THERMAL CONSTRUCTION AND ALTERNATIVE HEATING AND COOKING TECHNOLOGIES
Final Report

Bureau of Applied Research in Anthropology
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Final Report

Prepared for:

José Rodriguez
Edna Mendoza
Arizona Department of Environmental Quality

Tucson, AZ

Prepared by:
Diane Austin
Brian Burke
Krisna Ruette
Jeremy Slack
Ronald H. Villanueva

Bureau of Applied Research in Anthropology
University of Arizona
Tucson, Arizona

With the assistance of:
Paola Canova
Rolando Diaz
Brian Hawkins
Samantha Herr
Thomas Lance
Rudolfo Poe

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EXECUTIVE SUMMARY

The Thermal Construction and Alternative Heating and Cooking Technologies Project was funded by the Arizona Department of Environmental Quality (ADEQ), with support from the U.S. Environmental Protection Agency, to build upon successful collaborative relationships to improve environmental quality in communities located along the US-Mexico border in the cities of Nogales, Arizona and Nogales, Sonora ("Ambos Nogales"). The principal goal of this project was to assess approaches for reducing emissions generated by the use of wood and other combustible materials as fuel for household-level heating and cooking in Nogales, Sonora. To achieve this goal, researchers from the Bureau of Applied Research in Anthropology (BARA) at the University of Arizona undertook assessment, demonstration, education, and training activities in two colonias of Nogales, Sonora over the period from July 1, 2005 through August 20, 2006.

The research team focused on two general approaches to reducing household-level emissions: (1) reducing the *impact* of household-level heating and cooking by promoting the use of less-polluting technologies, and (2) reducing the *need* for household heating by promoting more thermally-efficient home construction technologies. Researchers selected from among the range of already-existing alternative heating, cooking, and construction technologies by considering technical factors (e.g., emissions reductions, ease of construction, possibility of using local materials, availability of necessary fuels, safety, and cost), locally-relevant socio-cultural factors (e.g., aesthetics, extent of necessary behavioral modifications, household labor patterns), and other factors that might affect the future expansion of low-emissions technologies (e.g., potential partners and local financial and human resources) in these communities.

Residents of Nogales consistently expressed interest in more efficient and less-polluting cooking and heating technologies, largely because these technologies also help to save money, but also because of the health benefits associated with improved air quality and reduced exposure to open fires and smoke. During the initial assessment period, the research team decided to focus on heating technologies only in conjunction with cooking stoves because many households used their stoves for both heating and cooking and few had separate devices only for heating. Based on input from interviews, household visits, and focus groups, the research team selected three energy-efficient, low-emissions stove designs: (1) solar ovens, (2) wood gas stoves, and (3) rocket elbow stoves. The latter two burn wood but are designed to do so efficiently and with reduced emissions. After discussing these technologies at introductory workshops and demonstrations, the researchers decided to eliminate the wood gas stoves from this project and to develop a second, portable version of the rocket elbow stoves. They then distributed three types of stoves—solar HotPots, permanent elbow stoves (Estufas Justa), and portable elbow stoves (Eco-Stoves)—to 56 households for testing.

As other studies have shown, it appears unlikely that new stove designs will entirely replace existing stoves. Families in Nogales tend to use a variety of stoves so that they can remain flexible to changes in fuel price and availability, seasonal heating needs, and different cooking needs. Nonetheless, many families consistently used the low-emissions alternatives introduced in this study, demonstrating that technological change at the household level can contribute to reducing air pollution. It will be important to continue to monitor the use of these alternative

stoves to examine seasonal variability in the use of such alternatives. Ideally, future projects will deliver multiple alternative stoves to each household, providing members a range of options for different cooking and heating needs.

To assess whether thermally-efficient construction materials might be widely accepted and might reduce the need for wood burning, the research team conducted interviews with homeowners in Nogales colonias and with other key informants. Factors that were identified as important to residents' decisions about home construction processes and building materials include affordability, availability of materials, ease of construction, ability to construct in phases, security, privacy, and level of fire risk. These considerations guided the team to investigate papercrete (also known as fibrous cement), sandbag technology, and the use of rammed earth and other earthen materials. Participants in introductory workshops and demonstrations were particularly interested in papercrete, a highly-insulative and fire-resistant material that uses recycled paper to create walls that resemble high-status concrete block structures and to construct well-insulated roofs. Researchers therefore led several hands-on papercrete workshops and helped community members develop plans for continuing the investigation of papercrete in Nogales. Though the benefits of alternative housing construction for reducing wood burning are less visible than those of replacing inefficient stoves, they are nevertheless important. Residents and community leaders in Nogales have expressed considerable interest in such technologies, and the process of introducing them to the community should be continued and monitored.

This research differs from many other investigations of appropriate technologies because the participating communities are in an urban setting. The criteria of appropriateness may be different than those developed in rural areas because of different aesthetic considerations, access to a broad range of fuels (wood, garbage, gas, and electricity), different divisions of household responsibilities, and different household employment patterns. This research has revealed, however, that the promotion of alternative technologies can yield environmental, health, and economic benefits for urban households. A future study will be needed to characterize wood burning throughout the city and to determine in which neighborhoods the approaches identified and evaluated in this study will be appropriate.

CHAPTER ONE: BACKGROUND ON THE PROBLEM

Investigations into alternatives to wood burning are not new. The social, economic, and ecological problems accompanying deforestation and wood shortages have led to a proliferation of efficient alternatives to standard wood-burning technologies. Rising concern with the health effects of poor indoor air quality has accelerated the search for low-emissions alternatives. In many parts of the world, such studies have focused on rural communities (see Masera, Diaz, and Berrueta, 2005; Zuk et al., 2006). While many Nogales, Sonora households share characteristics of their rural counterparts across Mexico where wood is commonly burned for heating and cooking, many differences are also apparent. This study is fairly unique in its focus on an urban community, especially one located on the U.S.-Mexico border where large quantities of wood and other combustible waste and scrap materials are available at relatively low cost and where poor air quality is a significant problem throughout the city, especially during winter months.

Air Quality

Small-scale burning of wood and other combustible materials is known to contribute to elevated levels of particulate matter (PM) emissions in Nogales, Arizona (United States) and Nogales, Sonora (Mexico). Other sources of PM include unpaved roads, hillside erosion, vehicle emissions, and industrial pollution. Scientists and policymakers are especially concerned about PM generated in urban areas, where metals, carbon, ammonium, sulfates, nitrates, and organic compounds make up and become attached to the airborne particles and are then transported into human bodies via the lungs.

Both cities regularly violate ambient air quality standards of their respective countries as a result of elevated PM levels. In Nogales, Arizona, PM_{10} levels have risen consistently since 1997 and the 24-hour PM_{10} standard has been violated consistently since 1998. According to some reports, as much as 85 percent of the PM_{10} in Nogales, Arizona was found to originate in Nogales, Sonora. While PM_{10} levels in Nogales, Sonora appear to be relatively stable over time, that city's higher levels led to regular violations of the 24-hour PM_{10} standard and acceptable annual averages. In Nogales, Sonora, the more dangerous $PM_{2.5}$ levels have contributed to violations of the US standard, though the 24-hour $PM_{2.5}$ levels have generally fallen within standard (Kimpel Guzmán, et al., ND). In Nogales, Kimpel Guzmán et al. (ND) identified road dust as the main source of PM_{10} and vehicular emissions as the primary source of hazardous air pollutants (HAPs), though concern about burning of wood and other combustible waste and scrap materials has been high enough to lead to the development of an Action Plan to address these sources (see below).

Elevated levels of particulate matter have serious negative effects on human health, child development, and economic activity. Particulate matter has been identified as a key factor in respiratory illness and an asthma trigger in Ambos Nogales (Arizona Department of Health Services 2004). In general, particulate matter has been linked to increased death rates among the elderly and people in poor health; causes include respiratory distress, higher rates of infection following particulate matter exposure, precipitation of acute cardiac events, and eye irritation and infections. Recent studies have shown that even young and healthy people are negatively affected by particulate matter. Lung damage occurs in the deep, thin-walled bronchioles of the lungs and results in fibrosis, a form of scarring, and abnormal thickening of the breathing passages, similar to the damage found in the lungs of heavy smokers (Andrew Churg in Raloff 2003). Growing clinical and epidemiological evidence indicates that the majority of excess PM-related deaths are attributable to cardiovascular disease (Lippmann 2003). A particular concern for border communities such as Ambos Nogales is that diabetics have been found to be particularly susceptible to the health effects of particulate matter. Diabetes can lead to severe cardiovascular disease and increased susceptibility to infection, and particulate matter aggravates both conditions. Based on several studies in US cities, the risk among diabetics for hospital admissions associated with particulate matter was found to be double that of the general population (Zanobetti, Schwartz, and Dockery 2001; Zanobetti et al., 2002).

Kimpel Guzmán, et al. (ND) estimate that PM emissions result in 8 to 14 percent increases in hospital admissions in Ambos Nogales and lead to a 3 to 5 percent increase in premature deaths in Nogales, Arizona and a 26 to 44 percent increase in premature deaths in Nogales, Sonora. Respiratory and cardiovascular illnesses can result in significant decreases in school and workplace attendance and, therefore, in the short- and long- term depression of economic activity. Indoor air pollution exacerbates the impacts of poor ambient air quality.

In a review of studies on the impacts of household-level burning of biomass fuels, Bruce et al (2000) found that smoke from biomass cooking fires has been shown to increase the risk of chronic obstructive pulmonary disease and acute respiratory infections in children, the most important cause of death among children under 5 years of age in developing countries. Biomass burning may also contribute to low birth weight, increased infant and perinatal mortality, pulmonary tuberculosis, nasopharyngeal and laryngeal cancer, and cataract. “Exposure to indoor air pollution,” they write, “may be responsible for nearly 2 million excess deaths in developing countries and for some 4% of the global burden of disease” (Bruce, et al 2000: 1078). According to the United Nations Development Programme, “(I)ndoor air pollution. . . accounts for a greater share of lost life expectancy in developing countries than malaria, but receives little attention” (UNDP 2005: 6).

Air pollution is clearly an ecological problem with severe public health and economic development consequences. To address the serious air quality problems of the region, the Border Liaison Mechanism Economic and Social Development Subgroup in Ambos Nogales and the Border 2012 Ambos Nogales Air Quality Task Force developed a 12-step *Plan of Action for Improving Air Quality in Ambos Nogales* (Border 2012 Ambos Nogales Air Quality Task Force and Border Liaison Mechanism Economic and Social Development Subgroup 2005). This study addresses Recommendation H of the Action Plan: Reduce Wood Burning. The goal of Recommendation H is to reduce the burning of wood and combustible waste materials through household-level actions that can be taken even without major investments in infrastructure and without significant changes to local and national policies. Such actions can have significant impacts on both household and community-wide air quality, especially during the cold, winter months when temperature inversions trap air pollutants near the ground.

Burning for Household Heating and Cooking

Wood is used for heating and cooking throughout the world, primarily because it is an available, affordable, and easy to use fuel source. The United Nations Food and Agriculture Organization (FAO) estimated in 1983 that three-fourths of the developing world's population depended on wood and other forms of biomass for heating and cooking, including surprisingly large numbers of people in urban areas (FAO 1983).

Relatively little is known about the extent and impact of small-scale burning in Nogales, though the practice is known to be common in some neighborhoods and to increase during the winter at the same time that temperature inversions trap air pollutants close to the ground. A 1999 study by researchers at Arizona State University indicated that 23 percent of Nogales, Sonora households burned wood (Sadalla, Swanson, and Velasco 1999). However, because that study was designed simply to document that pollution was being produced by *maquiladora* workers attracted to border communities, investigators did not examine frequency, extent, and seasonality of burning, as well as other factors that could help to reduce the incidence and consequences of small-scale burning.

This study has revealed that many Nogales, Sonora households maintain a variety of cooking devices. Many low-income families who have access to gas or elective stoves and water heaters will continue to use a variety of wood-based cooking and heating devices, including open fires, home-made 55-gallon drums with no exhaust mechanisms, and commercial wood stoves vented outside the house (see Appendix 1 for photos). Families select among these various stoves based on the food that is being cooked, seasonal weather conditions, and fuel price or availability, among other factors. For example, although many homes have access to gas stoves and water heaters, the recent rise in natural gas prices has prompted residents to use wood more often as a cooking and heating fuel. Similarly, residents with easy access to landfills frequently burn paper, plastic, packing foam, clothing, leather, varnished and painted wood, and other waste products.

This study has revealed that many poor families do not have devices exclusively for home heating. Instead, these families are more likely to use their wood-burning stoves for this purpose during the cold season and to leave the stoves burning for extended periods of time.

Home Construction, Insulation, and Thermal Efficiency

The type and quality of home construction may also contribute to small-scale burning. Indoor heating makes homes more comfortable during the winter season in Ambos Nogales, where elevations can reach 4,000 feet and average low temperatures dip below 40° F six months of the year. Families living in uninsulated houses made of a patchwork of found and purchased materials will experience colder conditions than those constructed of thermally-efficient materials. The latter will require less heating – and therefore less burning – during the winter, the time when temperature inversions contribute to high levels of air pollution across the city. Improving home construction materials could have the added benefit of reducing the frequency of house fires, a common problem in Nogales, Sonora. Other considerations for home construction include security, privacy, affordability, and availability of construction materials and skilled labor.

Outline of Report

This remainder of this report is organized in three additional chapters. Chapter Two describes the methodology and process by which data were gathered throughout the project. Chapter Three discusses the findings of the assessment of alternative technologies. Chapter Four presents an action plan aimed at helping achieve the larger scale adoption of the most promising methods and technologies identified, based on the results of all previous project phases. The action plan includes factors to be considered by community partners in pursuing and achieving implementation of effective methods to reduce emissions from wood burning.

CHAPTER TWO: DESCRIPTION OF METHOD AND PROCESS

The Thermal Construction and Alternative Heating and Cooking Technologies Project was funded by the Arizona Department of Environmental Quality (ADEQ) to build upon successful collaborative relationships to improve environmental quality in communities located along the U.S.-Mexico border in the cities of Nogales, Arizona and Nogales, Sonora ("Ambos Nogales"). The principal goal of this project was to assess approaches for reducing emissions generated by the use of wood and garbage as fuels for household-level heating and cooking in Nogales, Sonora. To achieve this goal, researchers from the Bureau of Applied Research in Anthropology (BARA) at the University of Arizona undertook assessment, demonstration, education, and training activities in two colonias of Nogales, Sonora over a 13-month period.

The research team focused on two general approaches to reducing household-level emissions: (1) reducing the *impact* of household-level heating and cooking by promoting the use of less-polluting technologies, and (2) reducing the *need* for household heating by promoting more thermally-efficient home construction technologies. Researchers selected from among the range of already-existing alternative heating, cooking, and construction technologies by considering both technical factors (e.g., emissions reductions, ease of construction, possibility of using local materials, availability of necessary fuels, safety, and cost), locally-relevant socio-cultural factors (e.g., aesthetics, extent of necessary behavioral modifications, household labor patterns), and other factors that might affect the future expansion of the spread of low-emissions technologies (e.g., potential partners and local financial and human resources).

Project Organization

The research design incorporated five to seven steps for assessing appropriateness of alternative heating and cooking and construction technologies in Nogales, Sonora (see Figure 2.1). The project began with (1) research into the range of potential alternative technologies for heating, cooking, and home construction, and (2) field research using interviews and focus groups to identify aspects of cooking, heating, and construction that affect the social acceptability of potential alternatives. Based on this preliminary research, the research team (3) created a short-list of potentially appropriate technologies. Team members then (4) identified potential partners who would help to assess these technologies and (5) conducted introductory and hands-on workshops to introduce the alternative technologies. These workshops were also data-gathering activities, revealing in some cases that the technologies were acceptable but needed improvement. In the case of the heating and cooking technologies, the research design included two additional steps. Where necessary to respond to the need for improvement, the research team (6) refined the technologies. Finally, the research team (7) distributed the technologies and monitored and/or evaluated their appropriateness.

After the initial background research, the research team divided the project into two phases. Phase One focused on heating and cooking technologies from the winter of 2005 through the summer of 2006. As mentioned above, heating was eventually discontinued as a separate research topic because heating and cooking are not distinct activities and many households rely

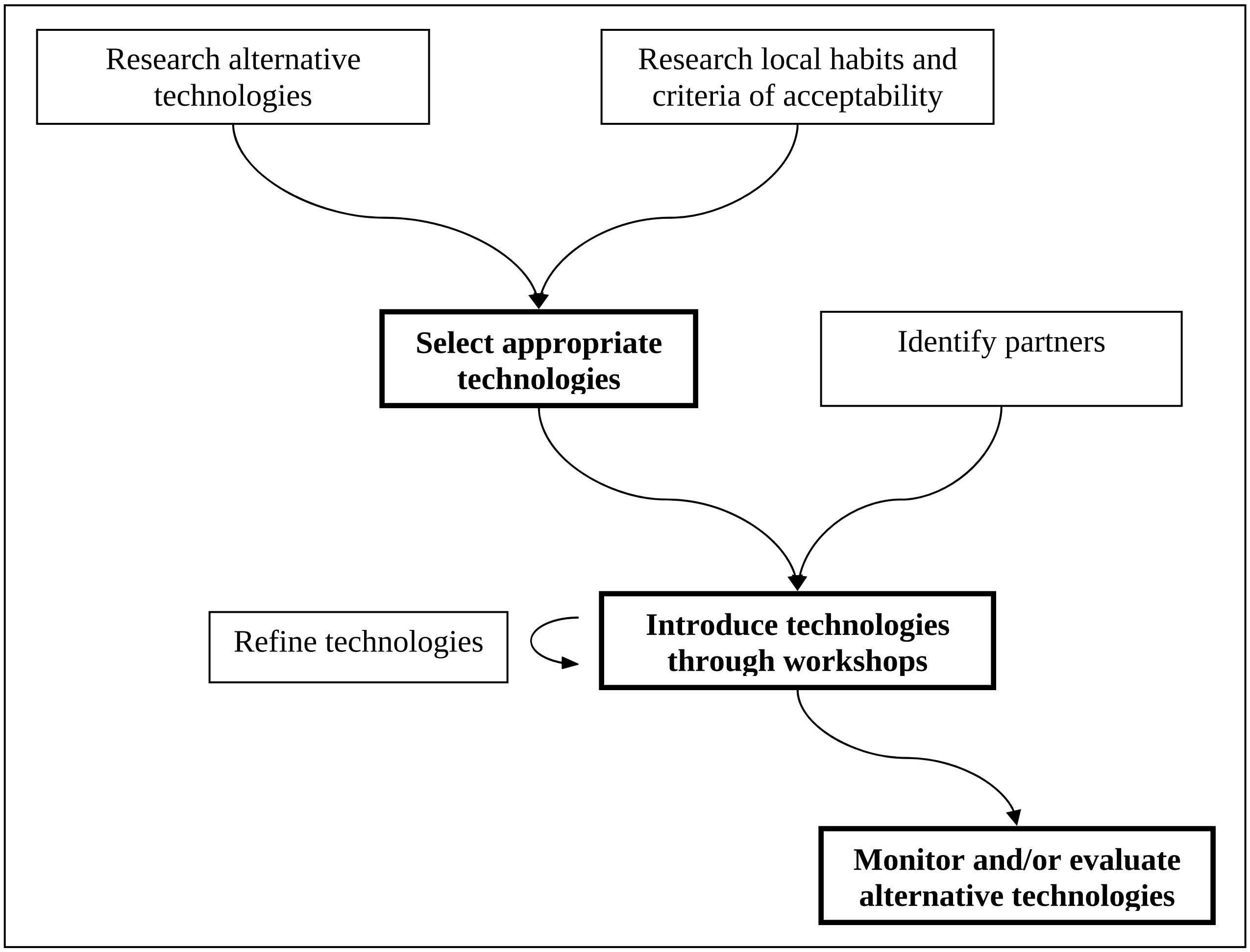


Figure 2.1: Research design for assessing the appropriateness of alternative heating, cooking, and construction technologies in Nogales, Sonora.

on stoves for household heat. Phase Two focused on home construction technologies. The community-based elements of this phase took place in the spring and early summer of 2006. This afforded ample time to construct and modify the heating and cooking technologies, to identify at least 40 households who would experiment with the alternative technologies, and to test some stoves during the hot and cold seasons before working in the community on the construction phase.

The seven steps of the research design were supplemented by research on appropriate technologies, community development, architecture and design, and financing. This supplementary research was intended to help identify resources available for enabling local adoption of the technologies determined to be appropriate for Nogales.

Site Description

Research activities began in Colonia Bella Vista, a 30-year-old colonia that includes both long-term residents in established houses and families living in unfinished homes of scrap material.

Bella Vista is located on the east side of Nogales (see Figure 2.2). An important feature of the colonia is the municipal garbage dump. Some residents make a living by recycling materials from the dump and use the dump as a source of fuels. In December of 2005, the project was extended to Colonia Flores Magón where residents who learned of it expressed interest in collaborating in the research as well. Colonia Flores Magón is younger and less developed than Colonia Bella Vista. Flores Magón is only eight years old and is located in southwestern Nogales, in one of the city's fastest growing regions. Compared with Bella Vista, Flores Magón has more houses made of scrap material and still in the construction process. Both neighborhoods are served by electrical utilities, though neither has access to public water or sewage. The municipal government does not collect garbage in Flores Magón and ceased garbage collection in Bella Vista towards the end of this project. Water and gas are transported to the colonias in trucks. Together, the residents of the two colonias presented a wide range of household burning practices and potential responses to alternative technologies.

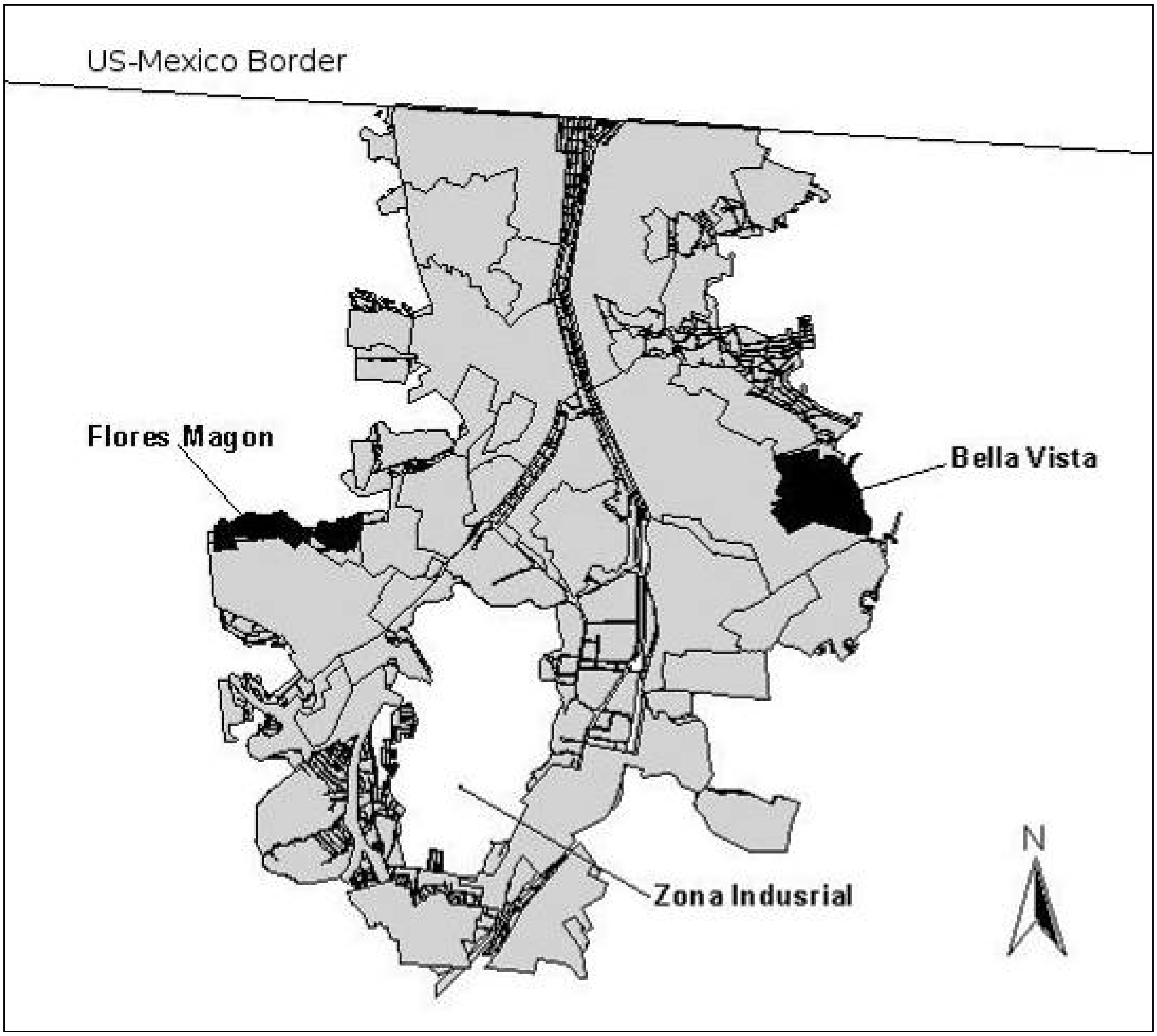


Figure 2.2: Map of Nogales, Sonora, with colonias Flores Magón and Bella Vista highlighted in black.

An important characteristic of both communities is that they contain community development organizations that were interested in participating in this project. These organizations helped to identify research participants, arrange and host workshops, and store stoves and other materials as needed. For this project, BARA researchers continued a long-standing relationship with the Casa de la Misericordia, a community center in Bella Vista that provides free meals to local children, offers adult education courses, and experiments with technologies (e.g., composting toilets, water harvesting, and gardening) that have the potential to improve the local environment and household finances. Staff at the Casa de la Misericordia suggested Flores Magón as another possible research site. A liaison to the neighborhood put team members in contact with ProBarrio, an NGO that has been active in Flores Magón, and that group served as a collaborator for this project.

In addition to collaborating with the community leaders of community development organizations active in the two participating colonias, BARA research team members worked with faculty and students of the Instituto Tecnológico de Nogales (ITN).and the Centro de Estudios Tecnológicos industrial y de servicios N. 128 (CETis 128). ITN faculty and students came from the postgraduate program in Business Administration and the Civil Engineering program. Participation at at CETis 128 was via the ecology teacher and the students in her classes.

Stove Research

Identifying Alternatives

Numerous alternative stove technologies have been designed and studied. Of these, eight alternatives to a simple open fire were identified through library and internet research and interviews with experts (see Appendix 2).

Natural gas and electric stoves are available in Nogales, Sonora and are low-emissions options. Because these stoves are already widely available in Nogales, however, they were not considered to be alternatives for this project. Conversations with participants revealed that families are unable or choose not to use gas and electric stoves at various times during the year or month for reasons such as the high cost of fuel, the need to heat homes in the winter, and the widespread belief that certain foods do not taste good except when cooked with wood. Furthermore, because dust from unpaved roads is a major source of particulate matter pollution in Nogales and gas is delivered by truck over such roads to the households in the study colonias, gas was not recognized as the most appropriate approach to cooking and heating for those households.

Assessing Appropriateness for Nogales and Selecting Three Alternatives

A series of focus groups and interviews were conducted in October 2005 with Bella Vista residents who use or have recently used wood burning stoves for heating and cooking. Data were gathered on dietary and cooking practices, approaches to heating and water heating, seasonal differences, and access to fuel (see Appendix 3 for questions that guided the discussions). In addition, research team members began working with students at the Instituto Tecnológico de Nogales (ITN). The process began with two workshops that were designed to increase the ITN students' skills in carrying out research and were focused on conducting interviews and developing research projects. The ITN students then conducted interviews with residents of a Nogales colonia and with workers at several maquiladoras to learn more about their heating, cooking, and construction practices. When residents of Colonia Flores Magón were incorporated into the project, data were gathered through informal conversations with female household heads. Additional information on cooking practices was collected at later introductory and hands-on workshops and throughout the stove monitoring phase.

Combining the data on alternative stoves with that on heating and cooking practices of Nogales residents, BARA researchers identified the factors most relevant to the adoption of new types of stoves in Nogales, Sonora and began to narrow the field of possible alternatives. A variety of technological and sociocultural factors were considered in selecting among these alternatives, including the intelligibility of the technology, necessary behavioral or lifestyle modifications, the availability of local materials for use and construction, affordability, aesthetics, local climate, and safety considerations.

Based on the research on potentially available technologies and the data gathered in focus groups and interviews, three stove technologies were selected for further assessment: (1) solar, with the solar HotPot designed by Solar Household Energy, Inc (SHE-Inc) as the example; (2) wood gas, with the MIDGE (Modified Inverted Downdraft Gasifier Experiment) as the example; and (3) rocket elbow, with the Estufa Justa as the example (see Chapter Three for details).

