has reported being able to reach the poorest of the poor while remaining a commercially viable operation. Instead, the target household customers generally had higher incomes, which often meant that the improved biomass stoves were displacing LPG use rather than traditional biomass burning, further reducing the health benefits of commercial stove activities.

Product demonstrations were identified as the most important driver of their stove's adoption in the marketplace. This suggests that, while media marketing may be important to attract early adopters, the fate of a given stove will ultimately stand or fall based on the combination of its own merits and the success of the company in developing a viable supply channel that can bring a large number of people into personal contact with the product. The companies that have achieved volume have focused significant attention on building up a scalable supply channel and remained actively involved in managing this channel. Two companies partnered heavily with women's self-help groups to quickly develop a core of village-level entrepreneurs who could sell the stove. In both cases, the dealer networks were diversified by adding proprietors of retail outlets, and margins typically run around 5–10 percent for the distributor and 10–15 percent for the retailer. Some companies initially priced the stove lower but then were forced to raise prices to make the business model more sustainable.

Source: Shrimali, G. Et al. 2011. In India: A study of sustainable business models, *Energy Policy,* vol. 39, pp7543–7556.

CASE 3. CHINESE NATIONAL IMPROVED COOKSTOVE PROGRAM

The Chinese National Improved Stove Program (NISP) was the cookstove dissemination effort to achieve the largest success at scale, distributing approximately 130 million stoves, most of which remained in use over a long period of time (Smith et al., 1993; Barnes et al., 1994; Sinton et al., 2004). China's NISP combined a central push with locally coordinated efforts to create functioning markets for stoves.

Key successful strategies followed by the program were: a) The creation of a national program (CNISP) and a government agency for the implementation of ICS (Bureau of Evironmental Protection and Energy or BEPE under the Ministry of Agriculture and its provincial counterparts) with direct contact with counties and villages; b) Preliminary work in the best areas for cookstove dissemination; c) Independent monitoring and evaluation conducted; d) little direct government contribution: 15-20 percent of total program cost through training administration and promotion; e) minimal money flow; and f) a sound strategy for commercialization of stoves.

BEPE covered all 34 provinces in China with more than 1,500 rural offices. In this form, the program operated at every level, from the National Ministry to the villages. Each year, the CNISP chose counties that were ready for intensive efforts. BEPE established a written agreement with each county in terms of times, ICS performance, and number of houses covered. After some years of operation, the program added two additional conditions: first, that the user pay 50 percent of the ICS value, and second, that the stove needed to be in use at least for three years after the installation. Each province advised BEPE of candidate counties for pilots and organized the inspection (organized teams conducted the monitoring and evaluation) to assess whether the contract had been fulfilled. The teams making on-the-spot examinations regularly offered help when needed. Counties promoted the adoption of ICS in different ways; for example, some counties chose to allow only houses with an ICS to buy fuelwood at a preferential price. BEPE gave awards for counties that met the checking criteria or for a craftsperson that took a training course for ICS construction. In other cases, special tax treatment was provided to ICS enterprises. The supply chain was reinforced by 1,000 rural energy companies working in the country. These companies received loans from the government to start up operations. The direct cost of stove materials and construction (more than 80 percent of total cost) was paid for by households. R&D was conducted at national, provincial, and county levels. The Government also organized competitions to help promote and improve the ICS.

CASE 4. THE UGANDA (UGASTOVE) COOKSTOVE CARBON FINANCE PROJECT

The carbon offset company Climate Care (now part of JP Morgan) implemented the first cookstove carbon finance project registered under the Gold Standard in Uganda, successfully scaling up local companies to manufacture, distribute, and monitor stoves. Approximately 40,000 stoves were sold between 2006 and 2009. New methodologies allowed for statistical sampling in order to verify emissions reductions (Harvey 2009). Kuteesa et al. (2009) explains that the project was rapidly scaled-up from a family-sized business to a commercial operation using carbon finance through a partnership between the company, international financiers, and Carbon Impact in Berkeley. Several stove types have been developed by the Uganda-based company Ugastove: charcoal stoves for domestic use, priced at US$11; an improved fuel-efficient, residential woodstove, priced at US$15; and a fuel-efficient, institutional wood stove. The new stoves reduced CO_2 emissions by 54 percent and maintained, on average, 94 percent and 86 percent continued use over one and two years respectively, according to project developers. Ugastove became Uganda's leading supplier of ICS technology in 2009, with significant increases in sales in 2008-9. Key to the scale up was the addition of carbon finance that constitutes a subsidy of 54 percent toward the costs of production and, as a result, lowers retail price to below the costs of production. The company notes that the demand is high, but it is the input of carbon financing that brings stove dissemination up to a scale. In addition to the indoor health benefits, the training of artisans has also improved employment opportunities alongside stove marketing, production, and dissemination (Kuteesa et al. 2009; Climate Care 2009).

Source: Climate Care, 2009. *Uganda efficient stoves: project map: Carbon Projects: Reducing Emissions: Low carbon technologies: Climate Care.*

Harvey, A 2009, Project design document form (GS-VER-PDD): *Efficient Cooking Stoves in Uganda. The Gold Standard.*

Simon, G.L., Bumpus, A.G., Mann, P. 2012. *Win-Win Scenarios at the Climate-Development Interface: Challenges and Opportunities for Cookstove Replacement Programs through Carbon Finance*

ANNEX IV

Carbon Finance and Cookstoves

Since the emergence of the Kyoto Protocol, climate market finance has been an important catalyst for low-carbon investment in developing countries. By enhancing the overall financial viability of low-carbon projects in low-income countries, it can leverage other resources and catalyze a shift of large financial and investment flows. In this context, climate finance can help to improve the viability of cookstove projects by helping to overcome financial or other barriers to investment. Types of climate finance include:

- Crediting mechanisms—whereby revenues are sourced from the sale of carbon credits. Eligible mechanisms for cookstoves include:
  - Clean Development Mechanism (CDM) if part of the biomass is non-renewable. The CDM also offers methodologies for cookstove projects that incorporate switching from fossil fuels, including reduction in use of non-renewable biomass, and fuel switching to 100 percent renewable energy supplies;
  - Voluntary carbon market (such as the Gold Standard or Voluntary Carbon Standard), which use either their own or CDM methodologies.
- New market mechanisms and instruments. This may be in the form of:
  - Pilot programs to assess the technical performance and market viability of high-tech cookstoves that deliver the best local (health) and global (climate) benefits;

– Technical assistance and funding to support cookstove entrepreneurs and manufacturers to foster the quality and quantity of cookstoves in the market and lower costs;
– Policy support to country governments to create enabling policy environments and direct public-sector resources to the problems that cookstoves can address.

This document outlines how these mechanisms can contribute to the financial viability of cookstove projects and quantifies the value of finance under the CDM given it currently generates the principal share of north-south carbon finance transfer.

CREDITING MECHANISMS

The CDM

The international primary carbon offset market under the Kyoto Protocol's CDM generates the principal share of north-south carbon finance transfer. In 2010, the primary CDM market was valued at US $1.5 billion.[24] Although cookstove projects account for an extremely small percentage of carbon reductions this percentage has grown rapidly. Projects and programs targeting improved cookstoves and reduction of non-renewable biomass can apply for four methodologies approved under the CDM: (i) AMS-I.C, now under version 18; (ii) AMSI. E, now under version 3; (iii) AMS-II.G, initially approved in February 2008 and revised in December 2009; and (iv) AMS-I.I, approved in February 2011. The most common cookstove methodology used to date is that of AMS IIG (see Table 13).

CDM projects may be developed on a project by project basis or under a programmatic approach. The programmatic CDM approach was introduced in 2007 to help overcome high transaction costs and complex organizational requirements for smaller projects, such as cooking stove activities. A POA is a set of individual small projects (CDM Programme Activities—CPA), which are comparable to individual small-scale CDM projects. CPAs may be realized in different locations and/or timeframes within the geographical and temporal boundaries of the POA. Adding up emission reductions from several CPAs, POAs can achieve much larger total emission reduction amounts than an individual CDM small-scale project.

The outlook for the CDM beyond 2012 is complex, particularly for projects registered post-2012 and in non-LDC countries given the EU Phase 3

24. World Bank, State and Trends of the Carbon Market 2011. Note that this is nearly a 50 percent reduction from the previous year.

TABLE 13. CDM AMS IIG Methodology

CDM AMS II G	
Available for	CDM, voluntary market
Scale	Small-scale (project activities up to 180 GWh total annual energy savings)
Assessment of baseline	Fossil fuel scenario
Eligible GHG reductions	Only CO_2 during combustion
Monitoring	Annual check of leakage factors, efficiency of all appliances in use, us-age of stoves, amount of biomass saved.
Time	Crediting only possible from date of registration

Directive to only accept CERs under these conditions. As a result, market participants are looking to the voluntary carbon market and new mechanisms as an alternative source of financing.

VOLUNTARY CARBON MARKET

The Over-the-Counter voluntary carbon market was valued at US $393.50 million in 2010, of which US $134.80 million is attributed to the Voluntary Carbon Standard and US $54.7 million is attributed to the Gold Standard.[25] The Gold Standard methodology for cookstove projects (AMS-II.G V.02) allows for the inclusion of upstream emissions reductions from charcoal production, as well as CH_4 and N_2O emissions reductions, which the CDM does not. The AMS-II.G V.02 is the most suitable and feasible methodologies for a stove project that reduces non-renewable biomass consumption. Its accounting, monitoring, and verification requirements are somewhat more onerous than the CDM methodology, which count only the carbon mitigated. Table 14 provides detail of this methodology.

TABLE 14. Gold Standard V.02 Methodology

Gold Standard V.02 methodology	
Available for	Voluntary market
Scale	Large-scale, no restrictions in project scope
Assessment of baseline	Real conditions
Eligible GHG reductions	CO_2, CH_4 and N_2O during combustion and fuel production
Monitoring Kitchen Surveys	As for AMS II.G plus biennial check of NRB and quarterly
Time	Pre-crediting of up to 2 years possible

25. Bank, State and Trends of the Carbon Market 2011

Whilst the scale of the voluntary market is dwarfed by compliance markets, the market experience it provides may lead to new and expanded methodologies for improved cookstoves under both the CDM and new market mechanisms.

NEW MARKET MECHANISMS

The form and scope of new carbon market mechanisms is still being negotiated at the UNFCCC level, however, much progress has been made at an operational level in terms of helping countries to identify suitable instruments to scale up mitigation efforts in line with their climate change mitigation goals and development objectives. Examples of funding sources include the World Bank's recently launched Carbon Initiative for Development (Ci-Dev).

CARBON INITIATIVE FOR DEVELOPMENT (CI-DEV)

The Carbon Initiative for Development (Ci-Dev), aims at helping low-income countries create sustainable access to financing for low-carbon investments through carbon markets. This initiative has three components:

- A **Readiness Fund** to support carbon capacity building, knowledge development and advocacy work for improving carbon market mechanisms, asset creation, and developing innovative approaches to leveraging carbon finance. This fund will be supported by donors and may be able to provide finance for technical assistance to support cookstove entrepreneurs and manufacturers to foster the quality and quantity of cookstoves in the market. It may also provide policy support to country governments to create enabling policy environments and direct public-sector resources to the problems that cookstoves can address;
- A **Financing Fund** to support early stage project financing by allowing the use of innovative carbon finance mechanisms. Front-loading of carbon revenues will be among the key objectives. Relying initially on donor resources given the high risks involved, this facility has the potential to be self-sustaining. In this way, the Financing Fund may provide support for pilot programs that explore the technical performance and market viability of high-tech cookstoves;
- A **Carbon Fund** to support carbon finance transactions. Buyers will provide resources for carbon asset creation in exchange for a right of first

refusal to sign an Emissions Reduction Purchase Agreement (ERPA) forward contract once the project reaches validation. The Carbon Fund will initially target certified emission reductions through the CDM in LDCs. It will broaden its geographical reach over time, as new market mechanisms appear and become eligible for compliance markets. Sellers will benefit from a long-term purchase agreements and a flexible pricing formula which gives them access to possible market upside. Buyers will benefit from a wide flexibility in selecting the projects from which they wish to buy and certainty on the cost of asset creation.

ANNEX V

Performance Tests: How Are the Central American ICS Different?