Identifying and Assessing Potential Partners

Successful community-based research and project development depends on the participation of individuals and groups from the community who are interested in and knowledgeable about the topic of concern. As soon as this project began, research team members began to search for potential partners, both within the community and beyond. Potential partners were identified through the approach known as snowball sampling where each participating individual is asked to name others and the project extends into the community through the social networks of the participants.

BARA researchers have been actively working with organizations and institutions in Ambos Nogales for more than five years through participation in the Asociación de Reforestación en Ambos Nogales (ARAN; see Diamente and Austin 2006), and this organization served as an important starting point for the snowball sampling approach. The project was announced and discussed at several regular monthly ARAN meetings, and many ARAN members expressed interest in the project. Representatives from the Colegio Nacional de Educación Profesional Técnica (CONALEP), Centro de Estudios Tecnológicos Industrial y de Servicios No. 128 (CETis 128), Asociación de Profesionales en Seguridad y Ambiente (APSA), Borderlinks, and ITN worked with research team members on this project. Borderlinks and CONALEP personnel guided researchers to ProBarrio, a community development NGO, the Fundación Empresariado Sonarense, AC (FESAC), a community foundation, and BANCOMUN, a microlending institution. Representatives from BARA and ITN gave a presentation at the March 2006 conference in Hermosillo, Sonora hosted by the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) to celebrate El Día Internacional de la Mujer. At that event, they made contacts with other organizations and Mexican agencies working to reduce wood burning in Mexico.

Finally, research team members also identified several individuals and groups through the internet. Over a half dozen organizations were contacted and asked for information or considered as potential stove suppliers. One group, Solar Household Energy, Inc. (SHE, Inc.), became actively involved in the project.

Using Workshops to Introduce Technologies and Select Local Research Partners

Four introductory workshops were held between December 2005 and April 2006 for a total of 309 people (see Table 2.1). The workshops combined hands-on construction of the MIDGE wood gas stove with demonstrations and discussions of all stove types and sharing of food cooked in the solar HotPots (see Appendix 4 for agenda and handouts). Two workshops were conducted in Bella Vista to account for seasonal differences in stove use and stove preference and to allow Bella Vista residents to see the portable elbow stove that was developed based on concern about the permanent Estufa Justa (see *Redesigning Stoves* below and in Chapter Three for details). The workshops served not only to demonstrate the selected technologies but also as a forum for collecting further information about stove use and the needs and preferences of Nogales residents. Workshop participants were invited by community leaders in Bella Vista and Flores Magón and were encouraged to bring neighbors.

Table 2.1. Summary of Introductory Workshops

Date	Location of Workshop	Number of Attendees
December 10, 2005	Bella Vista	22
February 25, 2006	Flores Magón	30
April 6, 2006	CETis 128*	240
April 28, 2006	Bella Vista	17
TOTAL		309

* The April 28, 2006 workshop was conducted at CETis 128 as part of the stove design competition described below.

Redesigning Stoves and Modifying Stove Use to Increase their Suitability for Nogales

None of the introduced stoves could meet all of the heating and cooking needs of Nogales residents. In addition, concerns and preferences expressed in interviews, focus groups, and workshops revealed several problems with the alternative stoves selected for assessment. Consequently, the research team addressed these problems by either modifying the stoves themselves or tailoring the monitoring protocol to meet community needs (see Chapter Three for details).

Use of the solar stoves required some adaptation of cooking styles and practices, so researchers decided to maintain more intensive contact with solar users to support their transition to solar cooking. Team members worked with representatives from SHE, Inc. to develop forms for monitoring use of the stoves. Researchers worked with local metal workers to produce and test different models of portable elbow stoves

Students from the Centro de Estudios Tecnológicos industrial y de servicios N. 128 (CETis 128) were recruited to develop additional models of all stove types identified in the initial assessment (solar, wood gas, and rocket elbow). Members of the research team and an ecology teacher at CETis 128 designed a program that included workshops on air quality and stove design, a design contest, selection of feasible designs, construction, and a final exposition, where local authorities judged the stoves based on criteria outlined in the rules of the competition (see Appendix 5 for competition rules and handouts). The competition started with a two class period workshop for six different ecology classes, each with 45 to 50 students. Each class was divided into three groups of 15 to 20 students, with each group focusing on redesigning one of three stoves: the solar cooker, MIDGE and elbow stove. These three groups were divided into teams o five or six students to create a proposal. 54 proposals were submitted and 22 were selected for construction. The purpose of this competition, in addition to the benefits of environmental outreach and education, was for the students to design stoves based on accepted models, in order for these stoves to better suit the needs of the residents from Nogales Sonora, while using materials readily available on the Mexican side of the border. In addition to small prize incentives, the students selected to construct a stove were given class credit and allowed to use this assignment as the final project for the semester. The exposition was judged by volunteers from the University of Arizona, Arizona Department of Environmental Quality, International Boundary Water Commission, CETis 128, and Colonia Flores Magón. The judges reviewed all stoves and selected nine winners, three of each type (see Figure 2.3). Over 200 teachers and students attended the expo at the school, and a story about the event appeared on Channel 4 in Nogales, Sonora. The winning stoves were displayed during a stove demonstration held at a community center in Colonia Bella Vista.

Figure 2.3. Judges at work during the CETis 128 Alternative Stove Exposition

Hands-On Workshops

After the introductory workshops and redesign period, three stove types were deemed potentially acceptable for Nogales and were selected for inclusion in the pilot testing phase: the solar HotPot (manufactured in Monterrey and shipped to Nogales), the Estufa Justa (constructed in Nogales using a design by the Aprovecho Research Center in Cottage Grove, Oregon), and the Eco-Stove (a portable version of the Estufa Justa designed and constructed in Nogales based on models from Brazil and Nicaragua; see Chapter Three).

Participants in the introductory workshops and stove demonstrations who wanted to pilot test one of the three stoves attended hands-on training workshops and/or in-home sessions to learn how to use and monitor their stoves. Because Estufa Justas and Eco-Stoves were constructed and/or assembled on site, their training sessions were typically conducted in homes and involved smaller numbers of participants. The solar workshops, in contrast, could accommodate up to 25 people at a time.

The first workshops were held in December and January. The second series of workshops were held in February and March, and the final series were held in May and June. Having the workshops at three different times of the year allowed researchers to observe the impact of weather conditions on initial stove acceptance. Table 2.2 summarizes participation in the specific workshops and distribution of stoves. Since all of the solar workshop participants had previously attended an introductory workshop, the vast majority of them had already decided that they wanted to use a solar HotPot. Many of the participants in the Estufa Justa and Eco-Stove workshops, however, had never attended previous workshops and simply stopped by to learn what was happening and/or help with construction. These participants learned about the stoves but did not receive their own stoves because of limited availability. As expected, not all of the stove recipients monitored their stove use. Nonetheless, 46 out of the 55 stoves were monitored consistently.

Table 2.2. Summary of Stove Workshops and Outcomes

Month	Type of Workshop	Number of Participants	Number of Stoves Distributed	Number of People Who Monitored
December	Solar	6	6	1
January				
February	Estufa Justa	20	1	0
March	Solar Estufa Justa	19 2	14 1	12 1
April	Estufa Justa	5	1	1
May	Solar Estufa Justa	30 2	30 1	28 1
June	Eco-Stove	3	1	1
July	Eco-Stove	3	1	1
August	Eco-Stove	2	1	1
TOTALS	Solar	55	50	41
	Estufa Justa	29	4	3
	Eco-Stove	8	3	3
	Total	92	57	47

An important finding is that leadership of these hands-on workshops could quickly move from outside experts to local users. For example, the first solar workshop was conducted by a representative of Solar Household Energy, Inc. (SHE-Inc), the organization that has designed and disseminated the solar HotPots. The next two solar workshops were conducted by SHE-Inc and BARA researchers. The final workshop in Bella Vista was solicited by solar users who wanted to share the technology with their friends and neighbors, and the research team agreed to conduct the workshop on the condition that the solar users themselves lead the training. This community-led workshop was excellent, and while researchers still helped to facilitate the training, leadership from community members probably helped to improve acceptance and understanding of the solar stoves and demonstrated that local solar users can help to disseminate the technology in the future.

Monitoring and Evaluating Use and Acceptability for Nogales

As shown in Table 2.2, a total of 56 stoves were distributed in the target colonias for in-home field testing. Research team members gathered baseline data on each household to which a stove was distributed. Participants used monitoring forms to document their stove use and cooking patterns for at least two months, and researchers visited each household at least once every three weeks to discuss stove use and ensure that participants were following the monitoring protocol. Stove users recorded the type of stove they used, the food they prepared, whether or not they heated water and for what purposes, and the wood or gas they purchased (see Appendix 6 for monitoring forms). Over the course of the project, the monitoring forms were modified to better meet the data needs of the research project and the ability of participants to provide data on stove use.

In all, 47 of the 56 alternative stoves introduced to Nogales, Sonora were monitored consistently. Solar stove users were generally more comfortable writing and completing monitoring forms on their own, and they therefore found the monitoring process easier. Users of the Estufa Justa and the Eco-Stove, in general, required more direct assistance from the research team during the monitoring phase.

Construction Research

Identifying Alternatives

Effective home heating requires not only heat generation but also heat retention. Neither wood nor cinder block walls, two common housing materials in Nogales, offer much insulation or thermal mass. Eleven low-cost alternative construction technologies were identified through library and internet research and interviews with experts (see Appendix 7). Because of interest in, experience with, and the relevance of alternative construction technologies to people on both sides of the border, construction research activities involved people from Sonora and Arizona. Both engineering and technological considerations and sociocultural factors were considered in the selection of the low-cost alternatives.

On March 3, 2006, research team members took a tour of Nogales with Arturo Frayre, a civil engineering professor at the ITN and former employee of both the Nogales municipal government and a private development company. Professor Frayre led team members throughout Nogales, Sonora, into both established neighborhoods and new colonias, and discussed development, housing construction, and deforestation within the municipality.

Preliminary interviews with Arturo and other knowledgeable individuals indicated that home construction and choice of building material depended on affordability, availability, security, privacy, and level of fire risk. This perspective guided the team in choosing and experimenting with what were perceived to be the most appropriate home building technologies. Thus, the team visited practitioners and experts in sandbag technology (California), papercrete (Nogales, Sonora and Phoenix), rammed earth and other earthen materials (Tucson). The team also experimented with building papercrete blocks.

Assessing Appropriateness for Nogales and Selecting Three Alternatives

A housing construction assessment was conducted in one colonia (Bella Vista) to assess the range of housing types (see Appendix 8). The assessment was developed by first gathering examples of housing surveys and assessments developed and used in various locations in the United States and elsewhere. A pilot assessment was developed then tested and modified several times until the results it generated were reliable and accurate. The assessment was then administered in Colonia Bella Vista. Then, interviews were conducted with Nogales, Sonora residents to supplement the housing assessment and provide data on the processes by which houses are constructed in the city. Data about the construction practices of Nogales residents were used to evaluate the range of alternatives to standard construction.

Identifying and Assessing Potential Partners

Researchers conducted long, semi-structured interviews with ten individuals in Phoenix, Tucson, and Nogales to gauge community interest in alternative construction technologies and to identify resources and potential partners for the project. As described above, researchers also worked with member organizations of the Asociación de Reforestación en Ambos Nogales (ARAN) to identify resources and recruit individuals to participate in meetings and workshops.

Research team members also utilized social networks within the University of Arizona to locate people and departments with an interest in alternative technologies who could serve as resources for this and future projects. Several university professors participated in interviews about construction technologies (see Chapter Three). In addition, research team members attended meetings of and made presentations for the student chapter of Engineers Without Borders (EWB) and involved EWB members in two fieldtrips to learn more about the project and the alternative technologies. Unfortunately, despite several attempts, the two groups were unable to develop projects of mutual benefit within the project period.

Using Workshops to Introduce Technologies and Assess Local Interest

Two types of workshops were used to introduce alternative construction technologies in Ambos Nogales. Thirty-seven community members and leaders with particular interest in housing practices and alternatives participated in introductory workshops at which three technologies – papercrete, sand bags, and rammed earth – were introduced and evaluated. Also, in response to local interest in papercrete, two hands-on workshops were conducted with local students and teachers, one in Nogales, Arizona and the other in Nogales, Sonora. Schools were selected for the introductory workshops because they are public spaces to which many residents come, and their teachers and administrators were excited about having students become familiar with the technologies and the project. In both cases creating benches for outdoor classrooms provided a mechanism for introducing the technologies to the communities for a functional purpose where they would be outdoors and exposed to the elements and could be monitored prior to anyone attempting construction of an entire building.

CHAPTER THREE: ASSESSMENT FINDINGS

As described in Chapter Two, this project assessed the appropriateness of several low-emissions heating and cooking technologies and thermally-efficient construction technologies for residents of two colonias in Nogales, Sonora. This chapter summarizes the findings of the assessment, from the initial focus groups and interviews through the stove monitoring.

Stoves – Issues for Nogales

An urban environment such as that of Nogales, Sonora creates a unique situation that requires modification of stoves designed for rural, deforested areas. To ensure that the research team identified and introduced stoves that would be affordable for Nogales households and potentially acceptable to the users, data about current stove use, costs, and cooking and heating practices were gathered from Nogales residents. Based on the findings of the initial data collection, three types of stoves were identified and introduced to residents of Colonias Bella Vista and Flores Magón. Fifty-six households were then selected to receive stoves and monitor their use. This section describes the process and what was learned.

Literature Review

As mentioned above, fuel scarcity and health concerns related to small-scale burning have stimulated the design and use of a relatively large number of alternative stoves in different parts of the world. A review of literature about these technologies revealed several well-tested alternatives to a traditional three-stone fire or three-stone fire with an insulating earthen wall (see Appendix 2). While some alternative stoves replace wood with other fuel sources, such as the sun or alcohol, others use wood more efficiently by concentrating heat on the cooking surface and controlling ventilation to ensure complete combustion of wood fuels.

The most prominent wood-burning alternatives can be grouped according to the mechanism by which they increase the efficiency of producing heat: (1) gasification and (2) the rocket elbow. Wood gas stoves (such as the MIDGE, Tsotso, and Vesto stoves) preheat incoming air while using that air to insulate the fire and prevent heat loss, thereby increasing the efficiency of burning low-quality fuel. Air inlets allow the stoves to function simultaneously as charcoal-producing gasifiers and charcoal, wood, or dung-burning stoves. The Vesto stove, produced in southern Africa, is the most technologically sophisticated of these stoves but is difficult to produce on a small-scale and is expensive to ship from the production plants to Mexico.

Rocket elbow stoves (such as the Estufa Justa and Eco-Stove) prevent heat loss through insulation of a highly-efficient elbow-shaped combustion chamber. The elbow concentrates heat on the cooking surface to cook more rapidly. The small diameter of the combustion chamber limits the size of wood that can be burned in the stove and ventilation through the elbow ensures more complete and efficient combustion. Ash (abundant in the research area due to widespread wood burning) is used to insulate the stove and minimize heat loss, and a chimney channels smoke outside and away from the cooking area. Rocket elbow stoves can be easily constructed using locally-available materials, though this research team encountered some difficulty locating potters or welders to make the elbow.

Solar stoves eliminate combustion altogether. Solar cookers focus the energy of the sun on a cooking pot and trap that energy to obtain cooking temperatures of 200 to 450° F. Three general classes of solar cookers exist: (1) parabolic cookers, which focus solar energy very precisely but typically have less insulation and require more of the cook's attention, (2) box cookers, which can be constructed inexpensively using recycled materials and achieve high cooking temperatures through good insulation, and (3) panel cookers, which use a simple reflective panel and dark-colored pots and are often easiest for new solar cookers to use. Solar stoves are best suited to areas with consistent sunshine. They typically require longer cooking periods and therefore require cooks to prepare food earlier in the day. Solar stoves can be made at home or purchased from several manufacturers. Because solar stoves require no fuel, initial costs are recuperated quickly.

Gaia stoves are similar to gas stoves but use alcohol as a cooking fuel. Alcohol is a cheap fuel source that produces fewer emissions than wood and can reach high heats quickly. Gaia stoves are likely to be widely accepted because they resemble gas stoves, but the ease of accessing large quantities of alcohol may hamper widespread adoption of this technology. Gaia stoves must be purchased from manufacturers.

Focus Groups, Interviews, and Workshops

During focus groups, individual interviews, and workshops, the research team collected data about regular cooking practices, existing cooking technologies, and local preferences with regards to cooking. Some key findings are listed below.

- Most families own multiple cooking devices (generally three, but exceeding six) and use multiple types of fuel. Virtually all families have at least one wood-burning stove, many of which are homemade using recycled materials such as tractor discs, 55-gallon metal drums, or cinder blocks. Other cooking devices include gas stoves, electric crock pots, electric stoves, and microwaves.

- The most commonly-used fuels are gas and wood (including wood from trees, from shipping pallets, and from garbage dumps) but poorer families with access to the garbage dump also burn clothing, shoes, plastic, rubber, shipping foam, and other materials in heating and cooking stoves.

- Diets and cooking habits are relatively consistent across the population. Breakfasts tend to be quick meals of coffee with eggs, cereal, or baked goods. The typical diet in Nogales centers around meat (primarily chicken, beef, and pork) cooked on a daily basis. Beans are generally cooked only once a week in large quantities (0.5-1 kg). Tortillas are often store-bought and heated at mealtime. Many families cook large soups and stews once a week and special dishes like menudo or barbacoa once or twice a month.

- Household cooks decide which stove to use for a given meal based on the season and temperature, the food to be cooked, and available fuels. During the cold winter months, cooks are more likely to use indoor wood-burning stoves that also heat the house, whereas during the summer they are more likely to use gas stoves, electric pots, or outdoor wood stoves. Slow-cooking foods like beans, stews, menudo, and barbacoa are generally cooked on wood stoves because gas and electricity are significantly more expensive. However, families with electric crock pots will often use these to cook slow-cooking foods during the summer months.

- Daily schedules of household cooks can significantly influence cooking practices and stove use. This is particularly relevant in Nogales, where seasonal employment, night work, and long factory shifts can make household cooks essentially unavailable for periods of the year. During these periods, households will often rely on faster-cooking stoves (gas, electric, and microwaves) and on the purchase of prepared food.

- Families also use stoves to heat water for coffee (year-round), washing dishes (year-round), and bathing (six to nine months of the year).

- The safety of cooking stoves is a serious concern. All of the focus group and workshop participants knew of people whose houses had burned down and whose children had been injured because of common cooking and heating activities. In addition, the 55-gallon drums used to make stoves often contain dangerous chemical residues and the metal degrades quickly when exposed to fire. Many household stoves are in disrepair.

- Household cooks are also concerned about healthy eating and tended to appreciate that solar stoves did not require oil and fat for cooking.

- Home ownership status and plans for construction and renovation affect participants' interest in different types of stoves. Renters and home owners planning renovation are typically more likely to desire portable stoves such as the Eco-Stove.

- Aesthetic preferences were varied. While many cooks were immediately turned off by MIDGE stoves constructed from recycled metal cans, others were excited by that possibility. Similarly, some cooks were impressed by the brick Estufa Justa but others preferred a more modern-looking metal Eco-Stove.

In summary, families in Nogales use a variety of stoves so that they can remain flexible to changes in fuel price and availability, seasonal heating needs, and different cooking needs. Key criteria to consider when selecting alternative stoves include: price, safety, fuel cost and availability, ease of use, versatility of stove, aesthetics, size, and permanence/portability.

Integrating Data from Literature and Initial Assessment: Alternative Cooking Stoves for Nogales

Three stove technologies were introduced at each of the introductory workshops. Each of these is discussed briefly in the following paragraphs and then the advantages and disadvantages of all three are compared.

Solar – SHE-Inc recently designed a new solar cooker to make it more affordable, efficient, and easier to use. The HotPot consists of three parts: (1) a solar reflector made of either aluminum or cardboard, which focuses the sun's energy on the cooking pot; (2) a black metal pot that converts sunlight into heat to cook the food within; and (3) a tempered glass pot with lid that surrounds the black pot and acts as a greenhouse, allowing light to enter but trapping heat around the cooking pot. The HotPot is manufactured in Monterrey, Mexico and would be difficult to produce locally because of the large capital costs required to shape tempered glass. It proved easy, however, to purchase pots directly from the factory. Cardboard and aluminum reflectors perform similarly, but cardboard reflectors are cheaper and shorter-lived, usually lasting two to three years. For this project, the less expensive cardboard reflectors were used so that more stoves could be distributed for testing.

Solar cooking is similar to conventional cooking but does require some adjustment. Food should be prepared early in the day to take advantage of full sun, which means that cooks often have to prepare for lunch in the morning and dinner at midday. Once food is placed within the HotPot, however, it requires no additional supervision and can be left for hours without risk of burning or spoiling. The HotPot can be used for almost all of the foods that Nogales residents eat regularly, including baked goods, but can not be used for frying. Cooking times vary based on the amount of sun, but meat can consistently be cooked in less than three hours on a day with sufficient sun. During the summer months in Nogales, it is possible to cook two or even three separate meals in the HotPot in a single day.

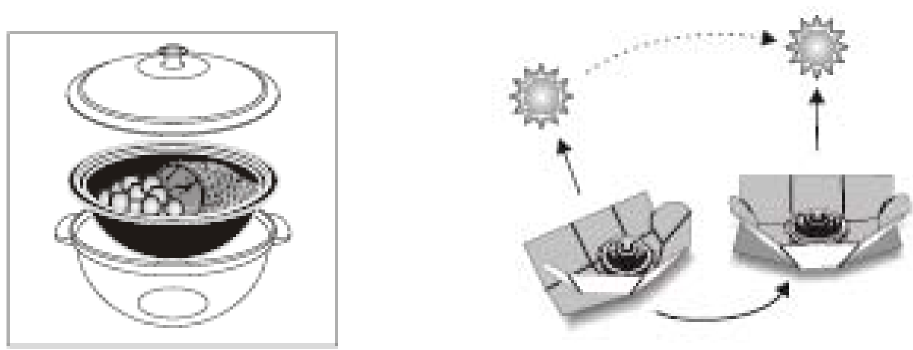


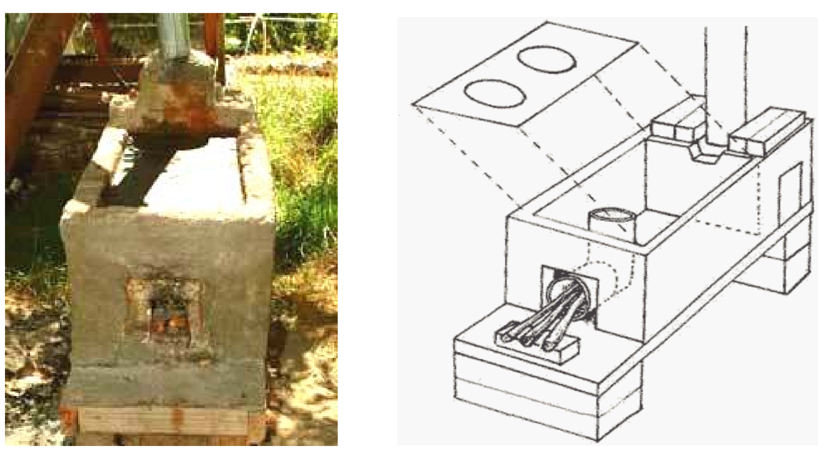
Figure 3.1. Solar HotPot developed by Solar Household Energy, Inc.

Wood Gas – The MIDGE (Modified, Inverted, Downdraft, Gasifier Experiment) was selected as an example of wood gas stoves. The MIDGE is easily constructed using three metal cans. Holes in the cans control air flow to burn wood efficiently, to insulate the fire, to concentrate heat on the cooking pot, and to minimize emissions. The MIDGE is filled with small pieces of wood and can burn for up to 20 minutes without adding more wood for a total burn time of 80 minutes. Food is placed on a grill above the MIDGE burner.

Photos © William Carr

Figure 3.2. Modified, Inverted, Downdraft, Gasifier Experiment (MIDGE) Stove

Rocket Elbow – The Estufa Justa is a large brick stove with an elbow-shaped combustion chamber. Wood burned in the elbow generates heat on a metal slab, or “plancha,” that is used as the cooking surface. The elbow is insulated using ash to eliminate any heat transfer to the sides of the stove and direct heat to the cooking surface. Smoke exits through a chimney and soot is deposited into a chamber in the rear of the stove, from which it can be cleaned regularly. Using a small and well-insulated elbow ensures optimal airflow, complete combustion, minimal heat loss, and minimal emissions. A portable version of the Estufa Justa was also created for this project using a metal stove body with metal legs. Studies show that elbow stoves use 33 percent of the wood that a campfire requires. The elbow stove provides the easiest transition for participants. It requires only minor changes in current wood burning habits to create a measurable reduction in wood burning and emissions. The main difference is that cooks must use smaller pieces of wood to ensure more complete combustion.



Photos © Aprovecho Research Institute

Figure 3.3. Estufa Justa developed by Aprovecho Research Institute

Table 3.1 summarizes the fuel requirements and emissions of each of these three alternative stoves, as well as of standard gas and electric stoves. A more detailed study would be necessary to quantitatively compare the total air emissions generated by the use of each stove, especially when taking into account the emissions generated by stove construction and shipment and fuel generation and distribution. However, the three alternative stoves produce fewer emissions than open fires and conventional wood stoves in Nogales, Sonora. Cooking with a solar oven generates no air pollution and the more complete combustion and faster cooking achieved by using the MIDGE and rocket elbow stoves markedly reduces total emissions and PM emissions compared with open fires and other conventional wood stoves.

Table 3.1. Fuel Requirements and Emissions for Select Stoves

Stove	Fuel	Emissions Compared with Open Fire
Electric	Electricity	Low emissions from cooking, but significant emissions from electrical generation and infrastructure creation and maintenance. Additional emissions from stove fabrication and transportation.
Gas	Propane gas	Low emissions from cooking, but significant dust generated by gas trucks driving through colonias. Significant emissions generated in gas extraction and transportation. Additional emissions from stove fabrication and transportation.
MIDGE	Wood	Lower emissions than open fire. No emissions from construction or supply of materials. No transportation required.
Rocket Elbow	Wood	Much lower emissions than open fire. Low emissions from construction and supply of materials. No transportation required.
Solar	Sun	No emissions from cooking. Low emissions from fabrication and transportation.

Table 3.2 summarizes the advantages and disadvantages of each stove type and highlights possible modifications that can improve the acceptability of the stove as well as serious limitations that reduce the potential for them to be used in Nogales.

Table 3.2. Advantages and Disadvantages of Stoves Discussed in Introductory Workshops

Stove	Advantages	Disadvantages	Possible Modifications	Serious Limitations
MIDGE	• Uses less wood • Creates little smoke when constructed correctly • Inexpensive to construct • Inexpensive to use • Easy and quick to construct • Made from all	• Difficult to refuel once lit • Only serves for quick-cooking foods (burns for an average of 25 minutes) • Cannot be used for beans • Does not provide household heat	• Housing apparatus to create multi-burner stove, provide grill or grate to support pot, increase stability, improve aesthetics, concentrate heat, and provide door to keep children out • Larger version of MIDGE to allow for	• Can be easily knocked over, posing fire hazard • Cannot support pot directly • Smokes if not correctly constructed

	recycled materials • Does not require much space • Flame looks like that produced by a gas stove	• Flames can reach heights of several feet • Requires substance such as alcohol to light, which increases potential fire danger	more fuel at one time and burn longer, though height of flame might be problem • Chimney to channel and control smoke output	
Solar Hotpot	• Does not use any wood or gas • Does not create any soot or ash • Enables healthier way of cooking • Stove cooks without requiring attention to add wood • Food does not burn • Nice appearance • Can bake in it • Can transfer food to another device if not fully cooked by sun • Portable • Does not require much space	• Have to use it outside where it may be knocked over or stolen • Can only be used part of the year when there are no clouds • Is not manufactured locally and requires purchasing • Does not provide household heat	• Design and construct similar device with locally-available materials	• Cannot leave outside without some sort of protection from dogs, cats, humans • Cannot be the only means of cooking
Estufa Justa	• Creates less smoke • Uses less wood • Affordable • Can be placed inside or outside of the house • Is safe for children and stove users • Attractive • Good as a heater in the winter; participants would feel comfortable leaving it on overnight • Soot/ash cleans easily • Easy to light	• Too large for some houses • Permanent stove not appropriate for some houses (e.g. renters) • May over-heat house during summer	• Design smaller, portable version that can be used in rental properties and can be moved inside or outside depending on the season	• None for technology • Finding local source for elbow proved difficult

Redesigning Stoves to Increase Their Suitability for Nogales

While the solar stove was efficient and acceptable in many ways, it was expected to be the most difficult to assimilate into daily routines. The research team therefore decided to maintain more intensive contact with solar users to support their transition to solar cooking. Unlike simpler solar stoves, the HotPots are manufactured using expensive equipment requiring significant expertise. Technical redesign was therefore neither feasible nor necessary given participants' concerns.