Improved stoves in Central America differ from ICS disseminated in Africa and Asia in some important aspects:

- They are larger in size and have a bigger combustion chamber.
- They have a *plancha* or *comal* made of metal sheet to make tortillas.
- Most of the ICS models allow for cooking multiple dishes at the same time with a single combustion chamber.
- With a *plancha,* ICS in Central America can conserve the residual heat which can be used to keep food warm, warm water for a bath, reheat a meal, dry wet fuelwood, etc.

In some models pots are placed over the *plancha* (see Figure 11) with no direct contact with fire. This means that to heat the pot, it is necessary to heat the *plancha* first, leading to heat loss in the process and lower thermal efficiency. Some models have rings that can be removed from the *plancha* (see Figure 12) allowing one or two pots to be in direct contact with the fire. In these models, there is no heat loss caused by transferring heat to pots indirectly through the *plancha,* but it is necessary to heat a large combustion chamber.

One of the most common methods to measure the stove efficiency is a water boiling test. WBT measures how much fuelwood and time is needed to bring 5 liters of water to boiling point and simmer for a certain time period. WBT was designed for stoves with one burner, such as bucket stoves (see figure 13), where the pot is generally in direct contact with the flame and there is a slot for one pot only. For an ICS with a *plancha,* the fuel and time needed will increase due to the larger combustion chamber and, for some models with a *plancha,* the heat loss due to the transmission from fire to *plancha* and then to pot. In this regard, more appropriate tests are needed to accurately measure the performance of ICS with a *plancha* in Central America. We suggest the following measurements based on popular ICS design and their common uses in the region:

- Amount of time and fuelwood needed to prepare 3 kg. of tortillas
- Amount of time and fuelwood needed to cook 1 kg. of beans, 1 kg. of rice, and to boil 5 liters of water.
- Homogeneous transmission of heat to the entire surface of the *plancha*. This is important to prepare tortillas.

FIGURE 12. Copan Stove

Source: Authors

FIGURE 13. Noya Stove with Removable Rings in the *Plancha* Stove

Source: Authors

FIGURE 14. Envirofit Stove

Photo: www.envirofit.com

ANNEX VI

Data Collection and Research Priorities for Central America

1. Incorporate household energy uses in the regular nationwide household surveys. It is cost effective yet lacking in most countries. Guatemala's Household survey data on household energy uses that has been most rigorously studied.

2. Improve, update, and harmonize the existing information on woodfuel use and ICS programs in CA. This includes launching a series of country studies about the extent, trends, markets, and prices of fuelwood and their policy context, building on existing efforts by OLADE, ECLAC, and other organizations. More emphasis should be placed on understanding fuel-stacking patterns (i.e. the combined use of cooking devices), cooking practices, and other end-uses served by open fires. Gender issues should also be studied in a similar regard. Country studies should also identify priority areas for cookstove interventions at the municipality (county) level based on environmental (impact of fuelwood harvesting on deforestation and degradation, net emissions of GHG associated with fuelwood use), social (number of users, expected growth rates, resilience of fuelwood use patterns), and economic criteria. Ghilardi et al. (2009) provides a contextual example of the type of study suggested for Mexico.

3. Conduct an independent field evaluation of existing ICS programs to assess the actual use, fuel savings, IAP reductions, acceptance levels, adaptation to local practices, durability, costs, and other relevant parameters related to existing cookstove programs. The most salient ICS programs in each country should be studied. Also, a thorough market

study needs to be conducted to identify the proper niches for different types of stoves and programs, to identify user's willingness to pay for the new stoves, and to segment potential ICS customers according to their specific circumstances (urban-rural; fuelwood accessibility, income brackets; cultural practices and gender aspects; experience with alternative fuels such as LPG; etc.).

4. Exposure measurement: Is there a measurable reduction in exposure to air pollutants from cookstove use?
5. Further work on economic and the related household energy policy: Is it really worth subsidizing, or will the market become robust on its own?
6. Within country regional variation between urban, peri-urban, and different rural regions: Is the opportunity cost the same or different? Might one region be facing either higher risk exposure or greater deforestation pressure?
7. Peri-urban market: Should it serve as the focus for shifting to LPG?

ANNEX VII

Glossary of Spanish Terms

Atole: Hot beverage prepared with corn flour. It can be mixed with chocolate, cinnamon, or vanilla to give it flavor.

Chicheme: Typical Panamanian beverage prepared with corn flour and milk. It differs from "atole" in that the corn is not well ground.

Comal: Similar to the *plancha* but circular and thinner. It does not have removable discs.

Guacho: Panamanian dish. Rice prepared with beans, yucca, and pork meat.

Guisado: Dish prepared with meat (can be chicken, cow, or pork) in a thickened sauce.

Nacatamales. Tamales made with corn flour and pork fat usually filled with pork meat.

Nixtamal: Mixture prepared with ground corn that has been left overnight in water with limestone.

Plancha: Large square or rectangular flat-iron griddle that is placed on top of a U-shaped fire and can accommodate several pots. In Guatemala and Nicaragua, it usually comes with one set of removable discs so people can place pots of diverse size directly on open flame.

Pupusa: Similar to a tortilla but thicker.

Tarea: Standard unit of measure for fuelwood used throughout CA. Usually, it is the amount of fuelwood a mule can carry.

Tortilla: Round flat thin bread prepared with nixtamal.

ANNEX VIII

Selected Definitions Related to Biomass Cookstoves

The 20th Century mindset on wood as cooking energy had been fixated on saving renewable biomass, an example of high theory married to environmental goals of distant and ill-informed elite. This fixation was largely technology-driven and product-focused, with a limited and static view of the users and the supply chains of fuels and services. While some portions of the cooking market do remain in the 21th Century, the emerging realities of the 21st Century—reflected in demographics, infrastructure, preferences, priorities, affordability, and technological changes in materials, controls, communication and logistics—call for a user-centric objective—say, "clean and convenient" cooking—and a consideration of the market in the context of all fuels, users, technologies, and end-uses. This note proposes that (i) "improved (wood) cookstoves" (ICS) or "advanced (wood) stoves" be treated as legacy terms that should now be dispensed with as far as newer stove designs are concerned; and (ii) building on recent and ongoing work on technical standards and market research, product development and marketing of newer types of stoves should be sharply distinguished as "modern" versus "conventional" types, with additional, less sharp distinctions and ratings reflecting user preferences and geographic variations. Use of the general term "biomass energy"—without regard to fuel quality, form, reliability, and use features should also be discontinued, replaced with specific labeling of fuel type. It is hoped that a user-centric objective and definition would encourage greater diversity in RD&D activities in wood energy for cooking.