The wood gas stoves received very low acceptance rates. Given this low level of interest, difficulties working with engineering partners, and the acknowledged shortcomings of the MIDGE stove, this technology was ultimately removed from the list of experimental stoves. Local partners who continued to experiment with the MIDGE stove, however, did create a prototype that may be widely acceptable in the future.

The majority of redesign efforts were devoted to the rocket elbow stoves. While initial assessments showed a very high level of interest for the large brick stoves, researchers who visited participants' homes to prepare for construction found that few families were able to accommodate a permanent stove structure in their home. Houses were either too small for the large stove or household heads considered their homes to be continually under construction and were unwilling to install a permanent structure that would restrict future remodeling.

This presented two options for redesigning this technology: either build the stoves outdoors or build a portable elbow stove. Since building an efficient stove outdoors would do little to reduce heating-related wood burning, it seemed that a portable stove would be most advantageous for the majority of participants. Portable elbow stoves are currently in use in Latin America (e.g., Nicaragua and Brazil), but attempts to order manufactured versions of these stoves failed due to communication problems and the cost of international shipping.[1] The research team therefore needed to construct portable elbow stoves locally.

Over the course of three months, researchers worked with four metal workers in Nogales, Sonora and Tucson, Arizona to produce and test different models of portable elbow stoves. The first—constructed from 55 gallon drums that are commonly used for household cooking and heating—proved unsafe and lacked the durability necessary for long-term use. The second was useful for testing different elbow materials and as a model for soliciting feedback from participants. The third lacked some of the insulative properties that make this technology both safe and efficient. The fourth was a sturdy metal stove with all of the necessary elements to replicate the best aspects of the permanent version in a portable form.

As users of the permanent elbow stove experimented with their stoves it became apparent that the materials used in the combustion chamber needed to be stronger. The team researched

[1] The Patsari Stove, a fuel-efficient stove that is similar to the elbow stoves and comes in both permanent and portable versions, was developed for rural southern Mexico by GIRA. GIRA was a recipient of the 2006 Ashden Award for Sustainable Energy (see http://www.ashdenawards.org/media_summary06_mexico). To date, GIRA stoves have only been constructed and used in rural areas in the south, but further investigation of the potential for extending the technology to the north is warranted and recommended in the Action Plan in Chapter Four.

ceramic, brick, and ultimately ¾-inch galvanized steel elbows to serve as the combustion chamber. The same metal worker who produced the best portable stove helped manufacture metal elbows. Unfortunately, it has been difficult for him to produce the quantity of stoves necessary for this project and several other welders who initially expressed interest in participating have not had the flexibility to build these stoves quickly and inexpensively. The large-scale distribution of these stoves in the future will require a reliable source of either ceramic or metal elbows and metal stove bodies, both of which may be acquired through large orders with local manufacturers.

This stove workshops and design competition demonstrated that efficient stoves can be constructed from a wide range of locally-available materials. It also generated a new wood gas stove based on the MIDGE that might be more widely acceptable to residents of Nogales. Further evaluation of the MIDGE technology, following the procedures described below for the solar and elbow stoves, will be necessary before any additional conclusions can be drawn about its appropriateness for Nogales.

Monitoring and Evaluating Use

Fifty-seven stoves were distributed to 56 people who elected to participate in the study to evaluate alternative stoves. Of the 57 stoves distributed, 47, or 84 percent, were used and evaluated by the study participants. Four individuals left the study, one because she moved away from Nogales, a second because she began working at nights and did not have the time and energy to participate, and the final two because they decided that they did not want to experiment with and monitor the stoves. Five other individuals, one of whom received two stoves, did not monitor their stove use.

Table 3.3 shows the initial fuel use patterns of the participants. None of the participants used wood exclusively, but 32, or 57 percent, used wood for some of their cooking needs. Only 20 participants did not have a wood stove at all. Many participants did not have a single, consistent set of stoves in use. Instead, their household stoves varied over the years based on the degradation of old stoves and new purchases of electric crock pots, gas, or store-bought wood stoves. Some participants loaned stoves to other family members for extended periods of time or even lost stoves when they had to relocate. Because this study is focused on air quality, efficient wood-burning rocket elbow stoves were only distributed to participants who were currently burning wood. Solar stoves, on the other hand, were distributed to all participants because (1) their use would represent an air quality gain among users of all stove types and (2) introducing them to users of all stove types would provide more information about general solar stove acceptability.

New stoves are most likely to be accepted if they can be used to prepare commonly eaten foods. At early focus groups and workshops, the research team collected a list of foods identified by participants as commonly prepared in Nogales. These foods included coffee, eggs, tortillas, beans, chicken, steak, soup, stew, squash, fish, potatoes, and menudo. To verify that actual cooking behavior mirrored reported cooking behavior, participants in the early phase of the study were also asked to record their daily meals. The research team found that participants' initial list of foods cooked included many of the most commonly eaten foods and that participants represented the frequency of preparation of each food with relative accuracy. Rapidly prepared foods such as instant soup and sandwiches were under-represented on the initial lists but were generally used when families encountered schedule changes or difficulties that altered normal eating patterns.

Table 3.3. Selection of Stove Based on Initial Fuel Use

Fuel Use at Start of Study	Number of Participants	Number of Participants Who Tried Solar Pots	Number of Participants Who Tried Rocket Elbow Stoves
Wood Only	0	NA	NA
Wood and Gas	19	13	6
Wood, Electric, and Gas	13	13	1
Electric and Gas	10	10	0
Gas Only	9	9	0
Electric Only	1	1	0
Unknown*	4	4	0
TOTAL	56	50	7

* Four participants withdrew from the study before complete baseline data could be gathered.

Virtually all of participants' most commonly eaten foods could be prepared in the alternative stoves selected for this study. All foods that require heating, boiling, and frying can be prepared on the wood-burning alternatives in the same way they are prepared over an open fire or a wood stove, though the wood-burning alternatives cannot be used for baking. The solar HotPot requires some modifications in cooking practice and cannot be used for frying, though it can be used for heating, boiling, water purification, and baking. Since the solar HotPot required the greatest behavioral modification for adoption, the research team was particularly attentive to the foods that were prepared using solar stoves. Table 3.4 shows that many common foods were consistently cooked in the solar HotPots during the study period. In addition to these common foods, household cooks experimented with a wide range of other foods including desserts, baked goods, tamales, meatballs, fish, Chinese food, and a variety of meat dishes. Household cooks in Nogales, Sonora seemed to adjust fairly easily to the solar cooking process.

Table 3.4. Use of Solar Hotpot for Common Foods

Type of Food	Cooking Success in Solar HotPot	Typical Cooking Time*
Beans	High	4-9 hrs
Chicken	High	2-5 hrs
Beef or Pork	High	2-5 hrs
Soup or Stew	High	2-5 hrs
Rice	High	2-4 hrs
Potatoes	High	2-4 hrs
Other Vegetables	High	2-3 hrs

* Note: It is difficult to precisely define cooking times because, unlike with other stoves, the solar cook does not constantly tend the solar oven and food can be left in the oven even after it finishes cooking without fear of burning. Factors such as the type of bean, whether or not beans were pre-soaked, and the quantity of food prepared can cause significant variations in cooking time.

Widespread use of solar HotPots would greatly reduce the amount of wood burning in Nogales. Households that typically combine gas and wood burning use open fires and wood stoves to prepare slow-cooking foods such as beans and menudo. Beans, a staple in Nogales, take up to five hours to cook on a wood stove and consume a considerable portion of most wood user's firewood. While gas cooks much more rapidly it is still much more expensive than wood, so people tend to make slow cooking foods with wood. Preparing these foods with wood saves large amounts of gas and money, and also allows the family to manage indoor temperatures. Many families cook slow-cooking foods on outdoor wood stoves during the warm months to minimize indoor temperatures and cook on indoor wood stoves during the cold months to help heat the house. As illustrated in the above table, solar HotPots proved to be a good alternative to wood stoves for many of these foods, particularly during the warm months. Rocket elbow stoves also serve as a good alternative to conventional wood stoves, as they are easy to incorporate into regular routines and reduce the amount of fuel wood needed and the level of emissions produced. Estimates of the reduction in wood burning based on use of the elbow stoves and solar HotPots are provided in Table 3.5. As mentioned above, however, it is difficult to precisely estimate the reduction in wood use and emissions production because families use stoves to heat houses as well as to cook.

Table 3.5. Reduction in Wood Use for Foods Prepared in Alternative Stoves

Type of Food	Conventional Cooking Time	Conventional Cooking Wood Use	Elbow Stove Wood Use Reduction Factor	Solar Stove Wood Use Reduction Factor
Water (heating)	1-3 hrs	1-2 raca	25-50%	100%
Tortillas	30 min	1 raca	25-50%	NA
Beans	3-5 hrs	2-4 racas	25-50%	100%
Stew	3 hrs	2 racas	25-50%	100%
Chicken	2 hrs	1 racas	25-50%	100%
Beef	2 hrs	1 racas	25-50%	100%
Menudo	3-8 hrs	2-5 racas	25-50%	100%

Note: These cooking times and wood use figures should be taken as rough estimates. Cooking times and wood use vary significantly based on the exact dish prepared and the type of conventional stove used. Common ways of measurng wood are also inconsistent and vary based on the type of wood used. The wood use reduction factors for the elbow stoves are based on tests conducted by the Aprovecho Research Center and participants' own (usually higher) estimates of fuel use.

Household data on stove use reveal that it is very challenging to estimate reduction in fuel use for the entire population of Nogales based on a sample of users. Lifestyles and household circumstances within the population vary tremendously and make generalization impossible. Households in Nogales' colonias vary in terms of their size, members' occupations, number of dependants, and social status. Each household also has its particular cooking and heating practices depending on its members' income levels, place of origin, type of house construction, access to wood, and more.

The following six brief case studies illustrate the variability in stove use and show how six different households adapted 'alternative' cooking technologies into their daily lives (pseudonyms have been used to protect the participants' identities). The case studies begin with a brief description of the physical characteristics of each household and provide information about its members. Then information is provided about members' daily cooking activities before receiving the alternative cooking device. Finally, each case study ends with a discussion of the participants' opinions, perceptions and challenges as they experimented with solar or efficient wood burning technologies.

Marta: A New Solar User

Marta was invited to participate in a solar workshop held in Flores Magón on March 18, 2006. During the workshop she seemed a little shy but very interested in knowing more about the solar pot. She participated in preparing and cooking potatoes and witnessed how other groups cooked vegetables and a carrot cake. She did not receive a pot that day, but two days later we delivered a pot to her house. At that time, we conducted a household baseline interview at her home in order to learn about her everyday cooking habits.

Marta is the mother of two children, an 8 year old boy and a 10 year old girl, both of whom attend the elementary school at Flores Magón. She and her husband are from Sinaloa and have been living in Flores Magón for about 10 years. Marta's unmarried sister also lives in the same house. Every year, Marta's parents come from Sinaloa to stay with their daughters for about six months. Nearby Marta's house lives another sister who works in a factory (*maquiladora*). She usually asks Marta's mother to make tamales so that she can sell them at the factory.

Marta's house is made out of cinder bricks covered with a flat concrete roof. It has two bedrooms, a bathroom, a kitchen area, and a living room. The house has glass windows, ceramic floors, and walls covered with stucco. Marta's family does not use heating devices during the winter. Marta's house may be considered a middle/high status home in Flores Magón. It is made out of bricks, has new furniture, kitchen cabinets, and a variety of appliances (washing machine, microwave, TV, etc).

Marta mainly works at home and is in charge of cooking food for all members of the household. Her mother also helps in the kitchen and is known to be a great seafood cook. Marta cooks most meals in a five-burner gas stove. She also uses a microwave for re-heating food. She told us that she does not use wood because she is very nervous and considers burning wood to be dangerous. Marta usually buys gas every month. Her 30 kg gas tank costs about 255 pesos. When she runs out of gas she does not cook until she recharges her tank as soon as possible.

Before receiving the solar pot Marta used her gas stove to cook beans once a week and flour tortillas and *cocidos* (stews) every two weeks. She indicated that beans and *cocidos* consume a lot of gas since they need to be heated for more than 2 hours. During the winter she heats 3 liters of water every day in her gas stove for washing dishes and making coffee, and 30 liters for bathing. In the summer she only heats about a liter of water for making coffee daily. Members of Marta's family do not need to heat water for bathing because it is usually warmed by the sun in their large plastic containers.

Before receiving the solar pot, Marta usually used her gas stove for cooking eggs, sausage, reheating tamales and beans, and making coffee for breakfast. For lunch she cooked chicken, meat, beans, meatballs, soups, potatoes, stews, fish, and enchiladas in her gas stove. At night her family usually ate bread with beans, quesadillas, hotdogs, or tacos. Marta's mother likes to cook special dishes during the weekend. Usually she makes shrimp or fish ceviche or tamales.

Marta has been one of the main solar pot users in Flores Magón. She was very enthusiastic about experimenting with this technology as she tried to cook different recipes. She told us that her husband suggested that she should use the solar pot every day in order to save gas. She found this pot very useful and easy to use. She usually places the pot full of ingredients outside around 9 o'clock in the morning and by mid day her meal is fully cooked. She was impressed by the smell of the food and its taste. During an interview, she commented, "La comida sale con un olor bonito." (Food comes out with a pretty smell.) Most of the meals that were cooked in the pot were eaten by Marta's mother, sister and children during lunch time.

During her first week of experimenting with the solar pot, Marta successfully cooked meat, chicken with broccoli, liver, and rice. She said that at first it was hard to know how much salt and water were required for the foods that were prepared in the pot. During the following months Marta experimented with cooking other foods, such as cakes, vegetables, and sweets. By June she also had tried cooking chicken legs for her dog, and *agua de jamaica*.

Table 3.6. Marta's Cooking Habits March to June 2006

Month	Frequency of Gas use	Frequency of Solar Use	Types of Food Cooked in the Solar Pot
March	14	4	Chicken, liver, rice, carrot cake, meat
April	29	12	Chicken, meat, soups, beans, pasta, meat, pork with chile and potatoes
Mayo	31	16	Rice with milk, nopales, chicken innards, ground beef with potatoes, liver, Jamaica drink, carrot cake, lentils
Junio	28	14	Foods not known because Marta began using the SHE-Inc monitoring calendar. (See Appendix 6.)

Marta can be considered an active solar user. She has consistently increased the use of the solar pot in four months and also tried cooking a variety of foods. On average she uses the pot three to four times a week for cooking at least one main course for her lunch. Her relative decline in using the solar pot during the month of June was mainly due to the beginning of the monsoon season and also to the end of school activity. She told us that for a week she was busy going to her children's school in order to attend their registrations and graduations. However, Marta has not reduced using her gas stove. She indicates that everyday she uses it for making coffee and eggs for breakfast. Nevertheless she told us that her gas cylinder has lasted longer since she started making slow-cooking foods in the solar pot. In sum, the solar pot has become a clear complementary technology in Marta's household cooking practices.

Marta indicates that she likes this technology very much, and she is happy that other women are experimenting with it. She recently agreed to become a local monitor for SHE-Inc, a non-profit organization that manufactures solar pots in Mexico. Her positive experience with this technology is crucial since she has been disseminating in the community the advantages of cooking with solar energy.

Julia: Experimenting with Solar Pots

Julia was invited to participate in the solar workshop held on March 18, 2006 in Flores Magón. She seemed very active during the workshop, as she participated in the preparation of cooked vegetables. Julia received the solar pot on the 20th of March. A week later we came to her house in order to conduct a household interview and learn about her cooking practices.

Julia is from Sonoita, Sonora, and her husband is originally from Chihuahua. They have been living in Flores Magón for 10 years. She is the mother of three children; two girls who are in high school and a boy who is about 10 years old. Her husband works as a mason, and she stays at home most of the time. Yet when income is needed she may work temporarily in local factories at night.

Julia's house is composed of two separate structures. One is a room made out of cinder blocks covered with a flat concrete roof. All five members of the household sleep in this room. The other unit is used as a kitchen and eating area. It is made out of particle boards and palettes, covered with corrugated metal. This structure was part of the original house the family built when they arrived at the colonia. The family is planning to build a new kitchen and living room out of bricks and cement. Julia's house may be considered lower middle class in Flores Magón. It is a house under construction, and the family is gradually replacing the temporary lower cost materials with bricks and cement. However, the house lacks glass windows and running water. Julia does not have a car and relies primarily on public transportation or rides from friends and neighbors. Julia told us that she is not economically stable. On several occasions she has had to pawn personal jewelry in order to pay her bills. She wishes to provide more financial stability for her children in order help them complete their educational degrees.

Julia and her daughters are usually in charge of cooking. Yet she says that her husband also likes to cook. They have an old four burner gas stove and an electric pan. Julia also cooks beans and stews on a grill that she places over two cinder blocks. She usually collects wood from wherever she can find it. Sometimes when her in-laws come to visit, they bring whatever wood they can find on the road. Julia told us that she already had burned her wooden fence, which was made out of factory palettes and recycled wooden scraps. When she runs out of gas, Julia uses the electric pan and the grill for several weeks until she can get money to buy new gas cylinder. During the winter, her 30 kg gas cylinder lasts about two months, while in the summer it may last three months since she does not need to heat water for bathing. She also has an electric heater that she uses only when it is very cold.

Before receiving the solar pot Julia usually cooked eggs and coffee in the morning on her gas stove. At noon she cooked soups, cabeza, beans, stews, and squash. At night the family would eat ceviche or bread.

Julia told us that she likes to use the pot very much. She thinks it is very useful, especially when she runs out of gas. Instead of burning wood, she started using the solar pot to cook beans. She cannot cook such foods in her electric pan. She started using the pot in March with certain frequency. In April her frequency of solar pot use decreased due to Easter Holidays. In May she went to Caborca to visit her family. Thus, she did not use the pot during this period.

Table 3.7. Julia's Cooking Habits before receiving the Solar Pot

Food	Frequency	Type of Stove	Time/Quantity	Quantity of Wood
Beans	1 x week	Gas Wood	1Kg / 3 hours 1 Kg/ 2 hours	2 racas[2] (6,605 cubic inches)
Tortillas	1 x week	Gas	1 Kg /30 min	
Soups	1 x week	Gas	30 min	
Stews (cocidos)	3 x week	Gas	2 hours	
Water	Every day for coffee during the winter and the summer	Gas Wood	1 liter 1 liter/ 15 min	6 tablas 15'' x 4'' x 1'') (360 cubic inches)
Water	Every day for bathing during the winter	Gas Wood	6 liters	

Table 3.8. Julia's Cooking Habits March to July 2006

Month	Frequency of Gas Use	Frequency of Solar Use	Types of Food Cooked in the Solar Pot
March Starting on the 20th	12	2	Beans, squash with cheese
April	6	4	Chicken, meat, squash
May	0	0	-
June	28	8	Chicken, squash, carrots with potatoes
July	19	14	Chicken, squash, potatoes

Julia started increasing her use of the stove very gradually. During the month of May, she did not use it at all because she went for vacations and visited her family at Caborca, Sonora. Table 3.8 shows that she has not experimented cooking many different kinds foods, nor did she try to cook beans again after trying it for the first time. We do not know the specific reasons for this pattern, but it seems clear that she has not started using the solar pot for making most of her slow cooking meals. We will require more data in order to understand if this pattern may change in the winter, and whether she may be inclined to use the solar pot even when it is cold. It is likely that Julia will use more wood during the winter.

Overall, Julia indicated that she likes the solar pot and expects to use it with more frequency. Yet, she argues that she does not have a good location in which to place it. She does not have a fenced patio, and she feels she cannot leave the pot unsupervised.

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[2] A medium raca or tarima is wooden shipping pallet composed of 16 wooden crossbeams (40 inches x 4 inches x 1 inch = 160 cubic inches) supported with 9 wooden pieces (5 inches x 5.5 inches x 3 inches = 82.5). The total volume was roughly estimated to be 3,302.5 cubic inches. This volume was estimated based on what participants considered to be a middle size raca. However racas may vary in size.

Diana: Eco-Stove User

Diana attended the introductory workshop held on February 25, 2006. During this event she expressed interest in using the Estufa Justa. Weeks later we conducted a household assessment at her home in order to evaluate if an Estufa Justa would be a good option for her family. During this interview we learned that she wanted to construct the Estufa Justa outside, on the side of the house. She said that she was planning to enlarge her kitchen on that side of the house and that she would like to replace her current barrel stove since it produced a lot of smoke.

We also learned that Diana is from Chihuahua. Her husband is a mason and she has two young girls. Their house is a one room structure with a bathroom, made out of cinder blocks covered with stucco. It has ceramic floors and a flat cement roof. Her household would be considered middle class in Flores Magón.

Diana works at home and she is in charge of cooking all meals. Before receiving the stove she cooked on a four burner gas stove and in a homemade barrel stove. She always made quick foods such as eggs, coffee, and vegetables on her gas stove. She cooked beans twice a week on her gas stove or on the barrel stove, depending on whether she had gas or not. She also cooked tortillas every third day on her gas stove. During the winter, every day she would heat water for bathing and coffee and for making stews on her barrel stove. In the summer she does not heat water for bathing.

We returned a week after our initial visit, in order to start the construction of the Estufa Justa. Igancia's husband provided enthusiastic and skilled assistance with this stove. As soon as we arrived with the building materials, he set to work and impressed us with how rapidly he understood the stove and with his skill at building. This type of collaboration helped us immensely as he was able to build another stove for one of his neighbors, requiring only our assistance with acquiring materials. This participation indicates how much Diana wanted to participate and her willingness to convince her husband to donate his time. He also saw the benefits of the new stove design and utilized his new knowledge to construct another stove right away.

Diana started using the Estufa Justa with a lot of frequency and enthusiasm. During our first monitoring interview she expressed that she was very happy and proud of her new stove. She did not complete the monitoring forms by herself because she does not feel comfortable writing and reading. In turn we decided to gather verbal data on her new cooking habits twice a month.

During our first visits in the month of March and April we learned that Diana used the Estufa Justa almost everyday to heat water and to cook stews, beans, chicken. She told us that she had cooked a stew in two hours and that she only used three pieces of wood (approximately 1,500 cubic inches). She explained that before, in her barrel stove, she used to burn 1 ½ raca (approximately 4,962 cubic inches) for cooking a stew for about three hours. She also said that the Estufa Justa did not emit any smoke, as did her old stove.

During subsequent monitoring visits, Diana told us that she had cooked beans, tortillas, tamales, potatoes, fish, and meat on the Estufa Justa. She indicated that her new stove would consume a lot less wood than her old barrel stove. She said that now she was able to cook many more foods with the same amount of wood. For instance, she was able to heat water, tortillas and cook vegetables with about 15 pieces of wood[3] (approximately 270 cubic inches). Before, she would burn this same amount of wood only for heating water.

[3] These pieces of wood were construction scraps brought by Diana's husband.

Diana also told us that before she would burn 1 raca (3,302.5 cubic inches of wood) for cooking beans. Now she can use the same amount of wood to cook her usual quantity of beans, water, tortillas, and a stew. She said,: "…Antes una raca se me iba en un ratito y nada mas podía hacer el puro fríjol." (Before a raca was gone in little while, and I could only make beans). She also indicated that her old stove would consume a lot of wood just to start heating the food. She pointed out that now when she runs out of gas she can rely on the Estufa Justa since she can cook many things with it. She explained that now her gas may last three months and that she will also use less wood.

Diana also added that she liked that the Estufa Justa did not produce smoke. She explained that before her barrel stove used to produce a lot of black smoke and soot. Diana feels very proud about her new stove. She said that many neighbors have stopped by to see it and have told her that they also want to build one. In addition, she said that her husband also likes the taste of beans and tortillas, when cooked on fire wood, and that he encouraged her to use the wood stove with more frequency.

<u>Lupita: New Solar HotPot User</u>

Lupita attended the solar work shop held in Flores Magón on the 6th of May. The following week we went to her home in order to ask her general questions about her everyday cooking practices. Lupita stays at home during the day and is unable to afford to use gas for the majority of her cooking. She uses wood that she collects to cook anything that takes more than a few minutes, especially beans, rice, tortillas, soups, and hot water for bathing. She uses a 55 gallon barrel that has been converted into a stove by removing the top and placing it inside the barrel to serve as a grate for the wood. Before receiving the solar pot she used to make slow-cooking meals in her barrel stove, such as beans and stews. Lupita also uses an open fire on the ground with a grate and two cinder blocks.

One of the most prolific solar users to come from the project, Lupita, a middle aged woman with three school age children, is from rural Sinaloa. She has two more children who live in Sinaloa but are now adults and independent. Lupita's house is made out of particle board and corrugated sheer metal, and has dirt floors. Immediately adjacent to this structure Lupita's family is building a cinder block structure. Lupita does not have running water, and she showed us how her neighbor's sewage runs into the house.

Table 3.9. Lupitas Cooking Habits before receive the Solar Pot

Food	Frequency	Type of Stove	Time/Quantity	Quantity of Wood
Beans	1 x week	Wood	4-5 hrs/2-3 kg	10 tarimas
Tortillas	2 x week	Wood	1 hr/2 kg	3 racas
Water	Every day	Wood	20 l	3 racas

The addition of the solar pot to her appliances enabled Lupita to dramatically decrease her wood burning. In comparison to other participants, Lupita has one of the higher frequencies of monthly solar pot use. She claims that she has almost stopped all wood-based cooking of beans and now uses only the solar pot. Lupita's substitution of solar for wood in the case of beans has enabled her to significantly reduce her wood use. She has also tried to cook a variety of food in her solar pot such as cakes, meats, grains, rice, pasta eggs soups and vegetables. Her monthly use of the solar pot also shows a gradual increase.

Table 3.10. Lupita's Cooking Habits May –July 2006

Month	Frequency of Gas Use	Frequency of Wood Use	Frequency of Solar Use	Types of Food Cooked in the Solar Pot
May	31	1	13	Carrot cake, beef soup, corn with vegetables, rice, beans, eggs, pasta, meat, and soy beans.
June	30	1	18	Chicken soup, meatballs, tuna with vegetables, beans, mole, rice with milk, beef soup, chicken, meat with chile and heat water,
July	31	0	19	Beef and vegetable stew, beans, meatballs, vegetable soup, rice, Jello, nopales with meat, mole, lentils, water (heated), tuna fish with potatoes, tomatoes and chiles.

In sum, we consider Lupita to be an active user of the solar pot. Her data shows a good adaptation of this solar technology to her everyday cooking practices. However, more data will be required in order to know if she will keep using the solar pot during the winter. She may shift to wood-burning devices in order to heat her home.

Ana Maria: Eco-Estufa User

Ana Maria participated in our first workshop held in Bella Vista on December 10th. She expressed interest in constructing an Estufa Justa at her home since she mainly cooks during the winter on a home-made barrel stove. Later, in February we went to her house in order to conduct a household assessment and evaluate if this stove would be suitable for her needs. During this interview we agreed to construct the stove outside of her house.

Ana Maria is a single parent of four children. She is originally from Cananea, but was raised in Carbo, Sonora. She has been living in Bella Vista for five years. She is in charge of cooking and stays at home in order to care of her children. She is regularly visited by her brother who provides her some economic support. She also has close relationships with her sister and aunt who live close by, and who also help with her children.

Ana Maria's house has two bedrooms and a kitchen area made out of particle boards, palettes, and recycled materials. The structure is covered with corrugated metal and has dirt floors. Her house lacks insulation materials in the windows and doors. She is not the owner of this property and has been requested to move her house to another area of the lot. This is why Ana Maria requested we build the stove at the place where she expects to build her new kitchen.

Every morning Ana Maria cooks eggs with ham, sausage, coffee, and beans in her home-made barrel stove. For lunch she cooks potatoes with bologna, soups with chile and cheese, and at night she may eat bread, beans, or reheat leftovers. Although she has a gas stove she usually cannot afford to buy gas. Thus, most of the time she burns wood, which she gathers at the garbage dumpsite in the colonia. Every week she and her sister collect pallets, pieces of old furniture, and wood construction scraps among other recycled materials.

During the winter Ana Maria turns on her wood-burning stove at 6:00am and keeps feeding the stove with wood all day, until 9:00 pm. She explained that her house gets very cold because she does not have windows and her walls are not well insulated. Thus she uses her stove as a heater for keeping her children warm. During the winter she consumes an average of 2 to 3 racas per day (3,302.5 cubic inches of wood per raca) for cooking and keeping the house warm. During the summer she may use the stove in morning and let it cool down until she needs to cook something for lunch or dinner.

Table 3.11. Ana Maria's Cooking Habits before receive the Solar Pot

Food	Frequency	Type of Stove	Time/Quantity	Quantity of Wood
Beans	2 x week	wood /gas	3 hours/1 kg	1 ½ raca
Tortilla	2 x week	wood/gas	1 hour /2 kg	1 raca
Water	Every day during the winter for bathing and coffee. During the summer, only for coffee	wood/gas	30 min/	½ raca

During the month of June, Ana Maria started using the stove al least twice a week. She mainly cooked slow coking meals such as beans and some stews. She also made her regular amount of tortillas. Yet when temperatures rose in the month of June and July Ana Maria started using the stove only once a week to make beans. She indicated that it was too hot to turn on the stove everyday. In turn, she tended to cook more quick meals, such as eggs and soups in her gas stove. Yet, she explained that in the winter she expects to use the Estufa Justa everyday for cooking most of her meals.

Initially, Ana Maria had said that she wanted the stove outdoors, but as this indicated that the stove would not be used for heating the research team set about designing a portable stove that could suffice for a heater and an outdoor stove. The reason that Ana Maria could not have a permanent stove inside the house is because the house itself is in danger of falling over the hillside and she needs to remove it and build a new house in the near future, thereby making the investment of a permanent stove in an impermanent structure unwise. However, the portable stoves produced in Nogales seemed too small to meet her needs, so Ana Maria decided that she would prefer to have the permanent structure after all. It is important to note that the size of the stove was an issue as well for most participants who wanted something that was portable and could fit into a cramped household.

For the majority of the Estufa Justa Participants, it was requested that they find a relative or friend to help with the labor, but considering Ana Maria's position, the team decided to build the stove without additional assistance. Three members of the research team set about constructing the stove with help from Ana Maria and her children. The stove itself was built without incident and the actual construction was only more difficult due to the difficulty of reaching the site. The tire stairway has been washed away and one must climb up the side of a hill and swing everything over a fence to get to her house. With some of the heavier materials, this proved quite difficult.

Ana Maria initially told us that she liked the stove because it consumed less wood. She said that before she would spend around 1 ½ raca for cooking her beans, while now she would only spend half a raca. However, she reported having some problems with the process of feeding wood into the stove. She said that the elbow stove design tended to suffocate the fire with excess ash in a small area. She also explained that the "plancha" (the smooth metal cooking surface) was too thick and would take too long to get hot and she has also voiced a concern that the concentration of flame on one spot of the stove limits the heat on the periphery of the cooking surface. We are now working toward fixing some of these technological problems with the stoves. Participants' experiences and comments have been crucial in understanding how and why they may or may not shift to use a new technology. After visiting her home to address some of these problems it was noted that due to the heavy rains, much of the insulating ash has been washed away from the inside of her stove and more must be added to raise efficiency.

Overall our data suggests that Ana Maria has replaced her home-made barrel wood burning stove with a more efficient stove. Yet more data is required of her cooking practices during the winter in order to analyze the frequency of use of her Estufa Justa. However, the sharp contrast in her experiences with the stove show that there is more work to be done. Again, we note that participants do not rely on a single cooking technology. Shifting towards more efficient wood burning devices depends on changes in temperature, economic resources, and whether or not the technology meets participants' expectations.

Berta: Experimented with Solar HotPot

Berta participated in our first focus group discussion held in October, 2005 at the Casa de la Misericordia in Bella Vista. In a group of about 12 participants, Berta actively shared some of her knowledge about cooking with wood burning stoves. She also told us about local wood gathering practices. During this activity we invited Berta to participate in an introductory workshop, which was held in the Casa Misericordia on the 10th of December of 2005. Berta's daughter went to the workshop on behalf of her mother. The next day we went to her house in order assess which device would be more suitable for her needs. Berta expressed more interest in the solar pot, since she recently purchased a used manufactured wood burning stove. Thus, that very same day she received a solar pot in order to start testing this technology for the first time in the colonia.

Berta is in her fifties and lives with five of her adult children. She is originally from Nogales and has been living in Bella Vista for more than 20 years. She mainly works at home packaging foam materials for factories (maquilas) located in Nogales. She also goes every week to the colonias' garbage dumpsite in order to collect scraps and recycled materials for building parts of her house, or to be used as combustible in her wood burning stove. Her children also bring some income to the household. Bertas's other two married daughters live close by and they tend to leave their children at her house while they work at local factories. Usually Berta's 17 year old daughter stays at home taking care of her nephews and cooking when her mother goes out to the colonias's garbage dumpsite (*tirabichi*).

Berta's house has one bedroom and a kitchen made out of cinder blocks. She has cement floors and her roof is made out of corrugated lamina. She has a porch fenced with recycled metal bars. Inside her kitchen she has a four burner gas stove and a portable single burner gas stove. On her porch she has a manufactured wood burning stove.

During the summer Berta uses the gas stove for cooking eggs and coffee for breakfast. For lunch she usually cooks in her gas stove soups, tortillas, rice, nopalitos with meat and chile, and ground beef with vegetables. For dinner she reheats leftovers or eats bread and beans. She also uses her wood burning stove to cook beans, but when she runs out of gas she may spend many days cooking all of her meals with the wood-burning stove. Throughout the winter, Berta places her wood-burning stove inside her house. She burns wood all day in order to keep her house warm and also for heating water and cooking beans, stews and tortillas. She told us that she and many people also burn clothes, packaging foam, and recycled paper when they cannot find wood.

Table 3.12. Berta's Cooking Habits before receive the Solar Pot

Food	Frequency	Type of Stove	Time/Quantity	Quantity of Wood
Beans	1 x week	wood /gas	3 hours/1 kg	1 raca
Tortilla	2 x week	wood in the winter, gas in the summer	1 hour /2 kg	1 raca
Water	Every day during the winter for bathing and coffee. During the summer, only for coffee	wood gas	30 min/	½ raca

After receiving the solar pot, Berta reported using it only twice in the month of March. After subsequent monthly visits at her home between the months of March and June we found out that she was not using the solar pot at all. She even gave it to a neighbor so that the neighbor could try using it. Thus, we conducted an interview with Berta in order to find out why she was not using the solar pot. Berta explained that she liked the pot but that she did not have time to use it. She said that she was scared of leaving the pot unattended when she goes out to the garbage dumpsite to collect wood or recycled materials. She explained that she has too many children at home at that she fears that they might break it or get burned. She also does not trust her youngest daughter to take care of the pot when the children are around. Berta explains that if she would have to cook beans or lentils in the solar pot she would have to stay all day watching the pot. Berta's explanations illustrate the complexities of shifting from one technology to another. She perceives the solar pot as dangerous and time consuming, even though solar pots were designed to be safe and to require less attention from the users. In addition Berta does not consider the pot adaptable to her household activities and lifestyle. Her data confirm that every household has different needs and perceptions of risk. In sum, adaptation of new technologies requires changes in perceptions as well as changes in people's everyday habits.

Stoves Summary

A key finding of the stove assessment is that households that burn wood as fuel generally require multiple options for meeting their cooking needs. Solar stoves are emissions-free stoves that require little to no maintenance and no fuel purchasing or collection. Solar energy is available year-round in Nogales, though insolation levels during the months of November, December, and January fall below the ideal 4 $kWhr/m^2/day$. As far as could be determined by the research team, solar cooking has never been systematically tested and evaluated in Nogales. A study conducted by the German Corporation for Technological Cooperation (GTZ), which tested six types of solar cookers in 200 South African households, revealed the following: (a) solar cookers complement but do not replace conventional cooking fuels; (b) commercial solar cookers range from $30 to $100 each; (c) to be widely accepted, cookers need to be user-friendly, efficient, durable, and affordable; and (d) at the time of the study, no solar cooker could satisfy all these requirements (OECD/IEA 2001). This same conclusion guided SHE-Inc, a US-based non-profit organization, to develop the HotPot, a new solar cooker that is efficient and affordable. SHE-Inc was eager to contribute to this project and had connections to a manufacturing plant in Monterrey, Mexico from which it was relatively easy and inexpensive to ship the stoves.

The wood gas and rocket elbow stoves increase the efficiency and reduce the air emissions of wood burning. Because scrap wood is available in Nogales and is commonly used by people without alternative sources of fuel, evaluation of more efficient and safer stoves was considered necessary. Research into companies providing various types of wood gas and rocket elbow stoves revealed that the cost of shipping alternative stoves to Nogales would make the cost of the stoves too great for the users who most needed them. The MIDGE and Estufa Justa were selected because they could be readily constructed in Nogales. Still, finding a builder for elbow stoves proved to be challenging.

Alternative stoves will only become widely used in Nogales, Sonora if they are available locally – for purchase or construction. The solar HotPots are manufactured in Monterrey, so they can be shipped within the country. Nevertheless, shipping increases the costs to the individual. Several study participants expressed interest in becoming HotPot distributors in Nogales, and this will be pursued in the future. It will require additional effort to find local builders of elbow stoves or another source of such stoves within Mexico.

Construction – Issues for Nogales

Improving housing construction is a less direct way to reduce emissions from wood burning than changing stove use, but it nevertheless warrants attention. A well-designed home will require less heating in the cold weather and can therefore contribute to a reduction in indoor wood burning. A well-designed home will also stay cooler and more comfortable in hot weather.

To be effective, a new approach to construction in Nogales must be appropriate to the expectations and resources of community residents. During this assessment, BARA researchers gathered information on alternative construction technologies, conducted interviews with experts who have utilized various alternative or “green building” approaches in many parts of the world, conducted interviews with Nogales residents and a did a visual assessment of one colonia to learn more about typical approaches to construction in the colonias, and held several workshops to share information about the alternatives and get feedback from participants.

Literature Review and Interviews with Experts

Concerns about the cost of fuel, thermal efficiency, and the desire to reduce the ecological costs of construction have stimulated the design and use of a wide variety of alternative construction materials (see Appendix 7). Principal factors in the selection of materials are cost, availability, safety, security, and community acceptability. Some common alternative technologies, such as straw bale, are inappropriate for Nogales because the materials (e.g., straw) are not available locally in large quantities. Others, such as Earthships or used tire structures, have proven to create significant indoor air quality problems for those living in them. Interviews with architects, planners, and experts in alternative construction produced the following principles and recommendations for the introduction and use of alternative building technologies.

- Regardless of the materials used in construction, households can achieve significant energy efficiencies by adapting to local climactic conditions, siting their buildings properly to take advantage of winter solar radiation and protect them from summer sun, and using ventilation mechanisms and strategies that move air throughout the home but minimize direct airflow between the inside and outside of the home. General information on ecological design can be found in Van der Ryn and Cowan (1996) and the website of the Ecological Design Institute, http://www.ecodesign.org/edi/aboutedi.html.

- In Ambos Nogales, summer heat is strongest from 13:00 to 18:00 each afternoon, with the western side of a structure absorbing the most heat. During winter, sunlight is strongest from 12 noon to 14:00 hours, and the maximum amount of sun exposure is toward the south. Some common-sense and well-known siting strategies include: (a) strategic placement of windows (not on the western side); (b) planting trees on the west side to serve as shading; trees should drop their leaves during winter to allow sunlight/heat to pass through to the structure; (c) use of cross and vertical ventilations (attics and cooling towers); (d) use of overhangs to minimize direct sunlight and heat; and (e) use of pergolas, ramadas, and window levers. Native trees such as Palo Verde and mesquite are good choices for shade because they need minimal water and are adapted to Nogales' climate. Ramada and pergola structures use a post and beam skeleton with perforated wooden slats to minimize direct sunlight and heat and control the microclimate surrounding a home by providing something through which the wind moves. Canvas coverings also can be used to capture moisture to help cool the air

- The roof, floor, and wall systems all require attention. Roofs are a critical part of the house in terms of energy efficiency and can be put to good use helping to manage a home's microclimate. Roofs should be used to reflect heat, collect water, and if feasible, collect energy (solar). Captured rainwater can be used to irrigate the landscape that helps control the microclimate of the structure. Roofs are also excellent sites for rooftop gardens. Roof insulation is very important, as is directional siting of roof panels. Significant heat loss can occur during cold months through cracks, leaks, and spaces that allow airflow between the inside and outside of the home, such as doors, windows, and the roof. Efforts should be made to reduce such loss by repairing cracks and leaks and reducing the spaces that allow airflow.

- Round/spherical structures require the least amount of materials. A curvilinear roof provides more light to penetrate and more shade, and is leak proof. It expands or contracts according to climatic conditions.

- A rain screen, which is a steel stud that creates a second wall approximately six inches from the main wall between the interior and exterior of the structure, traps air that is then heated or cooled and serves to insulate the home and control moisture.

- Key factors in the selection of building materials are: (a) availability; (b) cost and affordability; (c) time and effort to be devoted to the construction; (d) durability and life cycle of the building; and (e) ecological surroundings. Transportation costs must also be considered. Choosing an acceptable mix of building materials that addresses these variables is very difficult and may require significant compromises. Economic analysis of house construction looks at the prices of fixed costs (materials, labor, land, etc). but should also take into account future savings in fuel, the resilience of the structure, and the costs of upkeep, maintenance, and replacement. Selection is influenced specifically by the cost of labor, which can vary in locality and over time.

- To achieve maximum success, materials with a high thermal mass should be prioritized. Thermal mass, as opposed to simple insulation, allows air to move from one side of a wall or roof to another and is especially critical in areas, like Nogales, that experience high swings in temperature and relative humidity. High thermal mass also minimizes problems related to poor indoor air quality because it allows the exchange of air between the inside and outside of a building. At the same time, materials that facilitate thermal bridging (passage of heat from one side of a wall or roof to another) should be avoided.

- Adobe, a mixture of sand, silt, and clay, has a long history in Mexico, is a proven technology, and is structurally stable, but it is very labor intensive and is generally perceived to be the building material of the poor. Both brick and slipform construction are acceptable approaches for construction. Rammed earth structures are essentially a slipform approach to adobe.

- The region that includes north western Mexico and the US southwest has a long tradition of masonry; concrete slab construction is much more common than is wood.

- Construction technologies that can be formed by hand, are low-tech, solar dried, and can be used in self-help construction are likely to have the best chance of success.

- The single family residence is neither environmentally nor economically sustainable. In urban areas, free-standing homes are materially wasteful, use land inefficiently, and are not sustainable. The multiple story structure is more appropriate for densely populated areas, is cheaper to construct, and has lower environmental costs for individuals, the community, and the government.

In summary, alternative construction involves more than just selection of new types of materials. Equally important are building orientation, use of windows coupled with external vegetation and structures to maximize solar penetration in the winter and then provide shade in the summer, and the overall design of neighborhoods to support multi-family and multi-story structures. When building materials are considered, those that have high thermal mass, are amenable to use in self-help construction, and use masonry rather than wood are most likely to succeed. Buildings that are already constructed or under construction can be made more thermally efficient by adding insulation to walls, doors, roofs, and floors.

Interviews, Workshops, and External Home Assessment

colonias are developed in stages, and residents build their homes over time, often starting with simple structures and adding to those as they acquire the resources necessary to do so. Therefore, a significant number of homes in Nogales are under construction at any point in time. Two approaches are common. First, residents erect a temporary structure on their lot and were living in that structure as they construct their more permanent home. Second, residents complete one level of their home and live in the completed portion of the home while constructing additional levels.

Researchers conducted the visual external construction assessment and interviews with residents in Colonia Bella Vista in May and June 2006. Houses in Colonia Bella Vista are constructed of cinder blocks, wood, bricks, and metal sheeting. In order of prominence, walls are constructed of cinder block (vast majority), wood, and brick. Roofs are constructed of metal (vast majority), cement (especially in two-story structures), and shingles (rare). The maximum number of stories per house is two, and about a third of the homes were under construction during the assessment.

The majority of houses have doors and windows made of wood and glass, though a very small number have only blankets or cloth coverings. Houses were also examined for the presence or absence of gutters and downspouts, doors, windows, and door and window protection. Collection of rainwater offers a potential source of water, but only a few homes in Bella Vista have gutters and downspouts for rainwater collection. In contrast, the majority of homes have bars on both windows and doors for protection. Security concerns were identified during interviews and focus groups as a major issue for many urban residents, and these are reflected in the investment in protection measures.

Following the interviews and external home assessment, researchers organized workshops to present the three construction alternatives that were determined most appropriate for Nogales: (1) papercrete, (2) other earthen technologies such as rammed earth and cast earth; and (3) sandbags (see Appendix 9). All use locally available materials, can be constructed using the skills of local residents (though all require some training and practices, some more than others), and can be used to construct thermally efficient buildings. Another material, Aerated Autoclave Concrete, was initially included in the workshops but was eliminated because the material can only be produced in an industrial plant. While it deserves additional attention in the future, the infrastructure necessary to produce AAC does not presently exist in Nogales.

Two introductory presentations/workshops were prepared and offered to Nogales residents and community leaders. The first was a presentation and question-answer session for members of the Asociación de Profesionales en Seguirdad y Ambiente (APSA) and the second was a workshop held on June 10 at the Casa de la Misericordia in Colonia Bella Vista and attended by residents and leaders of colonias Bella Vista, Flores Magón, Jardines del Bosque, and Villa Sonora, members of APSA, and faculty and students from CONALEP and ITN. The principal advantages and disadvantages of the three selected technologies are presented in Table 3.13.

Table 3.13. Advantages and Disadvantages of Three Selected Construction Materials

Type of Material	**Papercrete**	**Rammed Earth/ Cast Earth**	**Sandbags**
Advantages	• Mixture of water, sand, recycled paper, and Portland cement • Is economical and environmentally friendly • Has a high R-value (good insulator), higher than cinder blocks or bricks • Mixture can be made by people of many ages and skill levels • Can produce bricks as strong as regular bricks • Uses any type of paper, though newsprint is most effective • Used for walls, roof, and mortar • With more cement and less sand, mixture can be used as plaster • Covered with a layer of stucco, walls do not absorb water • Is fire and insect retardant • Doors and windows can be cut into walls at any time to expand a structure • Can be made as bricks or slipformed • Can be made into thin panels and used to insulate walls and roofs • Can be used for one or two-story structures	• Mixture of earth (sand and clay) and Portland cement • Is economical and environmentally friendly • Can be compacted by hand or with mechanical or pneumatic devices • Rammed earth is slipformed for more rapid and uniform construction • Cast earth can be made into blocks of any shape • Strength can be increased with additional mortar • Has high thermal mass • Can be used with plaster or stucco • Is fire and insect retardant • Can be used for one and two-story structures	• Mixture of sand, stabilized with cement, lime, or asphalt emulsion • Is economical and environmentally friendly • Filling sand bags can be done by people of many ages and skill level • Dome and vault designs are very stable • Is fire and insect retardant • Has high thermal mass • Structures can be built quickly
Disadvantages	• Roof requires wooden lattice or beams • Mixture requires a lot of water • Requires a lot of manual labor • Large quantities of recycled paper, sand, and water must be transported to the construction site • Low thermal mass	• Requires beams for support	• Requires a massive weight to be stabilized • needs to be distributed properly • Properly distributing the weight of the sand and designing/ executing a vault/dome structure requires skills and experience • Most common in single story structures

Figure 3.4. Smoothing out a papercrete bench at Desert Shadows Middle School

At both introductory workshops and in discussions with experts and local residents, papercrete was selected as the most popular technology and the one that residents and community leaders wanted to pursue. Individuals at both the Casa de la Misericordia and ITN had investigated papercrete in the past and were pleased to learn that it would be re-introduced to Nogales. In addition to the introductory workshops, two hands-on workshops were held at local schools, one at Desert Shadows Middle School in Nogales, Arizona (see Figure 3.4) and the other at CETis 128 in Nogales, Sonora. The purpose of these workshops was to introduce papercrete as a low-cost but durable material that could be used for constructing benches that would be used for outdoor classrooms and learning centers while at the same time serving to demonstrate the technology within the communities and test its durability and performance in the Nogales climate. Both schools have requested that additional benches be constructed on their campuses during the fall of 2006 (see Chapter Four).

Construction Summary

There is a general hierarchy of home construction preferences in Nogales, Sonora, beginning with scrap wood and metal sheeting, advancing to concrete blocks, and ending with bricks. Within the colonias, many homes are constructed by residents or their relatives or friends. The most common building type in Colonia Bella Vista is cinder block construction. This reflects the status of the colonia as one of relatively advanced age and level of development. Lack of thermally efficient roofs is a particular problem in Colonia Bella Vista, and throughout Nogales. Security is very important to Nogales residents, and residents are very likely to invest in protection measures such as bars on windows and doors

Efforts to introduce more efficient building technologies will be successful if they match local practices and preferences. Common construction material alternatives such as straw bale are not appropriate for Nogales because of lack of basic materials and thus high transportation costs. Because roofs are critical for conducting or retaining heat, they play a critical role in thermally efficient housing design and require special attention. Many homes are already under constructing using cinder blocks, a thermally inefficient material. Increasing thermal mass and/or insulation for existing homes requires more attention.

Summary of Key Findings

A major factor affecting large-scale technology adoption is the level of local interest in and support for the technology and the introduction of that technology into the community. A major finding of this project has been that residents and community leaders recognize air pollution as a serious issue and express concern about the effects of burning wood and other combustible materials to both indoor and outdoor quality. In focus groups, at interviews, and during workshops, participants described problems with the use of open wood fires and inefficient cookstoves and expressed the desire for alternatives. As indicated by participation and interest in the hands-on workshops and distribution of alternative stoves, there exist high levels of support for the solar and elbow stoves and for papercrete in Nogales, Sonora. Participants not only expressed and demonstrated interest in alternatives, they worked with researchers throughout the project period to learn about them, try them out, and monitor their use. In summary, this project identified people from all sectors – neighborhood residents, NGOs, community development organizations, government, and academia – with an interest in supporting ongoing efforts in this area. This support can be translated into specific actions, as indicated in Chapter Four.

This study incorporated a research methodology that combined standard research techniques such as interviews and surveys with implementation through hands-on workshops followed by the distribution and monitoring of the selected technologies. Integrating findings from focus groups and interviews, workshops, and then stove distribution and monitoring proved critical for gaining an understanding of the range of conditions and circumstances facing Nogales households. The focus groups and interviews provided general information about the community; cooking, heating and construction practices; and household preferences. They were necessary for identifying the technologies to be introduced in the workshops. Selection of three alternatives was appropriate; fewer than that may have eliminated the options that were considered most likely to be adopted in Nogales while more than that would have required considerable time and resources to explore the technologies more fully with little likelihood of their eventual adoption. Nevertheless, it is important to note that new alternative technologies are being developed and implemented in many parts of the world, so it is necessary to continue to monitor the literature and watch for new options that may be appropriate to Nogales.

The workshops allowed researchers to observe reactions to the new technologies and gain additional information about feasibility, appropriateness to local circumstances, and the variation in households. Finally, the stove distribution and monitoring shifted the focus from the potential to the actual and revealed both challenges and opportunities for adapting the technologies for use in Nogales. The three approaches were complementary and allowed action to be taken (e.g., the distribution of stoves) during the assessment. This served to maintain high levels of engagement in the study and offered a more complete look at the feasibility and potential of alternative technologies in Nogales.

A key finding of the stove assessment is that households that live at the margin economically require multiple options for meeting their cooking needs; this finding is consistent with research done in other parts of Mexico and in Central America (Masera, Diaz, and Berrueta 2005; Zuk et al., 2006). Almost all households maintain more than one stove; most have access to gas stoves, which they use when they can afford and gain access to gas. A smaller number of households have electric cooking devices such as crockpots and tabletop electric burners. Wood stoves supplement the gas and electric stoves and are most frequently used to prepare food items such as beans and *menudo*, which take several hours to cook.

Three stove types were introduced to the community, two of which were selected by residents for further investigation. Forty-one households experimented with solar HotPots and six with rocket elbow stoves. The distribution of solar HotPots was greatly facilitated by donations from SHE-Inc. Problems developing locally-produced and adapted rocket elbow stoves prevented the construction and distribution of more stoves of that type. The choice of stove was also influenced by the season; most of the stoves were distributed in late spring when there was an abundance of cloudless days and solar energy. During the months of May and June, the solar HotPots were used to cook beans, menudo, and other foods that require several hours to prepare and are often cooked outside over open fires. Use of the rocket elbow stoves was generally low during the hot summer months. Because patterns of use were observed to vary significantly by season, further development, monitoring, and evaluation of the stoves is needed (see Chapter Four).

Most colonia residents build their houses in stages when they have materials and time. There is a generally accepted progression of housing materials used in construction, from wood and metal scraps, to cinder blocks, and then to bricks. Alternative materials will be most widely accepted if they can be used to build homes that look like block or brick homes but offer clear advantages to them. Of the construction materials introduced in this study, papercrete was the clear favorite in interviews, meetings, and workshops. Papercrete is made of recycled paper, sand, and cement. It was favored because it can be used to construct homes that look like block homes and are secure from theft, is made of readily available materials, can be made locally, is inexpensive, is thermally efficient, converts a waste product (used paper) into a resource, and is both fire and insect resistant. Potential problems with papercrete include the need for large quantities of water for production and the need for large quantities of paper and sand which must be transported to the production site. To fully evaluate papercrete as an alternative construction technology, it will be necessary to extend the housing construction assessment to small-scale implementation and monitoring (see Chapter Four).

Making housing construction more thermally efficient and environmentally benign will require more than simply changing the materials out of which structures are built. At each site, the home should be treated as a system with careful attention paid to building orientation and ventilation. Well-planned use of vegetation and outside structures such as overhangs, armadas, and window levers can significantly increase the energy efficiency of a structure. Regardless of building size or complexity, the builder can start with a few, simple strategies and graduate to more complex and expensive options. The strategies and options that are selected should complement one other. Finally, in contrast to the single-family dwellings that are prevalent in Nogales colonias, multiple story structures are cheaper, more environment-friendly, and can promote a sense of community (especially if privacy issues are addressed), and attention should be paid to developing thermally efficient multi-household units.

This project focused on evaluating potential alternatives to wood burning in Nogales. The research team also considered whether there exists the necessary social and financial resources to support the large-scale adoption of alternatives. Several solar HotPot users expressed interest in selling the pots to friends and family and the micro-credit organization BANCOMUN expressed interest in providing credit for small-scale venders. The logistics and costs of ordering solar HotPots from Monterrey, Mexico would be manageable for a small-scale enterprise. BANCOMUN would also consider providing financial assistance to help people obtain an ecological stove. Community members in Bella Vista and Flores Magón who helped with this project have the knowledge to build Estufa Justas and Eco-Stoves in the future and could be organized to provide workshops or manufacture the stoves on a larger scale (see Chapter Four).

CHAPTER FOUR: ACTION PLAN

The principal goal of this project was to assess approaches for reducing emissions generated by the use of wood and other combustible materials as fuels for household-level heating and cooking in Nogales, Sonora. The research team focused on two general approaches to reducing household-level emissions: (1) reducing the *impact* of household-level burning by promoting the use of less-polluting heating and cooking technologies, and (2) reducing the *need* for household heating by promoting more thermally-efficient house construction technologies. A key objective of this research was to match technological appropriateness (low emissions) with local cultural and material appropriateness. Thus, much of the research was directed towards assessing whether potential technologies were acceptable to residents of Nogales colonias, requiring the research team to consider the intelligibility of the technology, necessary behavioral or lifestyle modifications, the availability of local materials for use and construction, affordability, aesthetics, local climate, and safety considerations.

To reduce the *impact* of household-level burning, the research team identified, piloted, and assessed cooking technologies that either do not burn wood or burn wood more efficiently and with fewer emissions than common stoves. Researchers sought to minimize behavioral and diet modifications under the premise that these would decrease the likelihood of technology adoption. Researchers included wood-fueled stoves in this study, even though they will continue to release emissions into the air, because wood is a widely-used and affordable fuel in Nogales, Sonora. To reduce the *need* for burning, the team investigated construction technologies that are thermally efficient and require less home heating during the cold season.

The final step in this project was the development of an action plan that has the potential to achieve the larger scale adoption of the most promising methods and technologies, based on the results of all previous project phases. This action plan includes factors to be considered by community partners in pursuing and achieving implementation of effective methods to reduce emissions from wood burning. To this end, six actions are recommended for furthering the goal of reducing wood burning and its negative impacts in Ambos Nogales.

1. Develop a study to determine the nature and extent of wood and garbage burning in Nogales, Sonora

The current project has demonstrated that burning of wood and other combustible materials are linked. The focus of this study will be to characterize wood and garbage burning throughout the community and determine in which neighborhoods the approaches identified and evaluated in this study will be appropriate.

2. Continue to monitor solar and elbow stoves for at least six months

This task will enable members of the research team and the community to determine whether and how stove use changes seasonally and to gather the data needed to develop community-based programs for constructing, distributing, and selling alternative stoves.

3. Introduce solar and elbow stoves into at least two new colonias, involving experienced users as presenters

The current project demonstrated that local stove users are effective disseminators of information about alternative stoves. Throughout the project, stove users have been asked to help their neighbors and family members acquire stoves. Several present stove users will develop and deliver workshops to residents of at least two new colonias to further the spread of these technologies and help establish the customer base necessary for the successful development of community-based programs for constructing, distributing, and selling alternative stoves. This action will also include further investigation of the Potsari Stove and the potential for GIRA, the NGO that has helped design and distribute the stove, to expand its efforts north to Nogales.