STOVES USING WOOD FOR COOKING

The Webster's offers two definitions under "stove":

A: *a portable or fixed apparatus that burns fuel or uses electricity to provide heat (as for cooking or heating); and,*

B: a device that generates heat for special purposes (as for heating tools or heating air for a hot blast).

For the purposes of this note, definition A is adequate.

Stoves and fuels typically go together, and many stoves are restricted to just one kind of use—space heating, water-heating, beverage-making, cooking, re-heating of foods, so on.

Also, it is implicitly assumed that a stove is used repeatedly and for varying length of time. That is, a stove has a location—a home, a shed, a shop, a factory. A so-called "three-stone fire" is not a stove if it is used only once. Depending on the region, fuel availability, and affordability, people use more than one type of stoves. Historically, changes in shelter types and location have heavily influenced the types and uses of stoves. Many poor people lack a reliable, long-term shelter and thus do not have stoves or have stoves for limited purposes.

This leads to a general definition of a *wood cookstove is a stove that uses wood as the fuel and which is enough for at least cooking food.* (The term stove itself being defined as in Webster (A) above.) Wood cookstoves can generally be used for a variety of ways; for simplicity, this note neglects their use for space heating which implies unique patterns of fuel supply and use, emissions, and ash disposal.

Wood cookstoves in turn are found in different forms and made of different materials and use wood of different types, sizes, and chemical qualities. Some wood cookstoves can be used only with specific types and sizes of woods and specific types of cooking (e.g. baking or grilling).

Wood cookstoves can be further classified in many additional ways—size, market segment, principal use. Table A shows a general typology of stoves that can be applied to stoves for many fuels including wood. As urbanization proceeds, rural-urban transport and communication links become more extensive, networks for electricity and liquid/gaseous cooking fuels go deeper in the countryside and down the income groups, and housing stock modernizes, it is no longer tenable to limit the focus of cooking energy to wood, whether just households or just to rural areas. It is simply delusional to want to market 19th Century fuels and devices to 21st Century customers, especially shutting eyes to competing fuels and devices (and the option of purchase of processed foods and meals).

TABLE 15. A Typology of Stoves (can be applied to any fuel type)

Market segment	Home/small commercial; Event/medium commercial; Large commercial, industrial, institutional.
Size	# of burners, heat rate (GJ per hour max/min), longest continuous run
User's position	Standing, sitting, either, both
Portability	Stationary/portable/semi-portable
Materials	Metal (which?), Brick, Mud, cement, ceramic
Dedicated use?	E.g., water heating, tea samovar, injera-making, animal feed, beer, crop/produce drying
Production	Factory/artisanal
Quality control	Public, manufacturer, none
Delivery chain	Retail stores, on-site construction,
(Other elements to be added as desired)	

Note: Apart from woods of different physical or chemical properties, solid biomass fuels include charcoal, dedicated energy crops, agro-wastes, and animal wastes; other solid fuels include coals of different types and peat. Liquid fuels include bioliquids (alcohols, oils) and their derivatives (gels) and fossil liquids such as kerosene and in principle some other hydrocarbons. Gaseous fuels include biogas (from agro/animal/human wastes), liquefied petroleum gases (propane and butanes) in storage tanks, and piped natural gas. Electricity of whatever origin and direct solar heat as well as via some heat transfer fluid are additional, multi-purpose energy options.

IMPROVED WOOD COOKSTOVES

It appears that artisans and engineers have long tinkered with wood cookstoves to improve their performance and/or sales appeal. This was perhaps more so after during the 19th Century, as newer materials became available, combustion science was better understood (for wood or coal), and new uses developed in homes as well as commercial, industrial enterprises. By mid-20th Century, however, solid fuel use in cooking and heating had sharply declined in Europe and North America, and persisted mostly in the developing regions of Latin America, Asia, and Africa. These were also the regions that were slowly catching up in population growth and urbanization, and networks of modern energy were expanding even more slowly.

Among these countries, direct use of coal use seems to have been limited mostly to colder regions with coal availability, i.e., for cooking as well as heating. Wood use, by contrast, continued more in the middle latitudes and/or the plains where coal was not as abundant.[26] The "improved stoves" movement in these countries started during the 1950s to the 1970s. Its approach typically focused on a single fuel type (woody biomass) for a single user (principal cook in a family) for a single market segment (rural households),[27] and generally a simple, undifferentiated view of "cooking"—a hypothetical meal, 2–3 times a day plus perhaps making hot beverages.

26. Only a few countries in Asia, Africa and Latin America have a) long and severe enough winters to demand extensive space heating and b) abundance of coal as well as wood.
27. Some projects also covered charcoal cooking in urban areas and coal cooking and heating in some parts of the world.

The movement's main objective was to improve combustion efficiencies—measured in wood taken to boil specified amount of water, and, via such improvements, hopefully protect tree cover and possibly reduce the time spent on wood collection. These interventions often generally assumed no access to grid electricity or modern liquid or gaseous fuels (or that such access and use were prohibitively expensive). They were also, for the most part, based on "projects"—financed heavily by grants, covering high overhead costs, and fuelled by technological rigor and unbounded idealism to protect the environment—saving the trees. Some projects took on the complementary challenge of growing more trees. In short, trees in some form or shape provided the raison- d'être for "improved stoves" projects.

Improved wood cookstoves *can therefore generally be defined as stoves that offer higher efficiency of wood combustion compared to some baseline.* Since the baselines differed from place to place—and in most instances consisted of open "three-stone fire" which is not a stove at all in the first place—practically any stove could be taken as an "improved" stove. Once that, or any other proper "stove" was used as a baseline, another "improved" stove would emerge. What is more, these efficiency measures were typically only in controlled laboratory conditions and without much regard for efficiencies under the actual conditions of use and varieties of wood or cuisine or weather, practically no systematic long-term record of which has been available in any country.

That is, in effect, the term "improved wood cookstoves" is meaningless and beyond definition. At best, we had a design of an "improved stove" in reference to some arbitrary baseline, and all it took for that design to get this designation is for some experts to collectively agree.