4. Investigate additional stove and construction alternatives

After the stoves had been distributed and were being monitored, researchers became aware of GIRA, an NGO in southern Mexico that works in collaboration with the Center for Ecosystems Research of the National University of Mexico and other institutions to develop, evaluate, and promote the Patsari Stove, a locally adapted fuel-efficient stove design that was a 2006 finalist for the Ashden Awards for Sustainable Energy (see www.ashdenawards.org/media_summary06 _mexico). The Patsari Stove is similar to the Estufa Justa and Ecostoves introduced in this study; but it comes in four different models and may offer specific advantages for Nogales residents. To date, GIRA has only introduced stoves in central and southern Mexico, so the research team members will contact the organization and investigate the potential for expansion to the northern border.

5. Continue the development of construction alternatives

a. Hold another introductory workshop about papercrete and related alternatives
b. Construct papercrete benches
c. Hold a series of eight construction workshops to demonstrate the papercrete process and technology and result in the construction of at least two structures in Nogales.

Community leaders, teachers, construction workers, students and business people were invited to attend the workshops in the hopes that they would disseminate their knowledge of alternatives throughout Nogales through their regular work. One community leader in Flores Magón has begun to make papercrete additions to his house and restaurant and organized a workshop to share the technology with neighbors. Participants in the June 20 workshop organized themselves to develop a program for advancing papercrete construction in Nogales. To date, representatives from Colonia Flores Magón, the Casa de la Misericordia, the Associación de Profesionales en Seguridad y Ambiente (APSA), and CONALEP have taken the lead in pursuing papercrete construction during the fall of 2006. Representatives of these groups, assisted by BARA researchers, have begun to work closely with Mr. Barry Fuller of Tempe, Arizona (see www.livinginpaper.com) to develop an outline for a series of hands-on workshops through which members of those groups will participate in the design and construction of complete papercrete structures.

6. Continue investigation of funding mechanisms that will enable local residents to purchase alternative technologies and/or to develop their own microenterprises.

Representatives of BANCOMUN, a micro-lending organization in Nogales, Sonora, attended workshops and participated in interviews during this project. They recognize the need for funding mechanisms that can assist local residents to invest in these technologies, both as individuals and in the development of small businesses, and will help identify potential sources of support.

Each activity, a proposed timeline, a responsible party, and actual and potential sources of funding are summarized in Table 4.1.

Table 4.1. Actions to Further the Development of Alternative Technologies in Nogales

Activity	When	Who Responsible; Contact Person	Source of Funding
1. Study of wood and garbage burning in Nogales	8-06 through 7-07	UA; Diane Austin (UA) daustin@u.arizona.edu	USEPA/ADEQ
2. Monitor stoves	7-06 through 12-06	Community Monitors and UA; Diane Austin (UA) daustin@u.arizona.edu	SHE, Inc.
3. Introduce new stoves	8-06 through 12-06	CONALEP, FESAC, and UA; Rosalva Lepron (CONALEP) rosalva_lepron@hotmail.com	SEMARNAT
4. Investigate additional stove technologies	8-06 through 12-06	UA; Diane Austin (UA) daustin@u.arizona.edu	UA (in-kind)
5.a. Introductory workshop on papercrete and other alternative construction techniques	9-06	ITN; Arturo Frayre (ITN) arfra@prodigy.net.mx	ITN (in-kind)
5.b. Construct papercrete benches	9-06 through 12-06	Desert Shadows Middle School and CETis 128, UA; Diane Austin (UA) daustin@u.arizona.edu	UA, DSMS, CETis 128 (all in-kind), still seeking funds for Portland cement
5.c. Pilot papercrete construction	9-06 through 4-07	CONALEP, APSA, Borderlinks, UA; with the assistance of Barry Fuller, www.livinginpaper.com	Donations, still seeking additional resources
6. Investigate funding mechanism	9-06 through 12-06	BANCOMUN, UA;	BANCOMUN (in-kind)

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APPENDICES

Appendix 1: Photos of Commonly Used Stoves in Nogales, Sonora

Appendix 2: Alternative Stove Technologies Matrix

Appendix 3: Questions to Guide Focus Group Discussions

Appendix 4: Introductory Workshop Agenda and Handouts

Appendix 5: Handouts for Stove Re-Design Competition

Appendix 6: Stove Monitoring Forms

Appendix 7: Alternative Construction Technologies Matrix

Appendix 8: Worksheet for Housing Construction Assessment

Appendix 9: Presentation for Workshop on Housing Construction Alternatives

Appendix 1: Photos of Commonly Used Stoves in Nogales, Sonora


Outdoor wood-burning stove made with earth and cement, with metal plancha.


Wood-burning calenton made with a 55-gallon metal drum.


Wood-burning heater made with a 55-gallon metal drum.


Indoor wood-burning stove purchased from the store.


Gas stove.

Appendix 2: Alternative Stove Technologies Matrix

Cooking and Heating Technology/ Attributes	Open fire, 3 stone pit with grate	Earthen Wall	Tsotso	Vesto Stove	Estufa Justa (plancha stove)	MIDGE (wood-gas stoves)	Ecostove	Solar ovens/parabolic stove	Gaia Stove
1. Description	Open fire, usually 3 stones, firewood. Traditional	Made from sand (60%) clay (40%), sawdust, 12 mm of newspaper and cardboard wrapped around pot.. Traditional. Weight 6.6. kgs.	An efficient wood-burning stove made from sheet metal. Developed b y David Hancock in Zimbabwe in the 1980s with over 30K sold. Tsosto means "twigs" in Shona	Won Sept. 2004 Design Institute of south Africa (DISA) Chairman's Special Award. New Dawn has sold more than 1,000 stoves since its invention in 2002. Design preheats incoming air while using that air to insulate the fire and prevent heat loss. Increases the efficiency of burning low quality fuel. Vesto has 3 types of secondary air inlets allowing it to function as both charcoal-producting gasifier and a charcoal, wood, or dung burning stove	After Doña Justa Nuñez of Suyapa, Honduras co-designer. Uses inventor Dr. Larry Winiarski's "rocket elbow". Simple biomass stoves built around an insulated, elbow-shaped combustion chamber, which provides more intense heat & cleaner combustion with less fuel. The elbow is formed from 2 ceramic cylinders made of mixture of clay, manure and tree resin. Ashes or pumice usually used for insulation. It has a sealed metal plancha (griddle) that sits above a stove made of bricks, and a chimney for exhaust.	(Modified Inverted Downdraft Gasifier Experiment)	Innovative, vented, insulated, sealed woodstove. Fire is entirely enclosed within the firebox using a rocket elbow, and is insulated by material such as pumice rock. Uses a *plancha* which is heated first by flames and then by the hot gases circulating under the *plancha*. The small area for wood and insulation reduces firewood use and smoke (by half) compared to an open fire.	Solar ovens act like a crockpot. Thus, it slowly ooks food, pasteurize, and heat water	Stove *and* fuel featured in *Boiling Point* No. 43 in 1999. Concept started in discussions with Indian gov't 1995, then with , gov'ts & dev. practitioners in Central America, Caribbean & Africa. Involves bringing alcohol-powered appliances, available in Europe and North America, to the developing world, powering them not only with ethanol, but also with methanol, an alcohol produced worldwide on a vast scale from natural gas..

Cooking and Heating Technology/ Attributes	Open fire, 3 stone pit with grate	Earthen Wall	Tsotso	Vesto Stove	Estufa Justa (plancha stove)	MIDGE (wood-gas stoves)	Ecostove	Solar ovens/parabolic stove	Gaia Stove
2. Materials Needed - source - cost - labor cost - training needed?	Stones Manual labor Training on how to feed fuel	Sand, clay, water Manual labor	Composed of 4 components: - mani stove body with 2 wire handles and an insulated core - fire grate with punched holes - welded steel 'X' to support the pots - loose grate bottom to hold fuel in	25 liter can, $29	Construction time: approx. 4 hours to assemble parts. Material cost: approx. $25-$35US. In Honduras: Total cost of basic stove is about $60: • $10.50- plancha • $7.58- elbow (pottery, new baldosa elbows less than $1), • $4.37- chimney • $14.55-(mason/stove technician), • $15- transport • $8- training , inspection (very impt)	Prototype: - 55 oz can, - 16 oz can, - Large tuna can (12oz), or snug-ft can around larger can. - 4 each, 10(treads per inch) x 2 in. (length) sheet metal screws. - 2 Coat hangers or similar stiff wire - 4 each, 10 x 1 inch sheet metal screws Tools: - Hand can opener - Tin can snips. - Nail (3d) or equivalent hole punch. - Punch/drill for 1/4" hole - Wire cutter - Marker - safety gloves	Cement, brick, plancha, etc. Possible microenterpise project	Glass, insulated container.	Not sure if there is a cooperative venture on this.

Cooking and Heating Technology/ Attributes	Open fire, 3 stone pit with grate	Earthen Wall	Tsotso	Vesto Stove	Estufa Justa (plancha stove)	MIDGE (wood-gas stoves)	Ecostove	Solar ovens/parabolic stove	Gaia Stove
3. Supplier of technology	n/a	n/a	Desert Research Foundation of Namibia PO Box 20232, Windhoek, Namibia +2646123072 Drfn@drfn.org.na And Crispin Pemberton-Pigott http://www.newdawnengineering.com	Crispin Pemberton-Pigott http://www.newdawnengineering.com	HELPs US Office 15301 Dallas Pkwy. Suite 200 Addison, TX 75001 (972) 386-2901 (972) 386-4294 Fax 1-800-41- HELPS Guatemala Office 2a. calle 32-77, Zona 7 Ofi Bodegas, San Mateo #5 Guatemala, Guatemala 01007 011(502) 2433-9641 011(502) 2433-9641 x102 Fax info@helpsinternational.com TreesWater People http://www.treeswaterpeople.org/intl.htm Honduran Association for Development	Arthur Noll arthurnoll@onemain.com See below. Http://www.woodgas.com	Prolena http://www.rep p.org/discussiongroups/resources/stoves/Miranda/Prolena..htm Trees Water and People Ecofugao (Brazil) http://www.ecofogao.com.br/ HELPS Onil stove	Persons Helping People Solar Oven Society www.solarovens.org http://solarcookers.org/ http://www.she-inc.org/	Harry Stokes, Stokes Consulting Group, 22 Mummasburg Street, Gettysburg, PA 17325 USA Tel.: +717 495–4274; Fax: +717 334–7313; hstokes@blazenet.net Bengt Ebbeson22. Dometic AB, Zurcherstrasse 239, CH-8500 Frauenfeld, Switzerland Tel: +41 52 720 66 44; Fax: +41 52 720 66 50; bengt.ebbeson@dometic.ch

Cooking and Heating Technology/ Attributes	Open fire, 3 stone pit with grate	Earthen Wall	Tsotso	Vesto Stove	Estufa Justa (plancha stove)	MIDGE (wood-gas stoves)	Ecostove	Solar ovens/parabolic stove	Gaia Stove
4. Assessment/studies made of technology	Yes, see summary in WELL study 2001:22	Yes	Yes, see website (below)	Yes, see website (below)	Yes, several see APROVECHO http://www.aprovecho.net/ and REPP http://www.repp.org/discussiongroups/resources/stoves/index.htm	Yes several See http://hourneytoforever.org/at_woodfire.html for links	Yes, see websites of providers	Several	Some, contact provider
5. Availability of technology - Is it widely used (where)? - contact details - buy? Cooperative venture? Self-taught/Manual?	Worldwide.	Yes	Crispin Pemberton-Pigott http://www.newdawnengineering.com	Crispin Pemberton-Pigott http://www.newdawnengineering.com	APROVECHO RESEARCH CENTER 80574 Hazelton Road, Cottage Grove, OR 97424 Tel: (541) 942-8198 Fax: (541) 942-8198. Dean Still TREES WATER AND PEOPLE 633 South College Avenue. Fort Collins, CO 80524. Tel: (970) 484 367. Fax: (970) 224 1726 Stuart Conway E-mail twp@treeswaterpeople.org Website www.treeswaterpeople.org E-mail: dstill@epud.net Website www.efn.org/~apro	Yes. Web. Manuals. Different versions.	Nicaraga Honduras Brazil Rogério C. de Miranda and Frances G. Tilney, Ecofogones y Reposición Forestal, PROLEÑA/Nicaragua, Apartado Postal C-321, Managua, Nicaragua. Fax (505) 249 0116 Email: rmiranda@sdnnic.org.ni Partnershp fo Clean Indoor Air http://www.pasasa.org/new/	Afghanistan Bolivia	Yes. Seems though this is a commercial venture.

Cooking and Heating Technology/ Attributes	Open fire, 3 stone pit with grate	Earthen Wall	Tsotso	Vesto Stove	Estufa Justa (plancha stove)	MIDGE (wood-gas stoves)	Ecostove	Solar ovens/parabolic stove	Gaia Stove
- Technology transfer to client, service provider, Can technology be provided by local bus?	Participant observation. Trial and error.	Participant observation. Trial and error.	Buy unit, manual	Buy unit, manual	Training Workshop	Participant observation. Trial and error. Can purchase manual	Training Workshop	Training, workshops needed	Buy unit
6. Ease of Use	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Practical? Cooking efficiency - Speed - How well	Boils water quickly Heats pot in several areas	- 3.24 mins to boil 1L of water	Increases the efficiency (21%) of burning low quality fuel.	Increases the efficiency of burning low quality fuel.	Almost 2X as efficient as an open fire when used with three pots. Insulated low-mass rocket combustion chamber reaches near complete combustion so wood is burned more effectively. Estufa Justa is improvement but suffers from poor heat transfer to the pots. Wherever the pot is not touching the plancha, heat transfers into the room, not into the pot. Furthermore, only the bottom of the pot is exposed to the hot flue gases.	burn times will be 12-15 minutes without a pot on top, and up to 25 minutes with a pot on top.	Can b oil 500 ml of water in 3.5 mins comparable to an electric or gas stove	For slow cooking, pasteurizing, heating water	Similar to gas stove
8. Cooking Temperature	Variable	Variable	Variable	Variable	May exceed 1400 F	Variable	Variable	210-270 F, 300 F at the equatorial parts	Variable

Cooking and Heating Technology/ Attributes	Open fire, 3 stone pit with grate	Earthen Wall	Tsotso	Vesto Stove	Estufa Justa (plancha stove)	MIDGE (wood-gas stoves)	Ecostove	Solar ovens/parabolic stove	Gaia Stove
9. Heat radius	Variable	Around stove	Variable	Variable	Unlike many other chimney stoves that simply remove uncombusted smoke from the house and export it into the neighborhood, the Estufa Justa is designed to produce little or no smoke at all. Because the Estufa Justa achieves near complete combustion, most of the smoke is transformed into heat, so cooking takes less time and uses less wood.	Variable	Variable	Solar cooker itself	Variable
10. Location	Portable	Portable	Portable	Portable	Set, kitchen	Portable	Portable	Portable, outdoors	Portable
11. Fuel type	Biomass	Biomass	Biomass	Charcoal, dung, and wood burning stove.	Anecdotal reports from Suyapa have suggested a 25-50% decrease in fuel consumption compared to a Lorena (plancha) stove.	a. Any dry wood product no thicker than a number 2 pencil and 1-2 inches long. Fuel ideas; 1x2 inch limber cut down, Twigs, wood pellets	Biomass	Solar powered	Alcohol (ethanol, methanol,)

Cooking and Heating Technology/ Attributes	Open fire, 3 stone pit with grate	Earthen Wall	Tsotso	Vesto Stove	Estufa Justa (plancha stove)	MIDGE (wood-gas stoves)	Ecostove	Solar ovens/parabolic stove	Gaia Stove
12. Fuel source - collection strategy - transportation - storage	Collected, bought, scavenged, etc.	Collected, bought, scavenged, etc.	Collected, bought, scavenged, etc.	Collected, bought, scavenged, etc.	Wood	Collected, bought, scavenged, etc.	Collected, bought, scavenged, etc.	Solar	Bought
13. Amount of fuel used(where, when, how much, frequency)	Depends on use	- 81.1g of fuel of fuel to boil 1L of water - 69.9 g of fuel to simmer 1L of water for 45 mins - 151 g of fuel to cook 1L of food	Varies But economical	Varies But economical	1/3 of open fire requirements	300 g of sticks or chips burn for 30-45 mins at high efficiency with low emissions	40% less wood	2-4 hours to cook food	Varies But economical
14. Cost of fuel	Depends where you get your biomass	See above. Depends on source	Depends where you get your biomass	Depends where you get your biomass	Depends where you get your biomass	Depends where you get your biomass	Depends where you get your biomass	Free	Methanol- 4 U.S. cents Ethanol 12-25 U.S. cents
15. Who handles fuel?	Anyone	Anyone	Anyone trained	Anyone trained	Anyone	Anyone	Anyone	Anyone	Anyone trained
16. Fuel waste management (residue)	Ashes	Ashes	Minimal	Minimal	Ashes	Minimal	Minimal	None	Minimal
17. Emissions and emissions reduction data	Can burn relatively cleanly	Slight decrease in harmful emissons	No smoke	No smoke	Anecdotal: significant. Cleaner and brighter cooking areas	Not 100% efficient woodgas burner so CO_2 emitted. Low levels of tar and soot produced.	No indoor smoke	None	No indoor smoke

Cooking and Heating Technology/ Attributes	Open fire, 3 stone pit with grate	Earthen Wall	Tsotso	Vesto Stove	Estufa Justa (plancha stove)	MIDGE (wood-gas stoves)	Ecostove	Solar ovens/parabolic stove	Gaia Stove
18. Maintenance	If not done properly generates smoke, soot. Ashes	2 cents/L to operate	Minimal	Minimal	Life expectancy: ceramic stove liner can last up to ten years.	Minimal	Minimal	Minimal	Minimal
19. Perception of safety	Fire hazard, Health issues	Mid-range Health Issues	Safe. Reduced emissions	Safe. Reduced emissions	Safe. Reduced emissions	Safe. Reduced emissions. Burn risk	Safe. Reduced emissions	Good	Safe. Reduced emissions
20. Safety and health benefits of Technology	Fire-hazard	Mid-range	Safe. Reduced emissions	Safe. Reduced emissions	Safe. Reduced emissions	Safe. Reduced emissions	Safe. Reduced emissions	Surface areas can get hot	Safe. Reduced emissions
21. Cost of technology	Negligible	Negligible	$10-30	$10-30	$20-100+	Free (scrap materials) to $10	$20-100	Commercial version sold in U.S. $171 includes reflectors, 2 pots, thermometer, water pasteurization indicator	??
22. External Costs/Externalities (other costs, training, compatibility, etc.)	This is a last option for cooking and is used by those who cannot afford cooking stoves.	???				Actually produces 20-25% charcoal yield (woodstoves)			

Cooking and Heating Technology/ Attributes	Open fire, 3 stone pit with grate	Earthen Wall	Tsotso	Vesto Stove	Estufa Justa (plancha stove)	MIDGE (wood-gas stoves)	Ecostove	Solar ovens/parabolic stove	Gaia Stove
23. Comments	Researchers have taken a second look at open fire and have concluded that it is not so bad as it thought of before.			Also manufactures paper brick maker-burns 4 in a hour. Sells 2.5 US cents each	In Honduras, can be tiled (cost unknown) to beautify. Another variation is the Dona Justa de dos hornillas which has no holes in the plancha for soot-free pots.	Variants/modifications/ more modern ones include Juntos, VITA stove (Samuel F. Baldwin, “Biomass Stoves: Engineering Design, Development, and Dissemination”, 1987)etc. See “Wood-Gas Stove for Developing Countries” by T. B. Reed and Ronal Larsen 1996 “Testing and Modeling the Wood-Gas Turbo Stove” by T.B. Reed, E. Anselmo, and K. Kircher 2000	Ideal for tortilla making (up to 8 pcs at a time)	Costs Time Complement or main cooking equipment?	Can it run on biodiesel?

Appendix 3: Questions to Guide Focus Group Discussions

Focus Group Discussion Guide

In general, for each technology and fuel, the goal is to find out what people are doing now, when (per day and season) and where (inside/outside and where inside) they are doing it, who in the household is responsible for doing it, and what they would like to change in the near (within one year) and more distant (within five years) future. Some focus groups will begin with the focus on fuel and others with the focus on the activity and technology.

Cooking

What sorts of things do people in your household eat? Which of those things are cooked at home?
When do you cook? Daily? Seasonally?
How many people are you cooking for?
Who does the cooking?
How is the cooking done now? Stove? Oven? Utensils and pots? Does that change with different seasons?
Where do you cook? Inside/outside? Is the living space divided? What portion is devoted to cooking?
How often do you buy food? Where do you store it? Do you have access to refrigeration?

Heating

How do you heat your home? Does that change during the year?
When do you heat? During the day or night? Which months out of the year do you need specific means for heating?
Who is responsible for maintaining heat in your home?
Where is the heating device in your home? What portion of the living space is devoted to heating?

Water Heating

For what sorts of things do people in your household need warm or hot water?
How do you heat the water in your home? Does that change during the year?
When do you heat the water? Daily? Seasonally?
Who is responsible for maintaining the water heater?
Where is the water heater? What portion of the living space is devoted to heating water?

Fuel

What fuels do you use at your house? Are some fuels better than others? In what way? (interested in whether they have a sense of efficiency as well as cost, availability, etc.)
What are the primary sources of those fuels?
Who is responsible for getting the fuel?
How often do you get fuel delivered or do you go get it?
Does the amount of each type of fuel that you need change during the year?
Are there periods when you cannot get fuel? Why not? What do you do when this happens?
What other things could you use as fuel?
Do you have any safety concerns with the types of fuel you use? If so, what are they?

Appendix 4: Introductory Workshop Agenda and Handouts

Taller Comunitario sobre Tecnologías Alternativas para Cocinar y Calentar

10 y 11 de Diciembre de 2005

Casa de la Misericordia
Colonia Bella Vista
Nogales, Sonora, Mexico

Foto: David W. Vaughn & Ruth Saavedra de Whitfield

10-11 December 2005

Casa de la Misericordia

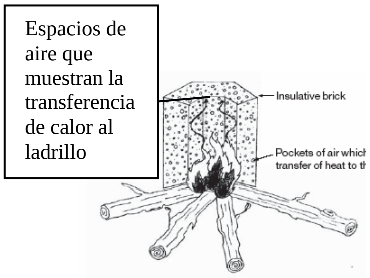
BorderLinks

ADEQ Arizona Department of Environmental Quality

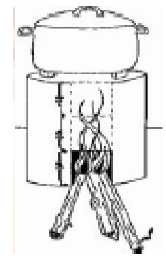
BARA The Bureau of Applied Research in ANTHROPOLOGY

Diez Principios Para el Diseño de Estufas que Consumen Leña

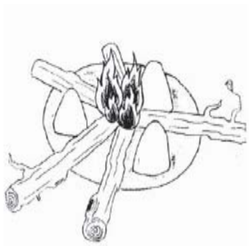
Centro de Investigaciones Aprovecho
Por Dr. Larry Winiarski



1. Insular alrededor del fuego utilizando materiales livianos y resistentes a altas temperaturas.



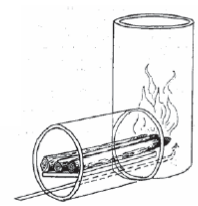
2. Colocar una chimenea corta y de material de aislamiento directamente sobre el fuego para acelerar la ventilación y para que el humo salga hacia arriba



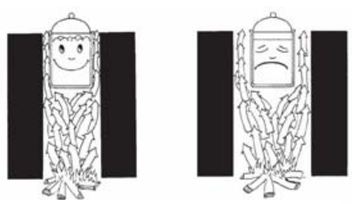
3. Calentar y quemar las puntas de los palos a medida que se van introduciendo al fuego para que produzcan llama y no humo.

4. Las temperaturas altas o bajas se crean de acuerdo a la cantidad de palos que se introducen al fuego

5. Mantener buena y rápida ventilación desde abajo del fuego hasta el carbón. Evitar que haya demasiado aire extra en el fuego para no permitir que se éste se enfríe

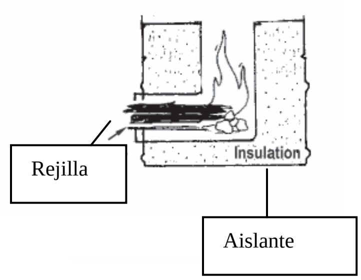


6. Si entra poca ventilación al fuego esto producirá humo y carbón en exceso.



7. Permitir la libre circulación del aire manteniendo libre una lección transversal en la estufa. Los tamazos de la apertura donde se encuentra el fuego, el espacio por donde corre el aire caliente dentro de la estufa y el tamaño de la chimenea deben ser aproximadamente iguales.

8. Usar una rejilla-parrilla debajo del fuego



9. Insular el trayecto que realiza el flujo del aire caliente , desde el fuego hasta la olla (o plancha) y su alrededor.

10. Maximizar la transferencia de temperatura a la olla con espacios de tamaño.

Tecnologías para Cocinar y Calentar

Cocinando Con Fuego

Fuego con 3 piedras

Estufas Solares

Estufa Ella

Estufa Ella

Gases Super Calentados

Estufa MIDGE
Estufa Vesto

Estufa Midge

Estufa Vesto

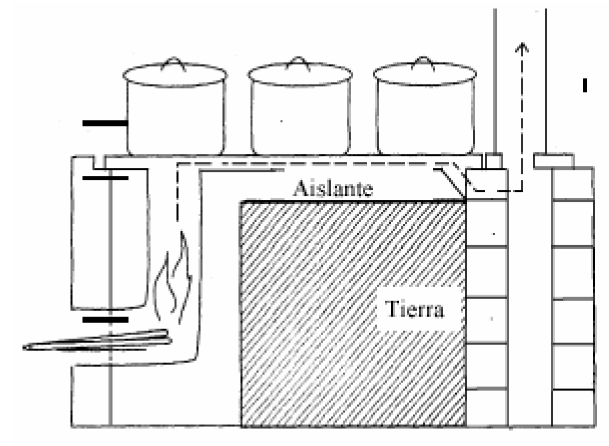
Codo de Misil

Estufa Justa
Eco-Estufa

Estufa Justa

Eco Estufa

ESTUFA JUSTA



Características

- ❖ Usa leña como combustible
- ❖ Temperatura de cocción máxima aproximada es de 1400F
- ❖ Costo de construcción: US$ 50-60
- ❖ Se construye en aprox. 4 horas
- ❖ Puede durar hasta 10 años.

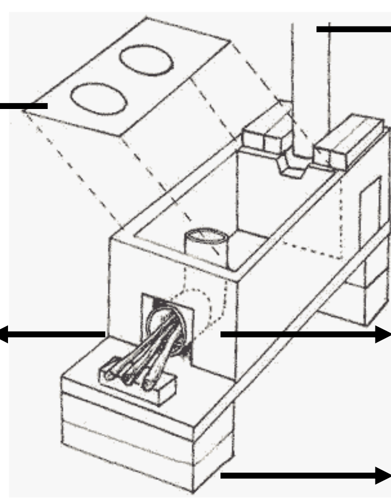
Ventajas

1. Cuando se usa con tres ollas es casi el doble de eficiente que usando fuego abierto	**2.** Produce poco o nada de humo porque logra combustión completa	**3.** Usa 1/3 de la cantidad de leña necesaria para cocinar con fuego abierto

Materiales para su construcción –

Plancha para cocinar

Chimenea: el tubo puede tener entre 6 y 20 pies de alto y 4 pulgadas de diámetro



El armazón de la estufa

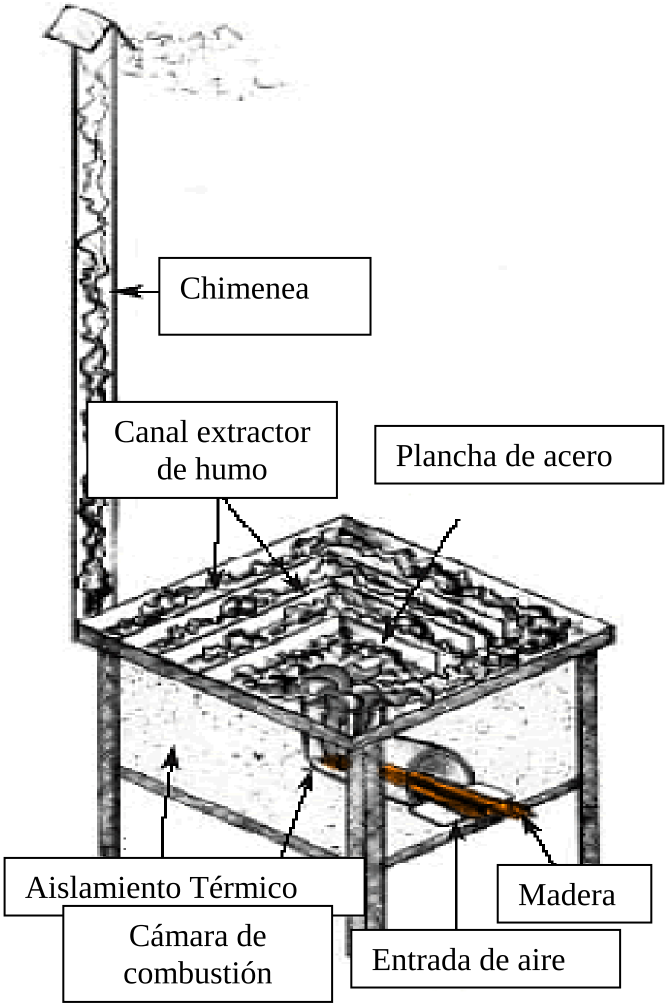
Cámara de combustión cohete

Base de la estufa: puede ser hecha de cemento, ladrillo, madera o adobe

Otros materiales necesarios:

- ceniza para rellenar la mitad del armazón de la estufa y arena seca o tierra para rellenar la otra mitad
- 2 carretillas de mezcla de arcilla y arena y 50 ladrillos de 5x8 pulgadas para construir el armazon de la estufa
- una pieza de acero de 1/32 pulgada de ancho y 12 x 16 pulgadas
- tierra blanca para pintar la parte exterior de la estufa

ECO - ESTUFA



Materiales de construcción

- 1 codo misil
- 1 plancha de acero
- 1 chimenea
- materiales para el aislamiento

Foto de PROLEÑA

Foto de PROLEÑA

Ventajas

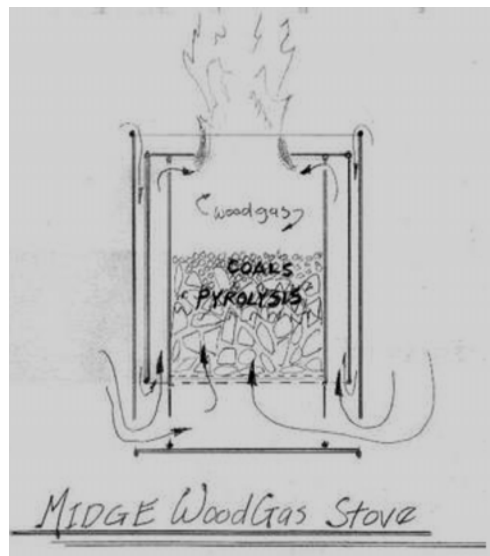
- Tiene un eficiencia del 20% si es manejada adecuadamente
- Utiliza la mitad de leña comparado a una estufa de fuego abierto.
- Ocupa poco espacio
- No permite la salida de humo

MIDGE

- ✓ Fácil de hacer y usar
- ✓ Económica
- ✓ Portátil
- ✓ Puede cocinar por 30-45 min
- ✓ Usa poco combustible
- ✓ No produce humo

Materiales

- 1 lata de 1.6 l (55 oz) para la cubierta
- 1 lata de 0.47l (16 oz) para el soporte del quemador interno
- 1 lata de 0.35 l (12oz) para la tapa
- 4 tornillos metálicos tirafondo de dos pulgadas y de paso 10.
- 2 ganchos de ropa o cualquier alambre rígido
- 4 tornillos metálicos tirafondo de 1 pulgada de paso 10.



Herramientas de construcción

- Abridor de latas
- Pedazos de latón para cortar lata
- Clavos o un perforador equivalente
- Taladro de 1/4 de pulgadas
- Cortador de alambre
- Marcador

Combustible

Cualquier tipo de madera de 1 a 2 pulgas de largo y no mas ancho que un lápiz, Paletas de Madera

VESTO

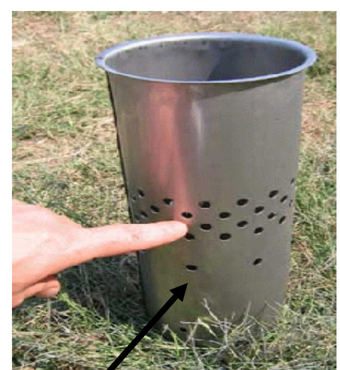
- Ahorra mas de 1/3 de combustible
- Eficiente
- Poco humo
- Portátil y liviana (5kg)
- Segura
- Prefabricada

Componentes

Cuerpo principal

Reguladores de aire

Base para colocar olla



Parrilla con hoyos

Combustibles

Ramas

Carbón

Estiércol

Bloques de papel

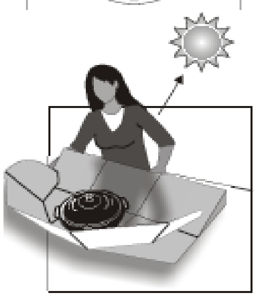
Olla Solar

Un complemento para su cocina

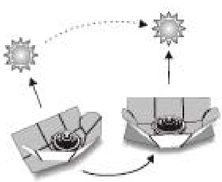
Usa energía solar
Económica
Fácil de usar
Duradera
Eficiente
No produce humo

Cómo utilizar la Olla Solar

Preparar los alimentos y colocarlos en el cazo metálico negro



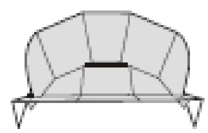
Dirigir el reflector hacia el sol



Ajustar el reflector después de dos horas hacia el sol si esto es necesario

Con el sol intenso la comida se cuece en menos de dos horas

Componentes



El reflector concentra la energía solar en el cazo metálico

El cazo metálico transforma la energía del sol en calor

La vasija de vidrio con su tapa mantiene el calor dentro del sistema

Fuente: http://www.she-inc.org/index.php

Appendix 5: Handouts for Stove Re-Design Competition

COMPETENCIA

- DE -

ESTUFAS

ALTERNATIVAS

- EN -

CETIS #128

- PRIMAVERA 2006 -

ÍNDICE

INTRODUCCIÓN

La polución y contaminación del aire en Nogales, Sonora es un cierto problema. Hay una variedad de razones por ésto, como el hecho que la mayoría de las calles no están pavimentados o que hay una falta de vegetación en unas areas. Pero, hay una causa más de polución muy común que nos interesa en el contexto de este proyecto y competencia, y ésa es la quema de leña en la ciudad.

De verdad, mucha gente en Nogales, Sonora usa madera o leña como combustibles para sus estufas, para cocinar su comida o calentar sus casas. Se usa la leña como combustible en vez del gas, por ejemplo, porque el gas suele ser caro y no tan disponible como la leña para esa gente. El problema con la quema de leña en estufas es que la leña produce mucho humo y ceniza cuando se la quema, y esas cosas entran al aire y infectan los pulmones de la gente cuando se las respira. Sí, se puede cambiar los tipos de leña que se usa en busqueda de un tipo de leña que no produce tan polución, pero ésto no solucionará el problema de la contaminación suficientemente.

Pero, hay otra opción. Esta opción no es cambiar el tipo de leña, sino que cambiar y aumentar las estufas que la usan. Si las estufas que tiene la gente consumieran la leña en una manera mas eficiente, y si producieran menos humo y polución, la gente todavía podría usar la leña que es disponible y barata (si no gratis), y las estufas que consumen leña no contaminarían tanto al aire de la ciudad.

Para realizar esta solución, unos vecinos de las colonias Flores Magón y Bella Vista, unos integrantes de la Asociación de Reforestación en Ambos Nogales, la Casa de la Misericordia y la Universidad de Arizona en Tucson, Arizona, se han juntados fuerzas. Después de mucho trabajo duro y investigaciones extensivas, unas alternativas para las estufas que consumen leña han sido descubridos y presentados a los vecinos de dichas colonias. La gente de esas colonias ya les gustan esas estufas alternativas, porque son mucho más eficientes en quemando la leña y producen mucho menos humo. El proyecto sobre estufas alternativas está creciendo rapidamente en Nogales.

Pero, hay unos problemas con las estufas alternativas seleccionadas y presentadas, ya que no son perfectas. Sí, son mejores en términos del consumo de leña y producción de humo, pero tienen ceirtos problemas. Por ejemplo, unas de las estufas alternativas más populares, la Estufa Justa, es muy permanente y duro de construir, y una versión portátil es necesaria. Además, con el MIDGE, otra estufa alternativa, una versión quizas más grande y segura es deseado, con una caja en que se puede juntar más que un MIDGE para formar una estufa con más que una quemador. Como ejemplo final, la Olla Solar, que concentra el calor del sol para cocinar comida, requiere mucho tiempo y es muy lento de calentar lo que esté al dentro de ella.

Por eso, a Uds., los estudiantes de CETis #128, se les proponen el gran desafío y honor de investigar como aumentar, modificar y mejorar las dichas estufas alternativas en la forma de una competencia entre de la escuela. En las siguientes páginas, se puede encontrar información sobre las tres estufas alternativas seleccionadas para el problema de la contaminación del aire por la quema de leña, con sus diseños básicos y los materiales necesarious para cada una. Al fín de este paquete se encuentra una conclusión con información sobre el objetivo específico de la competencia, las reglas de la competencia y fechas importantes para la competencia. ¡Buena suerte!

Diez Principios Para el Diseño de Estufas que Consumen Leña

Centro de Investigaciones Aprovecho
Por Dr. Larry Winiarski

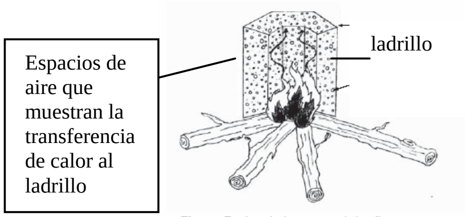
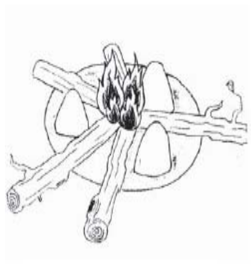


Figure 7 - Insulation around the fire

1. **Aislar** alrededor del fuego utilizando materiales livianos y resistentes a altas temperaturas.

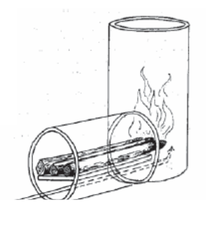
2. Colocar una **chimenea** corta y de material aislado directamente sobre el fuego para acelerar la ventilación y para que el humo salga hacia arriba



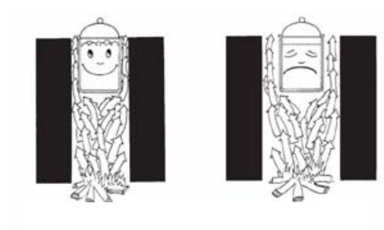
3. Calentar y **quemar las puntas de los palos** a medida que se van introduciendo al fuego para que produzcan llama y no humo.

4. Las temperaturas altas o bajas se crean de acuerdo a la **cantidad de palos** que se introducen al fuego

5. Mantener buena y rápida **ventilación** desde abajo del fuego hasta el carbón. Evitar que haya demasiado aire extra en el fuego para no permitir que éste se enfríe.

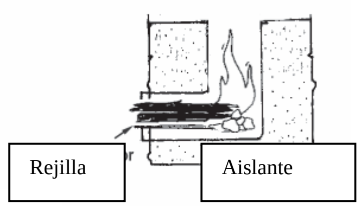


6. Si entra poca **ventilación** al fuego esto producirá humo y carbón en exceso.



7. Permitir la libre circulación del. **Los tamaños de la apertura** donde se encuentra el fuego, el espacio por donde corre el aire caliente dentro de la estufa y el tamaño de la chimenea deben ser aproximadamente iguales.

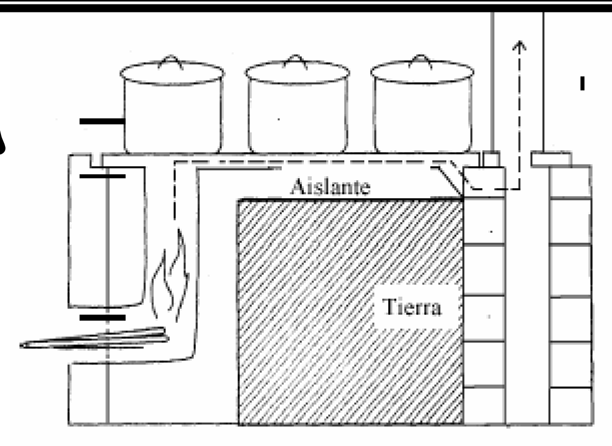
8. Usar una rejilla-**parrilla debajo del fuego**



Aislar el trayecto que realiza el flujo del aire caliente , desde el fuego hasta la olla (o plancha) y su alrededor.

10. Maximizar la trasferencia de temperatura a la olla con espacios de tamaño apropiados.

ESTUFA JUSTA



Características

Usa leña como combustible.
Temperatura de cocción máxima aproximada es de 400F.
Se construye en aproximadamente 4 horas.
Puede durar hasta 10 años.

Ventajas

1. Cuando se usa con tres ollas es casi el doble de eficiente que usando fuego abierto.

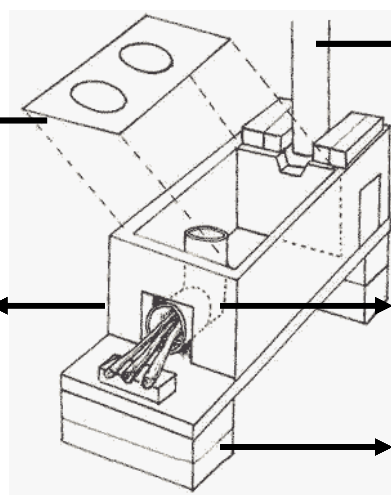
2. Produce poco o nada de humo porque logra combustión completa.

3. Usa 1/3 de la cantidad de leña necesaria para cocinar con fuego abierto.

Materiales para su construcción

Plancha para cocinar

El armazón de la estufa



Chimenea: el tubo puede tener entre 6 y 20 pies de alto y 4 pulgadas de diámetro.

Cámara de combustión

Base de la estufa: puede ser hecha de cemento, ladrillo, madera o adobe.

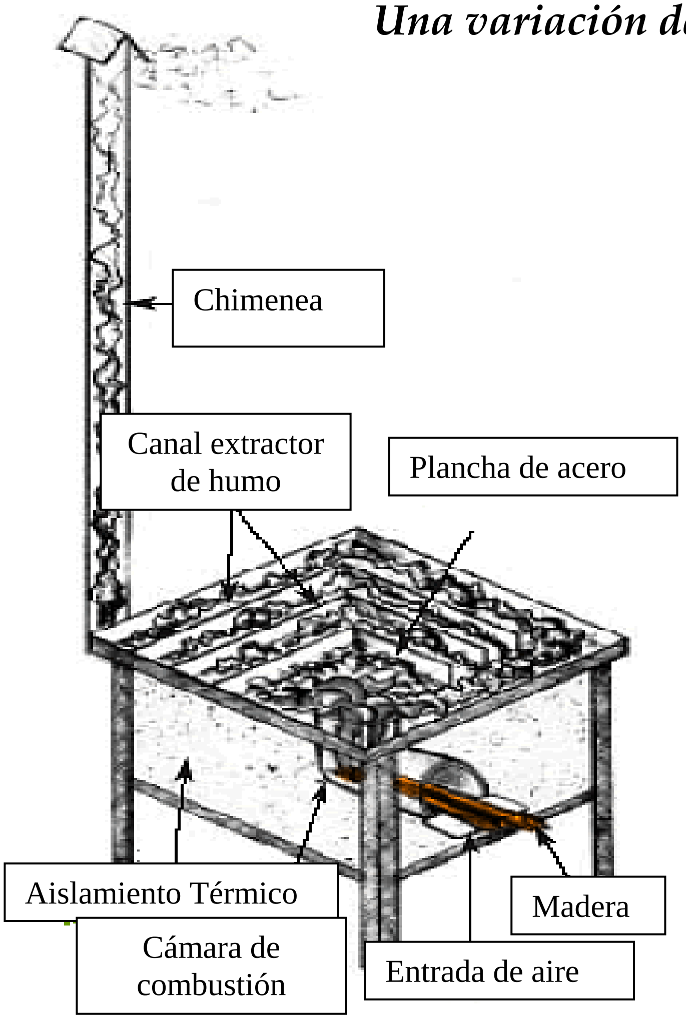
Otros materiales necesarios:
ceniza para rellenar la mitad del armazón de la estufa y arena seca o tierra para rellenar la otra mitad.
2 carretillas de mezcla de arcilla y arena y 50 ladrillos de 5x8 pulgadas para construir el armazón de la estufa.

una pieza de 1/32 de acero de 12 x 16 pulgadas.
cal para pintar la parte exterior de la estufa.

Fuente: Centro de Investigaciones Aprovecho: http://www.aprovecho.net/

ECO - ESTUFA

Una variación de la Estufa Justa



Materiales de construcción:

- 1 codo de combustion
- 1 plancha de metal
- 1 chimenea
- Materiales para el aislamiento

Foto de PROLEÑA

Ventajas:

- ✓ Tiene una eficiencia del 20% si es manejada adecuadamente.
- ✓ Utiliza la mitad de leña comparado a una estufa de fuego abierto.
- ✓ Ocupa poco espacio.
- ✓ No permite la salida de humo.

MIDGE

VENTAJAS:

- ✓Fácil de construir y usar.
- ✓Económica y produce menos humo.
- ✓Portátil.
- ✓Puede cocinar por 30-45 min.
- ✓Usa poco combustible.

MATERIALES:

- •1 lata de 55 oz para la cubierta
- •1 lata de 16 oz para el soporte del quemador interno
- •1 lata de 12oz para la tapa
- •4 tornillos o clavos metálicos de dos pulgadas
- •2 ganchos de ropa o cualquier alambre rígido

HERRAMIENTAS NECESARIAS:

- •Abrelatas
- •Tijeras para cortar metal
- •Clavos
- •Taladro de 1/4 de pulgadas
- •Marcador
- •Guantes de seguridad
- •Martillo

Fuente: Prototipo de Arthur Noll

COMBUSTIBLE:

- Cualquier tipo de madera entre 1 y 2 pulgadas de largo y no mas ancho que un lápiz.
- Tablas de Madera
- Ramas

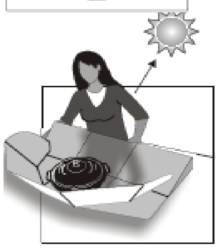
Olla Solar

Un complemento para
su cocina

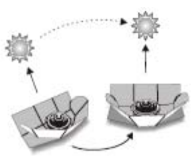
Ventajas:
- ✓Usa energía solar
- ✓Económica
- ✓Fácil de usar
- ✓Duradera
- ✓Eficiente
- ✓No produce humo
- ✓Segura

Cómo utilizar la Olla Solar

Preparar los alimentos y colocarlos en el cazo metálico negro.



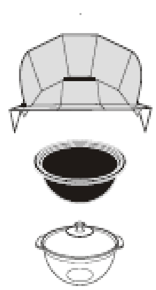
Dirigir el reflector hacia el sol.



Ajustar el reflector después de dos horas hacia el sol si esto es necesario.

Con el sol intenso la comida se cuece en menos de dos horas.

Componentes



El reflector concentra la energía solar en el cazo metálico

El cazo metálico transforma la energía del sol en calor

La vasija de vidrio con su tapa mantiene el calor dentro del sistema

Fuente: http://www.she-inc.org/index.php

CONCLUSIÓN Y LAS REGLAS DE LA COMPETENCIA

El objetivo principal de esta competencia es la creación y invento de estufas alternativas modificadas por Uds., estudiantes de CETis. Uds. tienen que usar los diseños básicos que nosotros de la Universidad de Arizona les ofrecemos y modificar y/o aumentarlos. Hay un objetivo secundario, que es que Uds. como estudiantes aprendan algo sobre polución y maneras de solucionarla. Como cualquier proyecto en una escuela, hay un objetivo de aprendizaje. Además, Uds. van a competir contra otras clases en su escuela. Ésta no es una competencia entre de escuelas (como CONALEP, por ejemplo).
Al fín de la competencia, las estufas modificadas que Uds. habrán hecho serán juzgados por un equipo de juezes. Los diseños mejores serán presentados a los vecinos de Nogales y quizas implementados en sus casas, más alla de ser concedidos con los mejores premios. Si Uds. quieren, pueden ir con integrantes de la Universidad de Arizona a las colonias para participar en la enseñanza e implementación de su estufa alternativa modificada. Finalmente, como cualquier competenica, esta competencia tiene reglas que se debe seguir. Lee la siguiente información cuidadosamente, y ponla en su mente.

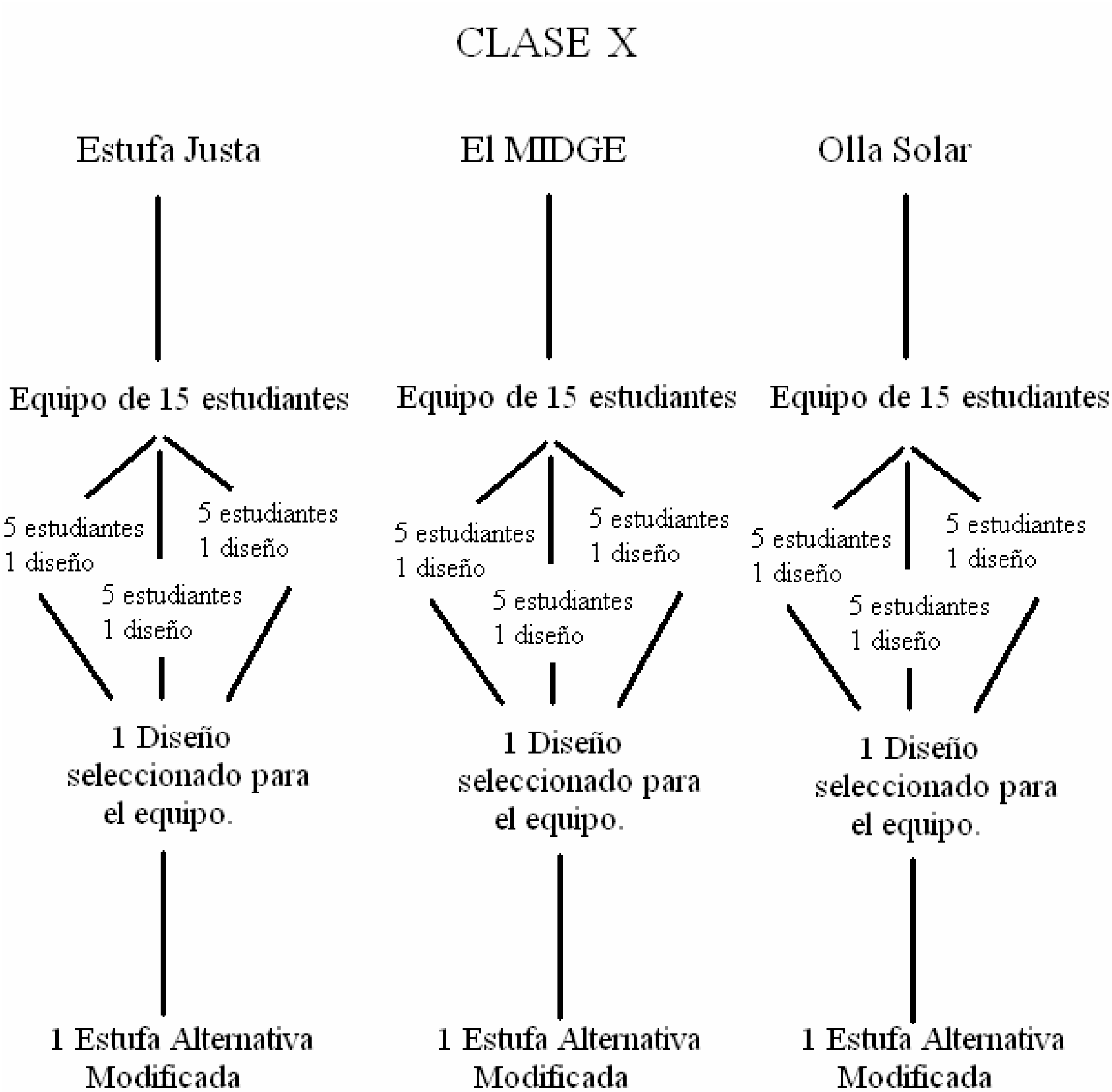
PROCESO DE LA COMPETENCIA Y FECHAS IMPORTANTES:
El 22 y 23 de febrero 2006: Los integrantes de la Universidad de Arizona introducen la competencia y enseñan sobre las estufas alternativas. Ésto es el comienzo oficial de la competenica.
El fín de febrero hasta el 15 de marzo: Los estudiantes de CETis planean y desarrollan sus diseños y presupuestos de las modificaciones para sus estufas alternativas modificadas.
16 de marzo: Los integrantes de la Universidad de Arizona toman los diseños y presupuestos desarrollados por los estudiantes de CETis para revisarlos.
20 de marzo: Los integrantes de la Universidad de Arizona regresan a CETis para decir cuales diseños y presupuestos ellos han seleccionados, y dar dinero ($20 para cada diseño seleccionado) para usar con el proceso de construcción de la estufa.
21 de marzo hasta el 4 de abril: Los estudiantes de CETis construyen sus estufas alternativas modificadas según los diseños y presupuestos seleccionados.
5 de abril: Día final de la competencia, y día en que integrantes de la Universidad de Arizona, vecinos de colonias Bella Vista y Flores Magón, y miembros de ARAN juezgan las estufas y les dan los premios a los estudiantes de CETis.

REGLAS PARA LAS ESTUFAS ALTERNATIVAS MODIFICADAS:
Se tiene que usar un máximo de materiales reciclados, para que las estufas sean fácil de duplicar por la gente. Lo más materiales reciclados, lo mejor.
Todos los materiales tienen que ser encontrados en Nogales, Sonora.
No se puede copiar los diseños básicos de las estufas alternativas que ya tenemos y sabemos. Lo más aumentada y mejorada la estufa, lo mejor.
Se puede buscar ayuda afuera de su grupo, como la ayuda de sus padres u otra gente conocida.

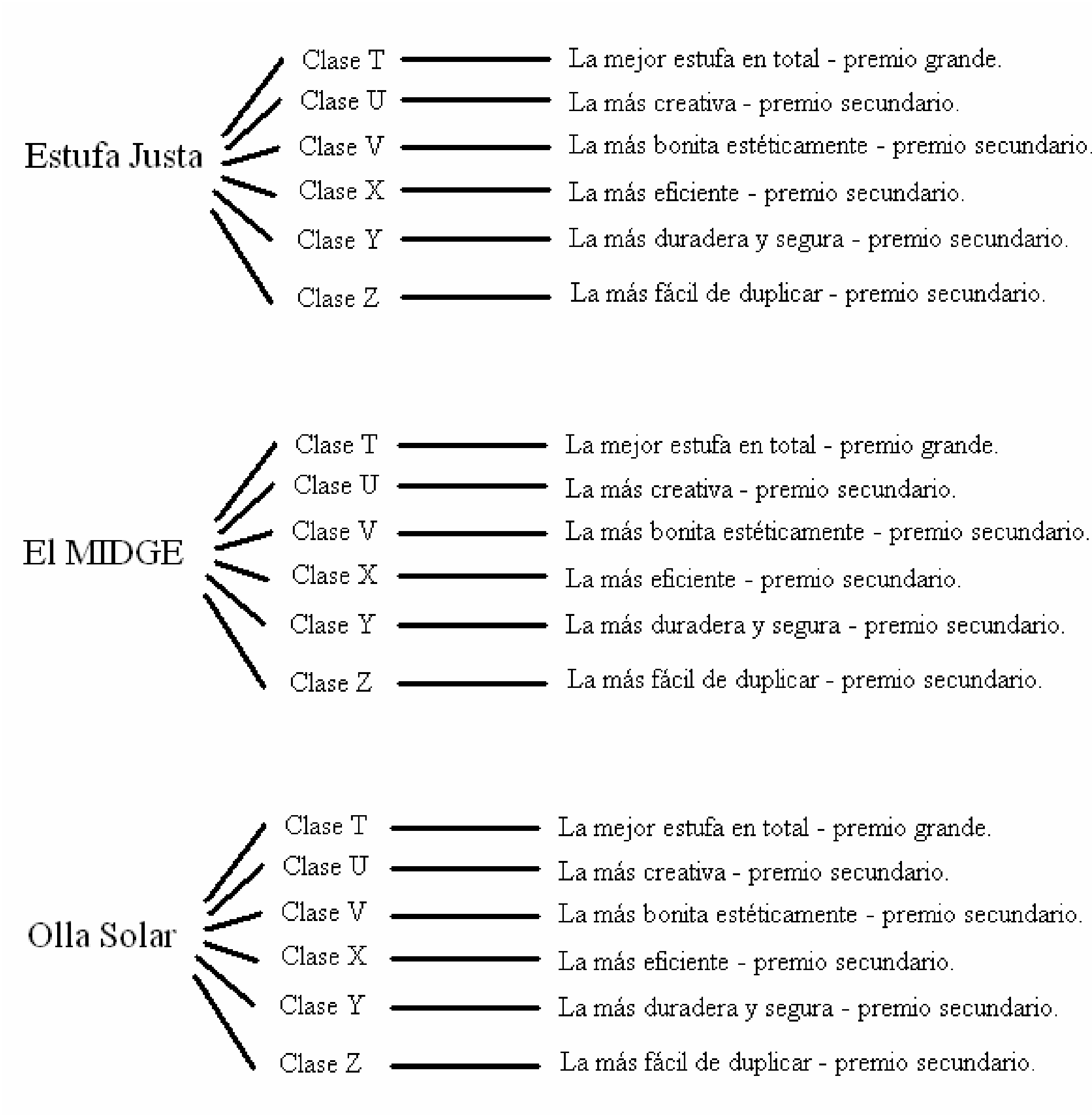
REGLAS PARA EL JUICIO DE LAS ESTUFAS MODIFICADAS:

Los juezes van a juzgar cada tipo de estufa contra el mismo tipo de estufa Por ejemplo, no van a juzgar los MIDGEs contra las Estufas Justas. En vez, todos los MIDGEs serán juzgados contra los otros MIDGEs, y todas las Estufas Justas serán juzagodos contra otras Estufas Justas, con premios para cada uno.
Hay seis categorías de criterio para juzgar las estufas de cada tipo:
La mejor estufa en total (esta estufa tendría características de todas las siguientes categorías).
La más creativa.
La más bonita estéticamente.
La más eficiente en consumer leña y/o calentarse.
La más duradera y segura.
La más fácil de duplicar (en términos de tamaño de materiales reciclados y facilidad de construir).
Los con la estufa mejor en total ganarán el premio grande. Las otras ganarán los premios secundarios.
Revisa los sigiuentes gráficos sobre la estructura de la competenica y los premios.