Fortunately, it seems to have not mattered much that "improved stoves" cannot be defined meaningfully. In the absence of systematic testing and record-keeping, it is not possible to state how many users bought any particular kind of "improved stove" and used it for how long to achieve what gains. The fuel reductions may have been entirely gratuitous from the users' perspective.

Towards the end of the 20th Century the promoters and the financiers began to recognize that such "improved woodstoves" projects were rarely successful in terms of mass adoption and sustained use. Saving wood or reduced exposure to smoke– in most cases available for free—or time—by children who did not spend that much time in schools and adults who did not have round-the-year employment of fixed hours a day—did not seem to be a high priority. This too may not have mattered, since the assumed linear causal link between continued dependence on wood use as fuel (accentuated by population growth and consumption growth) and loss of forest cover seems to have been purely conjectural. Whether or not the "improved woodstoves" saved any trees, it did not matter, since forest cover largely grew or declined as a result of unrelated influences. Some "improved wood cookstoves" did use chimneys—a ventilation method known to humanity from the cave days—but primarily as a means to improve air flow for higher combustion efficiency, not knowingly for the purpose of reduction of exposures to air pollution.

ADVANCED OR CLEAN WOOD COOKSTOVES

Around the turn of the Century, greater awareness of several decades of research on household air pollution—from incomplete combustion of wood and other solid biomass (agro/animal wastes), frequently escaping outside of homes—provided another impetus for the "improved stoves" movement. Rather than aiming at greater—but middling—combustion efficiency of wood, some promoters aimed at a significantly higher range. The "baseline" was no longer the "three stone fire" or some artisanal design based on historical practices without specific consideration of efficiency (or, optimizing such considerations against other considerations not necessarily known and measured). Rather, if the baseline was for example 20–25 percent efficiency, these newer stoves sought efficiency levels that were closer to theoretically achievable highs subject to other design considerations such as the size of the firebox, desired heat rates, and the like. It isrecognized that while greater efficiency need not translate into lower pollution, some designs could push the envelope in both directions.

Noble intents or ambitions, however, need not translate into more rigorous definitions or approaches. **Advanced wood cookstoves** can also be defined essentially in the same way as improved wood cookstoves—stoves that offer higher efficiency of wood combustion compared to some baseline, albeit presumably a higher one.[28] Even as some **advanced wood cookstoves** programs seek to pursue low emissions, i.e., **clean wood cook-**

26. See for example, C. Venkataraman, A.D. Sagar, G. Habib, N. Lam, K.R. Smith, ***The Indian National Initiative for Advanced Biomass Cookstoves: The benefits of clean combustion.*** Energy for Sustainable Development 14 (2010) 63-72. The paper does not define "advanced combustion" or "advanced stove" or "advanced biomass stove", effectively saying, "If you need to ask, we don't need to tell you and you don't deserve to know." It asserts "Given the combined goals of fuel efficiency, health protection, low climate impacts, and reduction of outdoor pollution it is now realized that the best approach is to move toward high-combustion-efficiency and low-emissions advanced-combustion devices that do not produce any significant pollution in the first place." Whether this is "best" from a user's perspective to the extent that such devices would be used in a sustained manner does not seem to be the experts' concern. The intellectual dead wood of 20th Century could be among the reasons three times as many people depend on 19th Century fuels and technologies today than did at the end of 19th Century.

stoves, they are hampered in these efforts due to lack of technical standards and testing protocols.

The core issue is that promoters of "improved" or "advanced" wood cookstoves ultimately run into the same bind—theirs is primarily a technology-driven perspective rather than a consumer-driven one, and even as they seek to produce "clean" cookstoves, such "clean" cookstoves so far exist on paper and in laboratories. This problem cannot be mitigated until and unless users accept the stoves and a field test of sufficient length and duration be obtained to confirm the "cleanness" of the stove.

MODERN WOOD COOKSTOVES

If the strictly technical approach to marketable clean cookstoves has a bit of a Catch-22 problem, one alternative is to dispense with such restrictive approaches. Instead, user acceptability and perceived benefits could be made central to stove design and promotion efforts. The primary focus is then on cleanliness and convenience as seen by the user. In a way this means respecting users' subjective assessments; this is not prima facie inferior to respecting experts' subjective assessments if only wrapped in dense theories and complex equipment and models. Users' subjective assessments need not be the sole determinant of cleanliness, nor should expert-selected tools and dose-response relationships, but some combination of expert-assisted technical standards as incorporated in designs and tested in actual performance. In other words, stoves that pass some technical threshold arrived at by expert consensus, should be marketed as clean; if they also happen to convey a sense of convenience and greater comfort, security and confidence, larger number of users will be able to confirm that sense.

This emphasis on "clean and convenient" is conveyed in a broader context of alleviation of energy poverty, atransition from traditional to modern energy. It is based on the observed trends in purchases of cooking fuels and appliances—including shifts toward purchase of prepared foods and meals (in other words an "outsourcing of the home kitchen").[29] It also recognizes that the introduction of electricity can change a kitchen—within the home, by offering more convenient means of thermal energy (water kettles, water heaters, toasters) or means of storage (refrigeration) and without, by taking away the drudgerous, mechanical work of kitchens to retailers or fee-for-service providers (e.g., flour milling).

29. There can be some "in-sourcing" or "reverse sourcing" too, e.g., making things at home one bought from outside or once used to make at home but had been buying from outside.

"Clean combustion" is not just a matter of fuels or appliances alone but the two together plus operating practices. Solid fuels can be burnt cleanly and conveniently; conversely, combustion of liquid or gaseous fuels may also be unclean. The Human Development Report of the UNDP does not recognize this, and treats solid fuel dependence per se as an indicator of deprivation (in its computation of the Multi-dimensional Poverty Index). Similarly, draft documents of the Sustainable Energy for All initiative treat solid fuel use as undesirable. This perception has to change if the more recent 21st Century designs of "advanced" woodstoves are to be marketed as clean and convenient, viable alternatives to fossil fuels or electricity.

As a beginning, it is proposed that wood cookstoves of recent and future designs be

i) classified according to principal market segment, fuel type, principal or dedicated use, and mode of production and delivery and

ii) further designated as "modern" or "conventional" according to certain technical characteristics as well as user preferences for convenience and versatility.