ESTRUCTURA DE LA COMPETENCIA (CON CLASE X COMO EJEMPLO):



ESTRUCTURA DE LOS PREMIOS:



COMPETENCIA DE ESTUFAS ALTERNATIVAS EN CETIS

Hoja del Diseño y Presupuesto

Clase: ____________________________________

Estufa: ____________________________________

Nombres: ____________________________________

____

____

____

____

____

____

Materiales para la estufa:

Nombre/Tipo	Cantidad	Coste de 1	Dónde se lo encuentra
____________________	_____	_____	______________________
____________________	_____	_____	______________________
____________________	_____	_____	______________________
____________________	_____	_____	______________________
____________________	_____	_____	______________________
____________________	_____	_____	______________________
____________________	_____	_____	______________________
____________________	_____	_____	______________________
____________________	_____	_____	______________________
____________________	_____	_____	______________________

Coste total de los materiales: ________________

DIBUJOS DEL DISEÑO DE LA ESTUFA

Diseño con los componentes seperados y nombrados:

Diseño con todos componentes juntos:

Vista desde arriba

Vista desde lado

Pasos de construcción:

1.)

2.)

3.)

4.)

5.)

COMPETENCIA DE ESTUFAS ALTERNATIVAS EN CETIS
Hoja de Revisión y Resultados

Clase: ____________________________________

Estufa: ____________________________________

Nombres: ____________________________________
____
____
____
____
____
____

1.) Escribe como pasó el proceso de construcción de su estufa. ¿Qué fue fácil y difícil? Si Ud. y sus compañeros tuvieron que hacer unas improvisaciones desde el diseño original, explica sobre ellas aquí.

2.) ¿Qué han aprendido Ud. y sus compañeros sobre estufas en general, y de su estufa espicificamente? ¿Que habrían cambiado Ud. y sus compañeros sobre su estufa en retrospectiva?

3.) ¿Cuáles recomendaciones o sugerencias tienen Uds. para otros que quieran construir estufas alternativas en general y unas como suya?

3.) Llena los siguientes espacios con la información necesaria sobre el uso actual de su dinero y su presupuesto.

Materiales y presupuesto original:

Nombre/Tipo	Cantidad	Coste de 1 o es reciclado	Dónde se lo encuentra
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________

Coste total de materiales: ________________________

Materiales y presupuesto actualmente usados:

Nombre/Tipo	Cantidad	Coste de 1	Dónde se lo encuentra
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________
________________________	______	______	__________________________

Coste actual del proyecto: ___________ Suma de dinero no usado: _____________

Appendix 6: Stove Monitoring Forms

This appendix contains examples of the monitoring forms distributed to users of alternative stoves. Each stove user was given a folder containing two monitoring forms. All users completed a simple checklist form to indicate which stoves they used each day. In addition, each user completed a form specific to the alternative stove they were using. Stove users who agreed to continue monitoring after the study period used only the general checklist forms.

The monitoring form designed specifically for users of the Estufa Justa or Eco-Stove was particularly problematic. Many users of these stoves lacked the time, incentive, or literacy skills to complete the form. In addition, wood use data were unreliably reported and not comparable from one household to the next because of the wide range of wood types and sizes used by households. The latest recipients of Estufa Justas and Eco-Stoves were asked to complete only the general stove checklist and were visited regularly to discuss their specific cooking experiences.

During the study period, the research team also experimented with a monitoring form designed by Solar Household Energy, Incorporated. This form, which resembles a calendar, was designed for solar cooker users with limited literacy. Participants in this study found the SHE-Inc form less clear than the original solar monitoring forms, and the research team found the data less detailed and less reliable.

General Monitoring Form for Eco-Stove or Estufa Justa Users

AGOSTO		Estufa a Gas	Estufa a Lena	Estufa Electrica	Estufa Justa o Eco-Estufa	Comentarios Adicionales
Martes	1					
Miercoles	2					
Jueves	3					
Viernes	4					
Sabado	5					
Domingo	6					
Lunes	7					
Martes	8					
Miercoles	9					
Jueves	10					
Viernes	11					
Sabado	12					
Domingo	13					
Lunes	14					
Martes	15					

General Monitoring Form for Solar Users

AGOSTO	Estufa a Gas	Estufa a Lena	Estufa Electrica	Olla Solar	Olla Solar y Gas para la misma comida	Comentarios Adicionales
Martes 1						
Miercoles 2						
Jueves 3						
Viernes 4						
Sabado 5						
Domingo 6						
Lunes 7						
Martes 8						
Miercoles 9						
Jueves 10						
Viernes 11						
Sabado 12						
Domingo 13						
Lunes 14						
Martes 15						

Eco-Stove and Estufa Justa Monitoring Form

Nombre: ______________________ Dirección:______________________________ Colonia: _________________

FAVOR LLENAR TODOS LOS DIAS (Cada vez que use Gas, Leña, o Eletridad para cocinar)

DATOS GENERALES				SOLO SI USO LEÑA					
FECHA	**ALIMENTOS**	**TIPO DE ESTUFA**	**AGUA**	**TIPO Y CANTIDAD**			**TAMAÑO**	**TIEMPO**	
		Gas Calentón Justa Eléctrico	Baño, Trastes, Café	**Racas**	**Tablas**	**Leña**	Tamaño de las tablas o Leña (en cm o cuartas)	Hora en que prendió el fuego	Hora en que apago el fuego
Día 1	Mañana:								
	Mediodía:								
	Noche:								
Día 2	Mañana:								
	Mediodía:								
	Noche:								
Día 3	Mañana:								
	Mediodía:								
	Noche:								

Solar Monitoring Form

Uso de Olla Solar					Clima				
Fecha	Inicio	Termino	**Tipos de Comida**	**Satisfacción** 1 = ☹ 5 = ☺	Soleado	Semi-soleado	Nublado	Viento	**Como funciono la Olla?** **(si tuvo dificultades, indique)**
				1 2 3 4 5					
				1 2 3 4 5					
				1 2 3 4 5					
				1 2 3 4 5					
				1 2 3 4 5					

Olla Solar

Abril 2006

Domingo	Lunes	Martes	Miércoles	Jueves	Viernes	Sábado
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23 / 30	24	25	26	27	28	29

Appendix 7: Alternative Construction Technologies Matrix

Parameter	Papercrete	Grancrete	Sandbag	Ferrocement	Insulated Concrete Forms	Expanded PolyStyrene (EPS)	Adobe	Tires	Strawbale	Rammed-Earth	Cast Earth
Type	Re-pulped paper fiber with portland cement or clay and/or other dirt added.	Cement-like, mix and spray on	Sand	'Ferrocement' as it is sometimes called, is really a form of reinforced concrete made of wire mesh, sand, water and cement, which possesses unique qualities of strength and serviceability.	Foam Block	1. Wire Mesh/Truss Panels 2. Pressed Cellulose Fiber Cement Board Panels - 3. Fiber-Reinforced Composite Panels	Adobe bricks * are made from sun-baked clay. They have been used for millennia to build durable, well insulated dwellings in the warmer, drier regions of the earth, where the soil is suitable.	For walls, load-bearing structures, etc.	Materials for a straw-based fibre or particle board can include , wheatstraw, oatstraw, flax, sisal, hemp, etc.	Indigenous soil, mud that is compressed.	"A structural material made with earth and calcined gypsum can replace wood or steel framing in residential and light commercial buildings, yielding energy and environmental benefits."
Description	Two types: a) wastepaper, sand, water, and concrete or, b) wastepaper, sand, water only	The Grancrete® house is a manufactured in-situ sandwich panel design. The core material used is generally 5 cm thick polystyrene board with strategically placed steel or aluminum stiffening. This material cures very quickly to form a hard, dense, concrete-like material that is fully bonded to the polystyrene core. In less than 30 minutes it is a s strong as conventional	A low cost building program that uses local materials and is cognizant of space constraints. The sandbag system or 'superadobe' system as a "basic construction technique involves filling sandbags with earth and laying them in courses in a circular plan. The circular courses are corbelled near the top to form a dome. Barbed wire is laid between courses to prevent the sandbags from shifting and to	An excellent choice because of its durability, and because it reduces the mass of materials in a structure.	ICFs have been successfully used by European builders for decades, and became popular in North America in the 1990s. This builder-friendly wall system is a variation of poured-in-place concrete construction and has found its way into many new homes across every region and in every price range. In ICFs, the forms are made of polystyrene and left in place after the concrete hardens. The polystyrene functions as the insulation and the concrete functions as the structure.	Excellent material for home construction because of its low thermal conductivity, moderate compressive strength, and excellent shock absorption. Use of EPS and a reinforced concrete coating circumvents the need for expensive wood in roof construction	**(From Wikipedia)** **Adobe** is a building material composed of water, sandy clay and straw or other or(ganic materials, which is shaped into bricks using wooden frames and dryed in the sun	Integral part of Earthships living structures. Uses scrap tires with earth rammed into it.	Straw for roofing has been used for millennia. More recently, the pressure on the world's forests and concern about greenhouse emissions has caused what was once an agricultural 'waste' to come to be regarded as a truly sustainable and energy-efficient building medium.	Used in numerous areas worldwide and historical eras. Structures made from soil but unique because of ramming, which makes it highly bonded " with a degree of cementation due to soil pore pressures, the electro-magnetic attraction of the clay particles, and the interlocking of the granular particles."	Used in residences & commercial scale structures, does not involve laying bricks or blocks or slowly compacting earth by mechanical or pneumatic action. An entire building is rapidly poured in place, forms removed shortly after the pour. Calcined gypsum has a fast set rate to a wet strength sufficient to support a wall, at a low concentration. 15 % calcined gypsum provides surprising strength immediately

Parameter	Papercrete	Grancrete	Sandbag	Ferrocement	Insulated Concrete Forms	Expanded PolyStyrene (EPS)	Adobe	Tires	Strawbale	Rammed-Earth	Cast Earth
		concrete.	provide earthquake resistance.								after setting. Steel reinforcing is not used.
Producer	Home-based technology	Casa Grande and Argonne National Laboratory (U. of Chicago and Dept. of Energy)	Arch. Nadir Khalili and Cal-Earth Foundation	Various	**Several:** Rastra®, the Quad-Lock System, I.C.E. Block, Advanced Eco Structures, and Arxx® . Check out Insulating Concrete Forms Association.	Various	Various	Various Michael Reynolds for Earthsips	Various	Various	Cast Earth
Contact Person/Details	Various.	Office of Technology Transfer, Terry Maynard, 630-252-9771, tmaynard@anl.gov, Argonne National Lab or Jim Paul, Grancrete, Casa Grandae, 804-730-0023, j.paul@grancrete/net. www.grancrete.net.	www.calearth.org (760) 244-0614, and send a fax. to (760) 244-2201	hoh@montrose.net Paul Sarnstrom -- Director Ferrocement Educational Network	**http://www.cement.org/basics/concreteproducts_icf.asp#**	**Henry Kelly (fas@fas.org) or Alliance of Foam Packaging Recyclers-** 1298 Cronson Boulevard, Suite 201 Crofton, MD 21114 USA (410)451-8340 (phone) (410)451-8343 (fax) Contact Us!	Various http://www.dirtcheapbuilder.com/		Various http://www.dirtcheapbuilder.com/	Various http://www.dirtcheapbuilder.com/	**build@CastEarth.com** build@castearth.com Harris Lowenhaupt
Typical Properties (qualitative)	Ideally for dry climates, but can be used in wet climates as well. Used for walls/roofing. Less dense than concrete. Multi-level structures possible. Good insulation properties				ICFs displaces usse of costly wood and metal forms. It is non-biodegradable, hence does not rot. They can increase the temperature range for pouring concrete to below freezing (freezing inhibits proper curing) by insulating the concrete until fully cured. ICFs can						Similar to rammed earth's qualities, but the calcined gypsum increases settling rate.

Parameter	Papercrete	Grancrete	Sandbag	Ferrocement	Insulated Concrete Forms	Expanded PolyStyrene (EPS)	Adobe	Tires	Strawbale	Rammed-Earth	Cast Earth
					also result in a higher strength wall than standard cast-in-place concrete due to more constant, predictable cure during all seasons.						
Benefits	-Dimensionally very stable both in moisture, drying out, and temp ranges - It will hold fasteners to some extent, especially screws, without cracking. -Highly insulating (about R-2 1/2 per inch). -Does not support flames, but will smolder for days if it does catch fire. (cement makes it fire-proof) 8) It resists rodent and insect infestation.	Completely fireproof, vermin and termite proof. Non toxic. Water proof. Will not shrink or crack. Efficient insulator for both thermal and sound. Durable - several times stronger than concrete. The construction methodology combined with the fast cure characteristics of the Grancrete® material allows structures to be built very quickly.	It is desirable because it is suitable to hot/dry climates, is cheap, is easy to set up, and uses indigenous materials. It has also withstood the test of time. Thus, the sandbag system is flood resistant, aerodynamic, good thermal mass, fireproof, stable with good tensile strength, and cheap.	Can be used in construction with a little skilled labor, utilizes readily available materials. Proven as suitable for boatbuilding, has many other tested or potential applications. Can be fabricated into almost any shape, more durable than most types of timber and can be used as a subsititute for either timber or steel in many applications. Structures don't need heavy plant or machinery for manufacture - the process is instead labor-intensive. (See vol 48 and 49 of Earth Garden Magazine	-High strength, namely resistance to high winds - Energy efficient / Comfortable / High Thermal Mass - Good noise abatement - Durable - Reduced number of subcontractors and construction steps - Extension of the building season	**RASTRA**'s beneficial qualities include: -4 hour fire rating -High insulation value -No toxic outgassing -Energy saving Sound attenuation -Pest resistant -Seismic 4 System ICBO ER-4203	Adobe structures are extremely durable and account for the oldest extand buildings on the planet. Adobe buildings also offer significant advantages in hot, dry climates, as they remain cooler as it stores and releases heat very slowly.				
Risk issues	-Off-gassing				In building and	Toxicological					

Parameter	Papercrete	Grancrete	Sandbag	Ferrocement	Insulated Concrete Forms	Expanded PolyStyrene (EPS)	Adobe	Tires	Strawbale	Rammed-Earth	Cast Earth
	-Fugitive dust -Will support molds if it remains warm and moist for too long. -Will wick moisture from the ground into the wall if it buried in dirt. -Bcomes soft and will deteriorate if kept damp (especially underground) for too long.	??	**??**	Radon off-gassing issues	construction, foam is a generic term for any materials which have been permeated with bubbles of a gas. It is mainly used for cushioning and building insulation. Foam rubber is traditionally latex rubber which has been whipped to make it frothy prior to being vulcanized. Synthetic or plastic foam (styrofoam) is made from a polymer of the styrene. These synthetic materials are notorious for outgassing formaldehyde which is used during their manufacture. Formaldehyde-related diseases include cancer, dermatitis, asthma. Another by-product of the breakdown of styrene is styrene oxide, which is can cause cancer, or liver and kidney damage. Many if not most synthetic PVC foams are loaded with toxins and should be considered too	tests by manufacturers have shown that fumes from burning EPS represent no greater toxic risk than fumes from natural materials, such as wood, cork, or wool.	Seismic issues	Stability if not properly set up.	Seismic and fire issues if not properly set up	Stability if not properly set up	??

Parameter	**Papercrete**	**Grancrete**	**Sandbag**	**Ferrocement**	**Insulated Concrete Forms**	**Expanded PolyStyrene (EPS)**	**Adobe**	**Tires**	**Strawbale**	**Rammed-Earth**	**Cast Earth**
					dangerous to recycle.						
Testing	Various testing done worldwide	Various, on-going	Complies with California housing code	**??,** Depends on actual material.	Various	Various, on-going	Various, depends on actual producer, manufacturer	Various	Various	Laboratory work done include: Wall 1 - Clay gravel mix Wall 2 - Clay sand mix Cube Testing Wall 3 - Unsupported at one end, to model tensile cracking. Computer Analysis (modeling possible)	Various
Costs	Affordable. Transport costs of sand, wastepaper collection. Energy costs for cement mixer. Cement and sand costs.	For less than $10,000US, laborers can produce Grancrete dwellings of 800 square feet; a typical apartment in a city like Bombay, India, is only 400 square feet.	$2,300 for a single unit (400 sq. ft. approx), $2,800 for double unit (800 sq. ft. approx.), includes shipping, CA residents please add sales tax. Additional charge of 25% for each repeated unit.	Depend on materials, labor, equipment, etc. Discussion with architect, engineer, etc. needed.	Depend on materials, labor, equipment, etc. Discussion with architect, engineer, etc. needed.	Depend on materials, labor, equipment, etc. Discussion with architect, engineer, etc. needed.	Depend on materials, labor, equipment, etc. Discussion with architect, engineer, etc. needed.	Depend on materials, labor, equipment. Discussion with architect, engineer, needed.	Depend on materials, labor, equipment, etc. Discussion with architect, engineer, etc. needed.	Depend on materials, labor, equipment, etc. Discussion with architect, engineer, etc. needed.	Building costs are job and site specific. Lifetime costs are substantially less than frame construction because of the high energy efficiency and low maintenance expenses of earth walls.
Describe level community acceptability and support	Site and case-specific. Information, Education, and Communication (IEC) needed.	Site and case-specific. IEC needed. Cost likely an issue.	Site and case-specific. IEC needed. Logistics need to be worked out	Site and case-specific. IEC needed.	Potential r barriers to use of ICFs:. -General unfamiliarity of code officials and inspectors with the product -Fire issues due to the use of foam	Site and case-specific. IEC needed.	Site and case-specific. IEC needed. Material supply an issue	Site and case-specific. IEC needed. Space an issue	Site and case-specific. IEC needed. Supply an issue	Site and case-specific. IEC needed. Construction materials an issue	Site and case-specific. IEC needed. Costs likely an issue.

Parameter	Papercrete	Grancrete	Sandbag	Ferrocement	Insulated Concrete Forms	Expanded PolyStyrene (EPS)	Adobe	Tires	Strawbale	Rammed-Earth	Cast Earth
					Termites and the use of foam below-grade -Structural concerns, especially for high loads due to backfilling, wind, earthquake; attachment/integration of walls, floors, roofs; and proper filling of forms with concrete Moisture protection Attachment of finishes						
How long to implement technology	Rapid, dependent on program	Rapid	Rapid, dependent on program	Rapid, dependent on program.	Rapid, dependent on program	Rapid, dependent on program	Rapid, dependent on program	Rapid, dependent on program	Rapid, dependent on program	Rapid, dependent on program	Rapid, dependent on program
Any success stories?	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international
Negative feedback?	Yes, see risk aspects.	Possibly cost	Possibly cost	Not popular in Nogales. Website says cost an issue.	Possibly cost	What kind will be used? Commercial products costly.	Yes, see risk aspects.	Yes, cost, logistics are issues	Yes, cost, supply, logistics are issues	Yes, cost and logistics are issues	Site and case-specific. IEC needed.
Prominent users?	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and internatn'l	Yes, U.S. and international	Yes, U.S. and international	Yes, U.S. and international
Recommendation/Comments:	Complete data set needed Pilot program needed Actual testing of materials Sealant investigation Long term monitoring	Costs and logistics	Complete data set needed Pilot program needed Actual testing of materials Sealant investigation Long term monitoring	Complete data set needed Pilot program needed Actual testing of materials Sealant investigation Long term monitoring	Costs and logistics	Costs and logistics	Logitics issues need to be addressed	Address issue of space and supply	Investigate supply	Complete data set needed Pilot program needed Actual testing of materials Sealant investigation Long term monitoring	Costs need to be investigated

NON TIMBER BUILDING MATERIALS

There are nearly one hundred non-timber materials described and listed alphabetically below.
These materials are not endorsed purely because they are mentioned here. It is more the case that the Guide wishes to delineate their relative merits and faults. Mostly they represent ways of using either none, or significantly less amounts of timber in construction. Some of the materials may not be universally available, but are intended to exemplify just some of the limitless possibilities for safe, effective and durable shelter-creation.
The outstanding materials, in terms of their environmental friendliness, versatility, availability, and ease of use are: **Bamboo, Biotecture, Earth, Grasses, and Hemp**.
In general, once human and natural ethical concerns have been considered, choose natural materials which breathe (ie, are hygroscopic)**, rather than synthetic materials.**

ALUMINIUM

Used for window frames, light-weight mouldings, for roofing, walls. Should be used sparingly as aluminum production is a highly polluting and energy intensive process. Buy recycled aluminium window frames, for example.
(**NB**: If you decide to purchase new aluminium window frames, please specify that the window reveals must not be made from rainforest timber.)

ALUMINIUM CANS

Mobile home: A Japanese man in 1996 sailed 16,000 kilometres across the North Pacific in a solar-powered 9.5 metre boat made from 22,000 recycled aluminium cans.
The headquarters of Solar Survival Architecture * in Taos of the USA uses recycled cans as a building material.
* See under Architects in the **Building** section of the Directory.

BAMBOO

The world's most useful plant. Bamboo is a very large grass rather than a tree, yet has a timber-like quality when used as a construction material. It is the fastest growing plant in the world and certain species can reach heights of over 100 feet at rates of up to 5 centimetres per hour.
This botanical cousin to rice and corn has over 1,000 species of varying sizes and characteristics makes it amazingly versatile: it may be used for building whole houses, furniture, cases, baskets, screens, farm tools, fishing rods, windmill blades, boatbuilding, record needles, paper, kites, blowguns, polish, diesel fuel, scales, food, medicine, chopsticks, incense sticks, musical instruments, blinds, tipi poles, concrete reinforcement, plastic reinforcement, scaffolding, cables, bolt subsititutes, piping, bike frames, various other structures and a host of other durable, useful, crafted items. Perhaps the bamboo grove itself could be considered an 'item' in that it has traditionally been a place for contemplation and spiritual enlightenment.
Bamboo is also used for brewing beer. An Edison light bulb in the Smithsonian Institute in Washington, D.C. has a bamboo filament which is still capable of burning after more than a century. At one time, unscrupulous Assamese traders were fraudulently selling the carefully trimmed culms of a

local bamboo species as genuine rhinoceros horn to the Chinese, who value the 'horn' for its aphrodisiacal properties. The bamboo cable-supported Min Bridge in Szechuan is over 1,000 years old.

With greater understanding of its qualities and propensities in the West, its reputation for invasiveness in the garden is now giving way to one of efficiency, workability, versatility, cost-effectiveness and earth-friendliness as a building medium. Due to its starch content, bamboo needs preserving to prevent borer attack and decay, but its cellulose content is also what makes it a source of paper pulp. Most of the bamboo used for manufacture (of mainly furniture and blinds) in Australia is imported from Southeast Asia, but plantations of the most useful species are springing up all over our country. (Note that China grows the most bamboo, while India is the largest exporter; but it is Japan which has traditionally been the greatest exploiter of the usefulness and beauty of bamboo).

When purchasing bamboo products, avoid any that have been treated with DDT solutions or similar to prevent borer damage. Instead, specify borax-treated bamboo.

(See also Rattan, under Cane. See Concrete in this list for information about bamboo-reinforced concrete. See the article Bamboo - the Rainforest's Universal, Renewable, Spiritual Resource. See Bamboo in the **Building** section and Bamboo in the **Books** section of the Directory.)

BAMBOO PLYWOOD

(See the article Bamboo Plywood, and Bamboo under **Building**, and Bamboo under **Books**, in the Directory.)

CARDBOARD

Two US companies, Gridcore and Simplex Products, make a fibreboard from cardboard boxes*, office waste, paper mill waste and manufacturing scrap. The board is very durable and, in Gridcore's case, envisaged as a substitute for plywood and/or gyprock.

* See also Building with Cardboard.

CLAY 1

Clay is used in house-bricks, mud bricks, rammed earth, pise, and terracotta roof, floor and wall tiles.

A type of clay called Bentonite is used as a sealing agent for ponds and dams, although it is rather expensive. (See also Gley, below)

(See also Adobe, and Natural Concretes)

COB

'Cob' comes from an Old English word meaning "a lump, or rounded mass". Cob builders use their hands and feet to form lumps of earth mixed with sand and straw. It is said to be easy to learn and and an inexpensive way to build, and apparently surpasses related techniques such as adobe, pise and compressed earth bricks, etc. Because there are no forms, ramming, cement or rectilinear bricks, cob lends itself to organic shapes - curved walls, arches and vaults. Earthen houses are cool in summer and warm in winter.

(See also Earth, Mud and Rammed Earth, below. See the article Building with Cob)

COMPRESSED EARTH BRICKS

Compressed earth bricks are like blocks of reconstituted sandstone. They are comprised of clay, sand and clay loam milled and mixed with cement. They are very energy-efficient to manufacture, requiring only about one-quarter to one-third of the energy needed for clay bricks, concrete blocks or even sawn timber. They are extremely strong, durable, and are recyclable. In Australia and elsewhere, the CINVA Ram is one of the most commonly used earth compression machines.

(See also Earth and Mudbricks)

EARTH 1

Earth is the simplest, cheapest, most easily worked, durable and most ancient building material. It is the best thermal and acoustic insulator, and is flame, rot and insect resistant. Earth walls breathe and help create stable indoor microclimates. Earth can be used raw or fired or baked as bricks. Mud brick or adobe dwellings can last for centuries. Ancient cob and 'wattle and daub' type structures still exist in the UK and Europe, hidden behind modern brick and plaster facades. Earth building has also traditionally been a great medium for experimentation in form and colour.

Architects now talk about earth-integrated buildings of varying degrees. These can be either above or partially below ground level, and with accompanying passive-solar design features. Earth can be piled against walls and up to the eaves of a conventionally constructed dwelling to give maximum insulation. Purpose-built homes can be designed to be completely covered with earth (apart from access for people, air and light), if the temperature range is extreme. An earth-sheltered house with a turf roof and (mud) slab floor provides a good, year-round comfort zone. Pressed earth blocks make an excellent construction medium, as do cob and rammed earth walls.

Leichtlehmbau or 'light earth method', is a newly arrived technique in the West, derived from an old European tradition of building light earthen dwellings. LEM, as it is called, is becoming popular in New Zealand. There are no known practitioners in Australia, yet.

The University of Minnesota's Civil and Mining Engineering Building actually goes 7 storeys into the earth instead of upward, placing 95 percent of the building below ground. A periscope system provides picture-window type views of the campus at ground level, and a series of mirrors provides solar lighting for all the below-ground classrooms and offices. Groundwater is pumped up to provide cooling for rooms at ground level.

One potential drawback for earth is its vulnerability to water and impacts. These are remediable characteristics, however.

(See also Cob, above, and Rammed Earth, below. See Builders, Earth, Adobe... in the Directory).