The latter distinction is absolute—a stove is modern or conventional, but more so or less so depending on minimum or maximum scores on technical performance (on cleanliness, subject to test protocols and standards that take into account variations in fuel quality, cuisine types, amount of cooking, food materials and seasonal influences)

As a beginning, Tier 3 or Tiers 2 and 3 as proposed in the Lima Consensus[30] (February 2011) could be so defined as to meet as many indicators of "modernity" in Table 2 as possible with the remainder Tiers assigned to the "Conventional". Simple "Yes/No" in terms of attributes and technical thresholds in terms of emissions and safety should permit such distinction. It may well happen that some stoves designated "conventional" may meet some technical standards of cleanliness and safety as for the "modern" label; this only indicates that, for a given universe of customers and uses, it is a "clean" stove but not convenient enough.

30. Lima Consensus on Stove Performance Rating. 2011 PCIA Forum, Lima. http://www.pciaonline.org/testing/lima-consensus

TABLE 16. Toward an Index of Modernity for Wood-based Cooking?[31]

	Attributes of modernity	
	Modern	**Conventional**
Fuel	Biogas, liquid biofuel (alcohol, oil), charcoal, solid wood, agro/animal wastes.	charcoal, solid wood, agro/animal wastes
Fuel form (solid)	Processed, uniform consistency (briquettes, pellets, chips, bricks)	Unprocessed
Fuel quality	"Small" variation in specs	No specs
Combustion airflow		
Gasifier?	Yes/no	No
Combustion fan?	Yes/no	No
Exhaust fan?	Yes/no	No
Performance standards		
Cleanliness (emission rates)		
PM 2.5	Maximum	Higher maximum
Ultra-fine particles	Maximum	Higher maximum
CO	Maximum	Higher Maximum
CO_2	No limit; only a reference value	
Methane	Maximum	Higher Maximum
NMVOC	Maximum	Higher Maximum
Safety		
(TO ADD TESTS); See Lima Consensus for example		
Principal user preferences/operating practices		
Convenience		
Heat rate (KJ/hr)	Max, min	Lower max, higher min
Flame control	Control knobs?	None
Start/stop time	Max	None
Ash volume/storage	Dedicated space	No dedicated space
Fuel delivery/ash pickup	Yes/no	No
Versatility/Use rate (hours per month)	(Depending on local habits and preferences)	
Suitability for multi-storeyed apartments?	Yes	Immaterial
Suitable for "slums"?	Yes	Immaterial
Pot size/type	High heat transfer efficiency	Immaterial
Pressure cookers?	Yes	No
Grilling/baking	Yes/No	Immaterial

31. Includes beverage-making, baking, grilling, water heating but excludes space heating.

ANNEX IX

Survey Analysis

In February 2011, a survey[32] was sent via email to 123 persons working on ICS projects in CA and Mexico.[33] 38 people answered the survey questionnaire. After reviewing the questionnaires for complete and consistent responses by people with working experience in CA and Mexico, we were left with 28 valid responses.

TABLE 17. Who Answered the Survey?

COUNTRY	RESPONDERS
Costa Rica	Proyecto Finca
El Salvador	Stove Team, Inversiones Falcón, Asociación Árboles y Agua para el Pueblo and Universidad Centroaméricana
Guatemala	Ecocomal S.A., ADIKAN, Fundación Raxche, Fundación Manos de amor, Ecologic, HELPS International, Ideas para Guatemala, Cometra, Hombres y Mujeres en Acción, a student from Berkeley University doing her thesis in Guatemala and Fundación Solar
Honduras	ADHESA, Universidad el Zamorano, Proyecto Mirador y EnDev-Honduras GIZ
Nicaragua	Proleña (2) and Universidad Nicaragüense
Panama	Proverdes
Mexico	UNAM and Foro para el Desarrollo Sustentable
Central America	BUN-CA and Trees, Water and People

32. The survey questionnaire is attached at the end of this annex.
33. Mexico was kept in the analysis because of the similarities in cooking customs and technologies with the rest of CA countries.

RESULTS

The survey was answered by 18 people working in foundations or NGOs, 4 people working in enterprises, 5 people working or studying universities, and one from an international agency.

According to those that completed the questionnaire, fuelwood is the main cooking fuel in the region, followed by LPG, Kerosene, and electricity (mainly in Costa Rica).

The main dishes cooked in the region are tortillas, beans, rice, eggs, fried bananas, vegetables, chicken, fish, meat, and bread. The importance of each one varies in every region and has to do with the availability and affordability of some products.

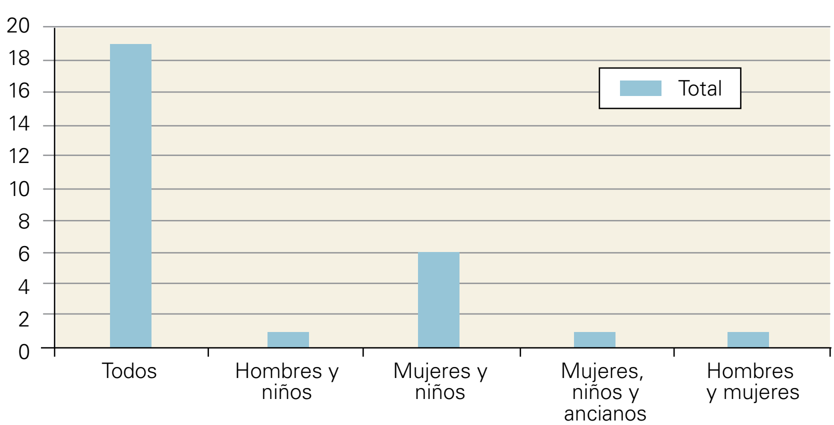
Besides cooking, the traditional stove is used to keep the house warm; to dry cloths, fuelwood, and food; to drive away insects; to protect the roof; to heat water (for drinking and for bathing); to light the house; to smoke food; and as a gathering place.

The traditional stove is often located inside the house or in a special room made for the sole purpose of housing the stove. This is true even in tropical regions.

Fuelwood users can be divided into urban and rural populations. Urban users mostly buy fuelwood. Prices vary widely, but even in countries with limited forest resources such as El Salvador, cooking with fuelwood is cheaper than cooking with LPG (without subsidies).

Rural users mostly gather their own fuelwood, but fuelwood is scarce in certain areas. Because of this, some people resort to gathering fuelwood from private properties, which creates additional problems, such as the risk of getting caught. Rural users spend an average of 10 hours per week gath-

FIGURE 15. Who Collects the Fuelwood?



Todos: evererybody, *Hombres:* men, *Mujeres:* women, *Niños:* children, *Ancianos:* elderly ering fuelwood, but this variable differs from region to region. In CA, fuelwood collection is a family responsibility, and most stakeholders answered that everybody in the family is involved in this activity.

IMPLEMENTATION PROGRAMS

The ICS models implemented by the different stakeholders are shown in table 1.

Some stakeholders have participated in the implementation of more than one model.

Half of the programs reported in the survey distributed less than 1,000 ICS.

The cost of the stoves implemented by the different stakeholders varies from US$25 to US$250. Users paid less than 30 percent of the stove value in more than 60 percent of the programs, with 20 percent of stoves given for free.

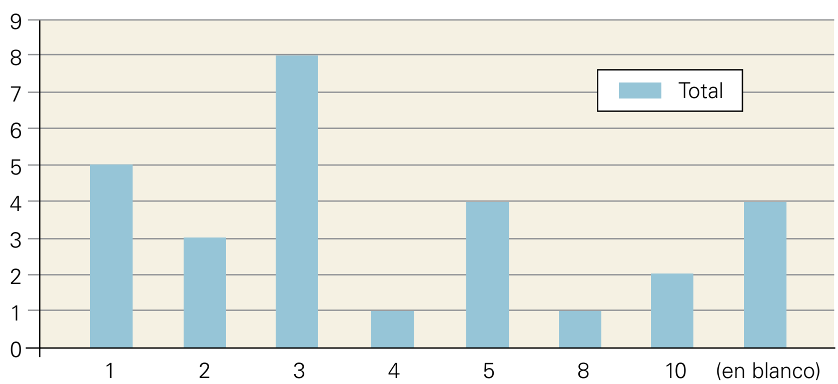
The stakeholders acknowledged the mixed use of open fire stoves and the ICS in 90 percent of the cases.

Almost all programs had an awareness-raising campaign component. Half of them were directed only to women. 22 programs included follow-up visits for the installed ICS, visiting the stoves between 1 and 10 times:

TABLE 18. ICS Models Disseminated

ICS MODEL	Justa	Justa 2X3	ECOCINA	ECOFOGÓN	Onil	CETA	CHULA	ROCKET	LORENA	PLANCHA	OTRA
# PROGRAMS	6	2	2	6	6	4	2	3	1	1	8

FIGURE 16. Frequency of Follow-up Visits for Each ICS Installed



The responses given to the question: **Why did you choose that particular ICS model?** (¿Por qué se escogió este diseño de cocina?) are shown in Table 19.

19 categories were created. Stakeholders were allowed to give more than one response.

TABLE 19. Responses to the Question: Why Did You Choose a Particular ICS Model?

Reasons to choose that particular ics model	Frequency
Price	2
Performance: saves fuelwood and reduces iap	13
Fits local cooking customs	3
Reach good temperature	1
Its performance has been certified	1
To try it	2
Because people know it	4
Because it uses local materials	5
Because it is built in situ	3
Because it provides employment	1
Because it is what the users choose	2
Because it is versatile	2
Because it is small	2
Because it is easy to transport	8
It was the best option for urban areas	4
It is easy to install	1
It is easy to build	1
Because it has a *plancha*	1
Because it is easy to maintain	1

These responses can be divided by:

Social reasons: 11 answers

Technological reasons 21 answers

Practical reasons 25 answers

The responses given to the question: **What problems have you had with the dissemination of this technology?** (Qué problemas ha tenido con la difusión de esta tecnología? are in Table 20.

18 categories were created. Stakeholders were allowed to give more than one response.

TABLE 20. Responses to the Question: What Problems Have You Had with the Dissemination of This Technology?

Problems faced during the dissemination of the ICS	Frequency
None	3
ICS is difficult to light when cold	1
ICS cannot cook some dishes	1
Program needed more follow up than given	3
Low ICS quality control (in situ models)	3
ICS needs small pieces of fuelwood	1
User can not control fire	2
User is not use to the ICS	7
Need of a more effective awarness raicing campaing	6
Low motivation	3
Price	5
Low adoption	1
ICS model required too much follow up	2
Difficult transportation (industrial models)	2
ICS were given for free	1
Low maintenance given by users	3
User wants a bigger flame	3
Unavailability of local materials	3

These responses can be divided by:

Problems with the technology: 11 answers

Problems with the implementation: 16 answers

Problems related with the user: 15 answers

Economic problems: 5 answers

The responses given to the question: **What factors influence the adoption of an ICS?** (¿Qué factores cree que influyen en la adopción de una cocina mejorada?) are shown in Table 21.

17 categories were created. Stakeholders were allowed to give more than one response.

TABLE 21. Responses to the Question: What Factors Influence ICS Adoption?

Factors that influence the adoption of an ICS	Frequency
Awareness raising campaign	8
Follow up	4
Appropriate technology	7
Ngo experience in the community	1
Social capital	1
Selection of the first users (early adopters)	1
Users low education level	2
Cultural customs	4
Price	2
Diffusion program (to show an ics working)	2
User age	1
User participation	1
Training	5
The simultaneous use of other fuels	1
The stove performance (that it really saves fuelwood)	3
ICS attractive to the user	3
ICS easy to use	1

These responses can be divided by:

Factors related with the implementation program: 22 answers

Factors related with the technology implemented: 14 answers

Factors related with the user: 9 answers

Economic factors: 2 answers

The responses given to **What have to be done to raise the adoption rates?** (¿Qué cree usted que hace falta hacer para mejorar los niveles de adopción?) are shown in Table 22.

17 categories were created. Stakeholders were allowed to give more than one response.

TABLE 22. Responses to the Question: What Have to be Done to Raise the Adoption Rates?

How to raise the adoption rate	Frequency
Bear in mind the users needs and likes	2
To choose an appropriate technology	1
Consider the men in the awareness raising campaign	1
To invest in an effective awareness raising campaign	10
Monitoring and evaluation of the ICS implemented	5
To control ICS quality	1
To certify the technology	1
To train providers and producers	1
To develop better technologies	2
To develop cheaper technologies	1
Provide subsidies	1
To train the user	4
To provide credits	3
To follow experts recommendations	1
Government involvement	2
Combine ICS with other energy services	1
To show ICS in local markets and fairs	1

These recommendations can be divided by:

Recommendations to improve the technology: 6 answers

Recommendations to improve the program: 26 answers

Recommendations to improve technology access: 6 answers

The responses given to **Recommendations for further ICS implementation programs in the region** (Recomendaciones para futuros programas de implementación de EE en esa región) are shown in Table 23.

23 categories were created. Stakeholders were allowed to give more than one response.

TABLE 23. Recommendations for Future ICS Programs

Recommendations for further ICS implementations in the region	Frequency
Strong awareness raising campaign	12
Good site selection	1
Coordination with government	3
Monitoring and evaluation	11
To consider men in the awareness raising campaing	1
To identify neediest people	1
To identify those with a better chance to adopt an ICS	3
Coordination with ministries of health and energy	1
To hire experts for the promotion campaign	3
To learn from other experiences	3
Mandatory certification of the ICS	2
Training of the user in the maintenance of the ICS	7
Never give ICS for free	2
ICS that fits user's needs	2
To give the user the possibility to choose from different ICS	2
To offer an ICS with more than one entrance	1
Quality control for in situ ICS	1
To keep the open fire out side of the house	1
To choose an ICS model that last longer	1
To carry out the program together with the community	1
To create local employment	1
To try to find a solution for those things that the ICS can not do	1
To document every ICS implementation experience	1

Those recommendations can be divided by:

Recommendations for the implementation program: 44 answers

Recommendations to improve the technologies: 8 answers

Recommendations to coordinate with other institutions: 10 answers

TABLE 24. Cuestionario sobre implementación de cocinas o estufas mejoradas de leña

Favor de responder en los espacios en blanco	
Nombre:	
E-mail:	
Organización o institución en la que trabaja:	
Puesto en esta organización/institución:	
País en el que ha trabajado:	
Regiones donde ha trabajado:	
Por favor conteste las siguientes preguntas para la región en donde tenga experiencia en el uso de leña para cocinar. Si es en más de una región y las diferencias son significativas, conteste un cuestionario por región.	
¿Cómo es el clima en esta región?	
¿Qué combustible utiliza la gente para cocinar en esta región? (puede dar más de una respuesta)	
¿Cuáles son los principales alimentos que se cocinan en esta región?	
¿Qué tan comúnmente utiliza la gente los siguientes tipos de cocina o fogón en esta región para cocinar? (opciones: mucho, poco o nada)	
Fogón de tres piedras	
Fogón tipo U	
Cocina mejorada	
Cocina de gas	
Cocina eléctrica	
Otra (describir)	
¿Qué tan frecuentemente utiliza la gente la cocina o fogón para estas actividades o servicios distintos de cocinar? (opciones: frecuentemente, rara vez, nunca)	
Para calentarse	
Para secar ropa	
Para ahuyentar insectos u otros animales	
Otro (describir)	
¿Qué tan frecuentemente se utiliza el fogón tradicional en los siguientes lugares de la casa? (opciones: frecuentemente, rara vez, nunca)	
Cocina incorporada a la casa	
Cocina separada	
Lugar con techo pero sin paredes (tejabán)	
Al aire libre	
¿Cómo es el acceso a la leña de los habitantes de esta región? ¿Es homogéneo? ¿De qué depende?	
¿De toda la leña que se consume en la región, aproximadamente qué porcentaje se obtiene por recolección, y qué porcentaje se compra?	
De recolección	Comprada
Los que recolectan leña, ¿de dónde la traen? (opciones: frecuentemente, rara vez, nunca)	
Terreno propio	
Terreno ajeno	

Bosque comunitario
Otro (describir)
¿Cree usted que la recolección de leña implica algún tipo de riesgo para el que la recolecta? (explicar):
¿Cuánto calcula usted que gasta mensualmente en promedio una familia en combustible para cocinar (en dólares)?
¿Cuántas horas en promedio emplea cada familia para recolectar la leña que necesita para una semana?
¿Quién hace la recolección? (mujer, hombre, niños, todos)
COCINAS MEJORADAS DE LEÑA
¿Tiene usted experiencia en la implementación de cocinas mejoradas de leña?
¿Qué tipo de cocina mejorada se implementó en esta región?
¿Cuántas cocinas se han entregado?
¿Por qué se escogió este diseño de cocina?
¿Enfrentó algún problema en la implementación de esta tecnología? (¿cuál?)
¿Cuál fue el costo real por cocina implementada, en dólares?
¿Qué porcentaje del costo real de la cocina pagó el beneficiario?
¿Cómo se pagó el resto?
¿Cómo diría usted que fue la adopción de la cocina mejorada? por favor calcule a groso modo el porcentaje de beneficiarias que usted considera para cada una de las siguientes categorías de adopción
MUY BUENA (La cocina se usa diariamente y se encuentra en perfectas condiciones de uso)
BUENA (La cocina se usa muy frecuentemente y se encuentra en buenas condiciones de uso)
REGULAR (Cocina en buenas condiciones pero solo se usa una o dos veces por semana)
MALA (Cocina en mal estado o con modificaciones que alteran su funcionamiento)
MUY MALA (Cocina destruida o sin utilizar)
¿Qué porcentaje de las beneficiarias del programa diría usted que continúa usando su fogón tradicional además de la cocina mejorada?
¿Qué factores cree que influyen en la adopción de una estufa mejorada?
¿Qué cree usted que hace falta para mejorar los niveles de adopción?
PROGRAMA DE IMPLEMENTACIÓN
El programa en el que usted participó ¿contó con una etapa de sensibilización?
¿A quién se le dio esta sensibilización? (a la mujer, al hombre, o a ambos)
¿Qué aspectos incluyó la sensibilización?
El programa en el que usted participó ¿hizo un seguimiento de las cocinas instaladas?
En promedio ¿cuántas visitas se hizo a cada cocina instalada?
¿Qué recomendaciones podría hacer para futuros programas de implementación de cocinas mejoradas en esa región?

MUCHAS GRACIAS

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