FERROUS CEMENT 1

An excellent choice because of its durability, and because it reduces the mass of materials in a structure. 'Ferrocement' as it is sometimes called, is really a form of reinforced concrete made of wire mesh, sand, water and cement, which possesses unique qualities of strength and serviceability. It can be used in construction with a minimum of skilled labour and utilises readily available materials. Proven as suitable for boatbuilding, it has many other tested or potential applications in agriculture, industry and housing. Ferrocement can be fabricated into almost any shape, is more durable than most types of timber and can be used as a subsititute for either timber or steel in many applications. Ferrocement structures don't need heavy plant or machinery for their manufacture - the process is instead labour-intensive.

(See back issues 48 and 49 of Earth Garden Magazine Ferrocement Tank; Ferrocement Roofs.)

FOAM

In the context of building and construction, foam is a generic term for any materials which have been permeated with bubbles of a gas. As such, it is mainly used for cushioning and building insulation.

Foam rubber, for example is traditionally latex rubber which has been whipped to make it frothy prior to being vulcanised (ie, treated with sulphur and heat). Synthetic or plastic foam (or styrofoam) is made from a polymer of the styrene. Commercial versions of these synthetic materials are notorious for outgassing formaldehyde which is used during their manufacture. Formaldehyde-related diseases include cancer, dermatitis, asthma. Another by-product of the breakdown of styrene is styrene oxide, which is can cause cancer, or liver and kidney damage. Many if not most synthetic PVC foams are loaded with toxins and should be considered too dangerous to recycle.

A non-toxic insulating foam called 'Air-Krete', is now marketed in the United States as an alternative to fibreglass insulation. Air-Krete is made from tiny magnesium oxide bubbles which encapsulate atmospheric air. Magnesium oxide is a natural mineral used for centuries to make fire bricks. Its higher cost is offset by its superior thermal qualities.

Non-toxic foams based on vegetable plastics may be possible.

GEODESIC DOMES

Geodesic domes, the sixties brainchild of R. Buckminster Fuller, have slowly made their way into the mainstream of architecture. Their geometric design allows them to enclose substantial spaces with minimal structural materials.

One example developed by the New Alchemists in the United States is termed the Pillow Dome. It comprises less than 4% framing on its surface, compared to 1025% for most greenhouses. The 9 metre dome weighs about 270 kg. Its plastic triangular panels are heat-sealed at the edges, clamped to the geodesic framing and then permanently inflated with argon. This prevents wind-flap and condensation inside the pillows while making pockets of still gas for insulation. The inflated panels pre-stress the building and give it the rigidity to withstand winds over 160 kmh.

The dome's pillow panels are inflated with dry argon gas, an inert noble gas commonly available through welding suppliers. Argon loses less heat through conduction and convection than air.

The Plastic glazing is a Dupont-manufactured product called Tefzel, three layers of which transmit as much sunlight as one layer of glass about 85%. Tefzel is non-toxic, chemically inert, and long-lived. It is one of the few plastics that transmits ultraviolet light and which helps to prevent the growth of fungal diseases on plants growing inside the dome yet blocks much of the long-wave infrared radiation, thus reducing potential heat-loss. Twelve fibreglas silos, each of approx 2 cubic metres capacity, are placed inside the dome to give it thermal stability.

GEOTECTURE 1

Geotecture refers to the design and construction of earth covered and earth sheltered housing. (See Clay, Cob, Earth, Mud, Natural Concrete, Pise, Rammed Earth, Soil Cement, Turf, Wattle and Daub).

GLASS

Glass is that ubiquitous, seemingly invisible barrier used in windows, doors, skylights, etc, of most Western homes. Like most manufactured products, it places a certain amount of strain on the environment during manufacture. The heat required for the process of fusion of the silica (sand),

sodium oxide, and calcium oxide (limestone - because of its alkalinity) with mineral oxides, colorants and broken glass (cullet) matter (sand) is quite considerable. Once in-situ, however, glass is relatively inert, long-lived and efficient at its task.
In the US, recycled glass is being incorporated into 'Syndecrete' cementitious floor tiles. Also, a Seattle company, Trivitro, converts recycled glass into an abrasive material suited for sandblasting which offers environmental and health benefits over traditional sandblasting minerals since it doesn't have crystalline silica or heavy metals in its makeup.
Look for salvaged windows at your timber recycler. If it's available and affordable, always opt for safety glass (ie, intact panes which have been either tempered or have layers of plastic or mesh to prevent disintegration). If you must buy new glass, check out energy-efficient ones such as Pilkington Smart Glass (see **Building Materials, Non Timber**, in the Directory).

GLASS BRICKS
Light-conducting glass bricks have been available through building suppliers for many years. Also, old bottles and flagons set in walls reduce the amounts of concrete or cement required, yet make ideal light-conductors and maintain privacy.

GRASSES
Mainly used for thatching, but grasses can also be used like straw in under-roof insulation. Vetiver grass, for example, is traditionally used for weaving window-shades, which, when moistened, give off a delightful fragrance. Grasses often provide an abundant raw material for walls, roofs and ceilings, etc, in areas which lack sufficient trees due to climatic or ecological reasons. European architects of the biological building school are beginning to reintroduce grass roofs.
Spinifex grass is a traditional material used by indigenous people on their dome-shaped shelters in north-west Western Australia. The grass tree (Xanthorrhoea) provided indigenous and the first non-indigenous Australians alike with durable thatching material.
In Africa's arid Sahel region, people move from their mudbrick homes into shady mat-tents to escape the intense heat (4045°C). The rectangular mats which 'tile' the roofs are often woven from grasses (but may be made of palms or rushes).
The Fijian bure is comprised of a bush timber frame with a thatched roof of grass or reeds, and grass or palm matting walls.
Australia's many species of Sedge grasses which grow in fresh and saltwater marshes may have great potential for home building - either thatched and woven for roofs and floors, or tied in thick strong bundles to form walls and columns.
(See also Reeds, Palms and Seagrass.)
GYPSUM 1
Gypsum is comprised of hydrated calcium sulphate; it forms the base for Plaster of Paris. More commonly these days it is used in plasterboard (Gyprock) for roofing, wall lining and flooring, etc.
PAPER
A German company, WS Handelsund *, manufactures coffins weighing only 12kg, made from 85% waste paper and which pack flat. They cost half the price of a wooden coffin, yet their appearance and functionality is very similar. The manufacturer claims a number of environmental benefits for

their product, including reduced air pollution during cremation. (If the Australia-wide hemp trials are a success this year, we may even get to see Australian-made hemp coffins.)

* See under Non-Timber Building Materials in the Directory.

PLASTICS (Avoid PVC! Use non-synthetic materials, or PVC-free Polypropylene or Polybutylene instead)

Plastics function quite well in inground applications, or where materials are likely to be exposed to persistent damp, bacteria, or poor ventilation. They are also used for mouldings, insulation and durable facings on board products.

However, the Guide recommends that you opt for more environmentally friendly materials whenever possible. Plastics are made from non-renewable petroleum byproducts, are energy-intensive to produce, involve the use of toxic chemicals and create toxic waste during their manufacture. Most plastics are not biodegradable, making for an ever-growing dilemma of how to safely and ethically dispose of them. (Scientists have yet to devise a viable plastic-eating bacteria.) Too much plastic is abandoned in landfills after only one use - as take away food containers, plastic bags, packaging material, etc. Countless land and marine animals die every day after being choked, strangled or poisoned by plastic rubbish - plastic bags, bread tags, six-pack rings, plastic foam, etc. Plastic refuse is also an horrific visual pollutant in the urban and rural areas and marine environments of the world. (Customers at burger restaurants and takeaways are mostly unaware of the fact that they are paying for the plastic packaging which all too briefly holds their fast food before being discarded and all-too-often blowing away into the ecosystem.)

Plastics don't 'breathe' like natural materials (wood, stone, earth, cotton, hemp, etc) and in fact often emit noxious fumes or hormone-disrupting, biologically active chemicals (phthalates, dioxins) - such as from PVC products, or when they are burnt (highly dangerous).

Products which contain the organochlorine PVC include: pipes, guttering, windows, vinyl flooring, wallcoverings, shower curtains, blinds, non carbonated drink bottles, cooking oil bottles, cling film, margarine tubs and boxes, interior trim, sealants and underseal in cars, tubing, probes, catheters, blood bags and gloves in hospitals.

Greenpeace*, which argues that 99% of current PVC products have a safer alternative, has been fighting long and hard to prevent the use of PVC plastic building materials in the construction of the Sydney Olympic Village. Unfortunately, Australians rank second to Americans in their consumption of PVC products. Recent (and hopefully short-lived) comebacks for PVC have seen it featuring in designer clothing and inflatable designer furniture. Chemicals used to manufacture PVC include the persistent and toxic organochlorine group of chemicals. Production also creates highly dangerous dioxins and hexachlorobenzene (HCB) as waste products. Additives during manufacture include lead and DEHP, both highly poisonous. Pthalates added to PVC are suspected carcinogens.

Older plastic water pipes release pseudo-oestrogens into the water supply. These are implicated in the ever-decreasing sperm counts and increasing feminisation of male animals and humans worldwide.

The U.S. Consumer product Safety commission warns that 'miniblinds', which are made in China, Taiwan, Mexico and Indonesia contain PVC, which degrades to lead dust after being exposed to sunlight and heat. Lead is added during production in order to stabilise the plastic materials in the blinds. Young children have been found with high lead levels in their blood due to ingesting dust from the miniblinds. Horrendous health problems have ensued, including mental and physical retardation and kidney failure. Sweden, Germany and Austria have banned the use of PVC in construction and other applications.

Plastic-based (petrochemical) paints don't allow vapour-exchange in timber, which can lead to its premature breakdown - the exact opposite of what is desired.

Recycling of plastic is very energy-intensive, polluting, and is only third best in terms of a program to "reduce, reuse, recycle". Yet many more recycled plastic products are coming on the market. Those plactics which best lend themselves to recycling are polypropylene, polystyrene, polyurethane, polyethylene (PET, HDPE). Also perspex, polycarbonate and ABS plastics can be recycled. (Processors of all these can be found in the NSW EPA's Recycling Directory).

Polymer Corp. of Queensland has developed a process which fuses and laminates mixed, recycled plastics making them suitable for use as a wallboard (the Guide is not aware of the degree of outgassing from this product, however). Their innovation is that they have managed to devise a technique which can utilise different kinds of plastics. This has been a challenge for the recycling industry because it has been extremely difficult to reprocess plastics with different characteristics, and it has been very hard to get clean, single-type used plastics from the waste-stream.

In Holland, countless thousand of recycled plastic coffee cups, bottles and yoghurt containers were melted down and remoulded to make 50 metre-high, earth-filled noise barriers which were placed alongside a railway line. It was apparently an easy material to work with and also competes well with concrete and steel barriers in terms of price**.

The Japanese car maker, Honda, has opted to establish a new company to manufacture new items, including tables, chairs and simulated wood flooring - all with plastic left over from car production. Also in Japan, a lingerie maker has developed a new line of women's underwear - made from soft cloth and lace produced from chemically processed fibres of crushed plastic bottles. American and European outdoor clothing manufacturers have been using recycled plastic fibre for some time to make thermal clothing.

The US organization, Rainforest Relief***, is promoting the use of post-consumer recycled plastic lumber for waterfront construction ie, piers, wharves, pontoons, and above-water applications. They believe it to be an excellent way of reducing consumption of rainforest timber. It is longer lasting and therefore more economical than wood and other materials, which is important for government budgets. It can be recycled again after use, and does not leach chemicals.

Non-PVC and non-petroleum-based bioplastics and vegetable plastics are being developed by scientists and these are slowly finding their way onto the market as their cost of production decreases, although nature has already developed such things****.

(See also Fibre Reinforced Thermoplastics)

* See under Chemicals, Toxics Groups in the Directory.

** More info: Municipality of Tilburg, P.O. Box 90155, 5000 LH Tilburg, Holland. ph: 0011 31 13 428811.

*** See under Forest Activist Groups in the Directory.

**** See Gley and Hemp, above. See also under Non Timber Building Materials, in the Alternative Directory.

RAMMED EARTH 1

Rammed earth building (sometimes also called either Poured Earth, &/or PISE), requires the use of minimal amounts of timber and maximum amounts of onsite (free!) raw material, ie soil. It is a viable, resource- and energy-efficient option: rammed earth is one of the least labour-intensive of the earth building modes and requires little maintenance. For these reasons, its popularity is continuing to grow.

The rammed earth technique's viability is site-dependent, however, as many soils are not compatible, and because the cost of importing appropriate soil is economically and environmentally expensive. It is important to test soils for compatibility before attempting this means. Cement may be added to sandy soils to improve strength and stability; clay soils are often strong enough without cement. Rammed earth floors and walls have excellent insulation properties. Construction is effected by means of pouring and/or packing earth into timber forms and building up sections of wall, then removing the forms when the new sections of wall are sufficiently dry. Any imperfections, cracks, or damage are easily fixable with mud render. Constructing roofs with generous eaves to protect walls from the worst of the weather is always advisable.
(See Cob, Earth, PISE, above, and Sawment, below. See the article Rammed Earth - with a veneer of science. See Builders, Earth Adobe, and/or The Earth Garden Building Book, in the Directory.)

RUBBER

Rubber appears mainly to be used for flooring in Australia. Several companies manufacture and/or import enviro-friendlier rubber-based floor coverings. (See also Tires, below. See Non-Timber Building Materials in the Directory. NB: For info on availability of imported Indian Rubberwood, see under Timber Industry Promotion Groups, in the Directory)

RUBBLE 1

Also known as 'Slipform Stone building'.
(See back issues 9 & 42 of Earth Garden Magazine)

SAND

Sand is included in every mix of mortar, ferro cement, and concrete. It is one of the main ingredients of 'sawment' and soil cement (see below). In the US, it is being bagged and wired in layers to build very strong, stable structures.
(See the article Adobe & Super Block Technology).

SAWDUST

Used for heating fuel, makeshift floors, and weed-suppressing on garden paths. (See also Sawment, below.)

'SAWMENT' (Sawdust, Sand and Cement) 1

This is a building medium gaining acceptance in the Northern Rivers region of NSW and will no doubt be a strong contender for mainstream applications. A moist mixture of the three materials is packed into wall-cavities to provide thick, solid walls - a low cost way to get excellent insulation properties. Can be used either in construction or to retrofit an existing dwelling.
(See also the article Sawdust, Sand & Cement.)

STONE 1

Stone, in its many varieties, is among the most practical, durable, and aesthetically-pleasing of building media - one of the cheapest too, if it is available onsite for construction. Quarried stone types such as sandstone, granite, slate, marble, basalt (also known as blue metal gravel, good for concreting, roads and paths), and river stones are all popular choices, although their price of some of them often limits their use to feature work. (Being non-renewable, quarried stone will continue to become ever-more expensive.) It should be noted that quarrying is essentially industrial mining, which makes especially the harder stones, such as granite and marble quite energy-intensive materials by the time they are on site (quarrying, handling, processing, storing, shipping, etc).

Although renowned for its durability, stone can be prone to splitting if exposed to water and/or temperature extremes.

Stone floors and walls can also create an inivisible hazard by introducing significant levels of **radon**[1] gas into the home.

People who quarry or process stone must protect themselves from **silicosis** which is a respiratory ailment caused by inhalation of stone dust containing free silica. Silicosis affects breathing capacity, resistance to respiratory disease, and results in scar tissue in the lungs. Stones containing large amounts of free silica include quartz, granite, sandstone, slate, jasper, opal, amethyst, onyx, soapstone, diabase, dolomite, travertine, serpentine, marble and limestone. Stone masons, sculptors, carvers and other processors also have the obvious hazard of flying chips and thus need to to wear protective goggles when chipping or grinding.

Owners of older stone buildings should be encouraged to repair and refurbish them with recycled (salvaged) stone if there are no local sources of raw material. There is a product on the market called Rock-Face Block, which combines a sandstone fascia with a lightweight concrete block. This gives the appearance, strength and durability of a sandstone block, but for less than half the price.

(See Environ Biocomposite and Terra Firma Blocks in **Non-Timber Building Materials** and Builders, Earth, Mudbrick... in the Alternative Directory. See also Bush Rock, and 'Granite' above, and Tufa, below.)

STRAW

Straw for roofing has been used for millennia. Packed straw walls were common during the Tudor period in England and more recently the good folk in parts of America and Canada used straw bales to build walls when lumber was in short supply. More recently, the pressure on the world's forests and concern about greenhouse emissions has caused what was once an agricultural 'waste' to come to be regarded as a truly sustainable and energy-efficient building medium. At least one house in Sydney has been extended using pinned, cement rendered and chicken-wire reinforced straw bale construction. The cost worked out to be about half that of the nearest equivalent material (cavity brick) while having hugely superior insulation properties.

STRAWBOARD

Materials for a straw-based fibre or particle board can include , wheatstraw, oatstraw, flax, sisal, hemp, etc.

(See Biocomp in **Non Timber Building Materials** in the Directory. See also International Kenaf Association under **Non Timber Paper**.)

STRAW BALES

(See the articles in Straw Bale Building)

TIN CANS

Last century, when lack of finances or materials prevented other options, many huts were built of used kerosen tins, bully beef cans, etc. Tinned Dog Hut in W.A.'s Norseman goldfields had flattened tin 'shingles' for the roof and walls of whole cans laid like bricks in clay mortar. Period photos also show people living comfortably in 100,000 litre water tanks.

TIRES

Car and truck tires rescued from garbage landfills (!) are now being used in the United States to build houses. There has however been consternation at the prospect of old tires 'out-gassing', ie giving off noxious gases after being reused or reprocessed. Material from recycled tires has been used for retreads, acoustic materials, roofing, runways, road base, oil spill absorbers, aggregate, asphalt, speed bumps, barriers, mud flaps, doormats, car floormats, packaging, toys, watering systems, animal bedding, fences, garden borders, artificial reefs.*

Ranchers in Arizona in the United States are constructing erosion-control 'dams' made of old tires, which slow rainwater runoff and act as sediment traps. (The initiative was necessitated by 300-odd years of overgrazing by cattle). The U.S. now has a scrap tire recovery rate of 95%. Two Australian companies, Flexitec Pacific and Regupol, manufacture floor coverings and pavers, etc, from old car tires.

(See under Builders, Car & Truck Tires, in the Directory and The Tyre House Book, **Books, Building with Tyres**.)

* It has been claimed that old tires may leach cadmium, but the Guide is unable to verify this or whether it applies only for specific brands or composites, or for older makes only. The US Environmental Protection Authority has issued a report that there is no undesirable out-gassing from tires.

WATER

Apart from being essential for the chemical curing of concrete and cement, water is better known for its aesthetic (and life-giving!) properties in and around the average Western dwelling. Yet its insulative abilities give it enormous potential in the design of low-energy buildings of the future. Water-filled bottles, for example, can be built-in to make attractive, inexpensive, light-conducting walls which reduce the need for conventional materials such as bricks and render, yet can be masked to provide great insulation properties.

(See also Aquatecture, Glass and Ice and Snow, above.)

WIRE

Barbed Wire is used in conjunction with bags of sand or earth to create building units, based on ancient techniques.

Fencing wire has been used for decades to secure temporary shelters. Many bamboo houses are lashed with wire.

(See the article, Adobe & Super Block Technology)

1. **RADON GAS HAZARDS**

One unseen hazard with stone and other materials is that **radon gas** is often associated with areas which contain deposits of granite or slate. Radon is radioactive (and carcinogenic), colourless and odourless, and is a byproduct of the decay of uranium and radium. It can be found under the earth where we walk, in tar and bitumen, and in masonry building materials like brick, stone and concrete. It can also be present in groundwater.

Indoor levels of the gas are usually much more toxic than outdoor levels, so interior stone floors, etc should be assessed for this possibility and well ventilated.

Like all forms of radiation, exposure to radon gas has a cumulative effect; ie, there is no 'safe dose' or harmless level of exposure over a period of time. Documented diseases from long-term low-level exposure include leukemia, kidney cancer, melanoma and childhood cancers, birth defects and genetic mutation. Radon is said to be responsible for 20 percent of all lung cancers (the other 80 percent being tobacco-related).

To eliminate radon buildup in homes with significant levels of the gas, they should be thoroughly ventilated twice per day and/or have underfloor ventilators or gas drains installed and/or close all gaps and cavities with a (non-toxic) sealer.

The release of radon and other radioactive compounds is more prevalent where the land is subject to faulting, or where rocks such as granite occur. (Baggs, 1996)

Concrete, earth, rocks, rubble, gypsum, conventional bricks, compressed earth bricks, rammed earth walls and adobe blocks these should all be checked for radon outgassing levels (there are monitoring devices available: consult your builder, architect or engineer)**.** Pole Houses with their high ground-clearances may be the best structures to build in high radon areas. Earth-sheltered houses must have coninuous waterproof membranes in the walls and floors these also provide a barrier to radon.

Appendix 8: Worksheet for Housing Construction Assessment

Colonia ____________ Calle ____________ Fecha ____________ Encuestador ____________

Escriba "8" si no puede distinguir

									Tipos de materiales de las paredes de la primera planta: (marque todos los que aplican). Si >1, hacer un circulo alr. de predominante.						Tipos de materiales del techo de la casa/primera planta: (marque todos los que aplican). Si >1, hacer un circulo alr. de predominante.						Tipos de materiales de las paredes de la segunda planta: (marque todos los que aplican). Si >1, hacer un circulo alr. de predominante.						Tipos de materiales del techo de la casa/segunda planta: (marque todos los que aplican). Si >1, hacer un circulo alr. de predominante.						Marque todos los que aplican		Escriba: 0 si no existe, 1 si algunos existe y otros no, 2 si todos existe				Indique si hay un negocio en el lote: (marque todos los que aplican)			
ID	Cuadra	# de estructuras en el lote	# de viviendas terminadas	# de viviendas no terminadas	# de unidades en esta estructura (1, 2, o >2)	# de otros estructuras	No. de la vivienda (0 si no tiene)	Número de plantas de la vivienda	Madera	Bloques de cemento	Ladrillo	Enjarrado	Adobe	Otros	Madera	Lámina de fierro	Lámina de cartón	Cemento	Tabilla	Otros (teja, adobe, etc.)	Madera	Bloques de cemento	Ladrillo	Enjarrado	Adobe	Otros	Madera	Lámina de fierro	Lámina de cartón	Cemento	Tabilla	Otros (teja, adobe, etc.)	Tubos de desague del techo	Canaleta para el desague del techo	Ventanas	Puerta(s)	Protección de ventanas	Protección de puerta(s)	Llantera o servicio para autos	Abarrotes	Chatarrería	Otros
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Colonia

ID	Comentarios adicionales
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Colonia ________ Street ____________________ Date ________________ Interviewer ____________

Write "8" if you can't tell

					1, 2, or >2				Type of materials of the walls of the first floor: (mark all that apply). If >1, circle the one that is predominant.						Type of materials of the roof of the first floor/house: (mark all that apply). If >1, circle the one that is predominant.						Type of materials of the walls of the second floor: (mark all that apply). If >1, circle the one that is predominant.						Type of materials of the roof of the second floor/house: (mark all that apply). If >1, circle the one that is predominant.						Mark all that apply.		Write: 0 if does not exist, 1 if some exist and others do not, 2 if all exist				Indicate if there is a business on the lot: (mark all that apply)			
ID	Block	# of structures on the lote	# of finished houses	# of unfinished homes	# of units in this structure	# of other structures	House No. (0 if does not have)	# of floors of the house	Wood	Cinder/cement blocks	Brick	Plaster/stucco	Adobe	Other	Wood	Metal sheeting	Tar paper	Cement	Shingles	Other (tile, adobe, etc.)	Wood	Cinder/cement blocks	Brick	Plaster/stucco	Adobe	Other	Wood	Metal sheeting	Tar paper	Cement	Shingles	Other (tile, adobe, etc.)	Tubes to take water from the roof	Roof gutters	Windows	Door (s)	Protection of windows	Protection of doors	Tire or auto service shop	Convenience store	Junkyard	Other
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ID	Additional comments
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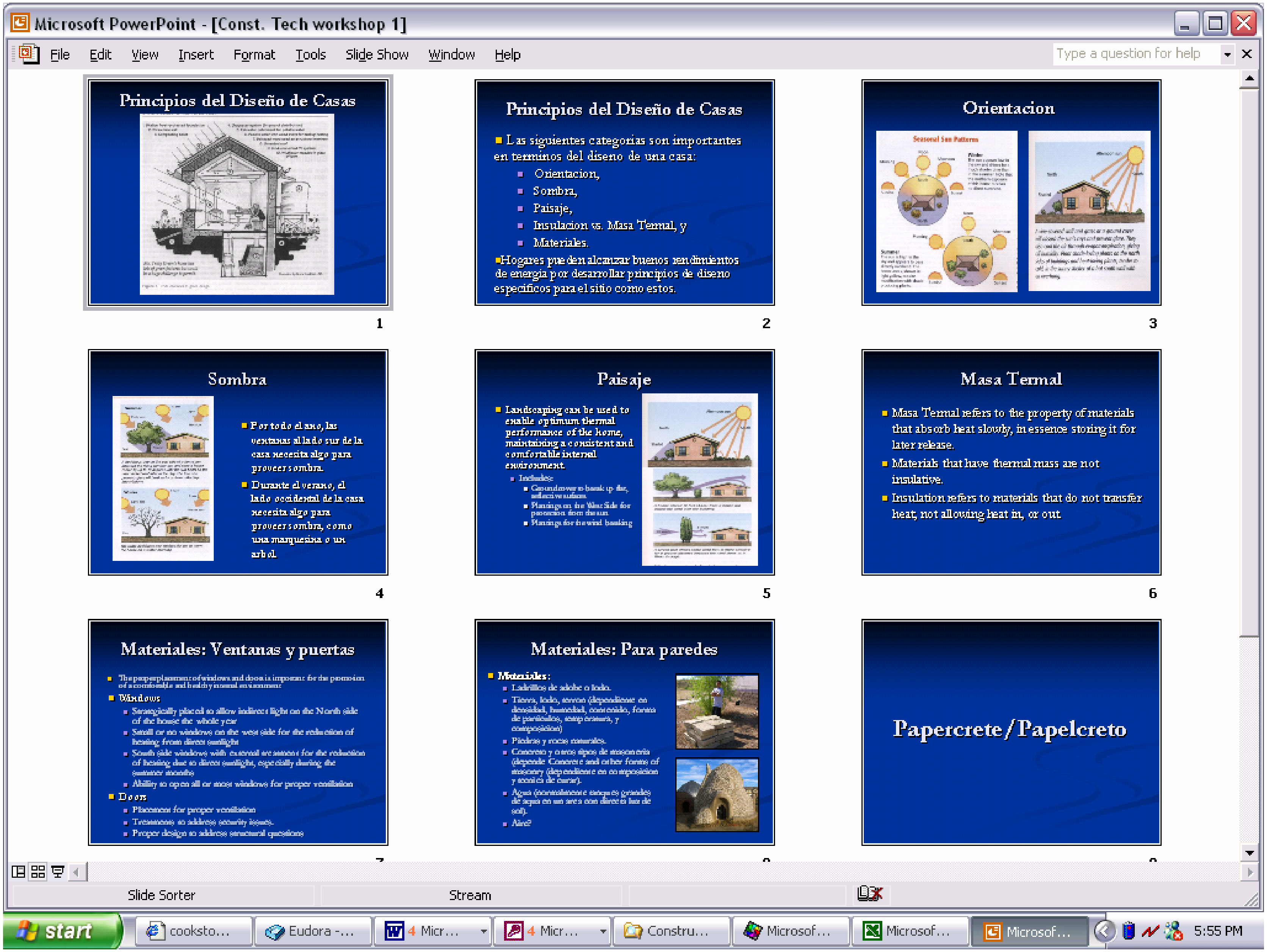
Appendix 9. Presentation for Workshop on Housing Construction Alternatives



Microsoft PowerPoint - [Const. Tech workshop 1]
File
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Tools
Slide Show
Window
Help
Type a question for help
Principios del Diseño de Casas
1
Principios del Diseño de Casas
Las siguientes categorias son importantes en terminos del diseno de una casa:
Orientacion,
Sombra,
Paisaje,
Insulacion vs. Masa Termal, y
Materiales.
Hogares pueden alcanzar buenos rendimientos de energia por desarrollar principios de diseno especificos para el sitio como estos.
2
Orientacion
Seasonal Sun Patterns
3
Sombra
Por todo el ano, las ventanas al lado sur de la casa necesita algo para proveer sombra.
Durante el verano, el lado occidental de la casa necesita algo para proveer sombra, como una marquesina o un arbol.
4
Paisaje
Landscaping can be used to enable optimum thermal performance of the home, maintaining a consistent and comfortable internal environment.
Includes:
5
Masa Termal
Masa Termal refers to the property of materials that absorb heat slowly, in essence storing it for later release.
Materials that have thermal mass are not insulative.
Insulation refers to materials that do not transfer heat, not allowing heat in, or out.
6
Materiales: Ventanas y puertas
Windows
Doors
Materiales: Para paredes
Materiales:
Papercrete/Papelcreto
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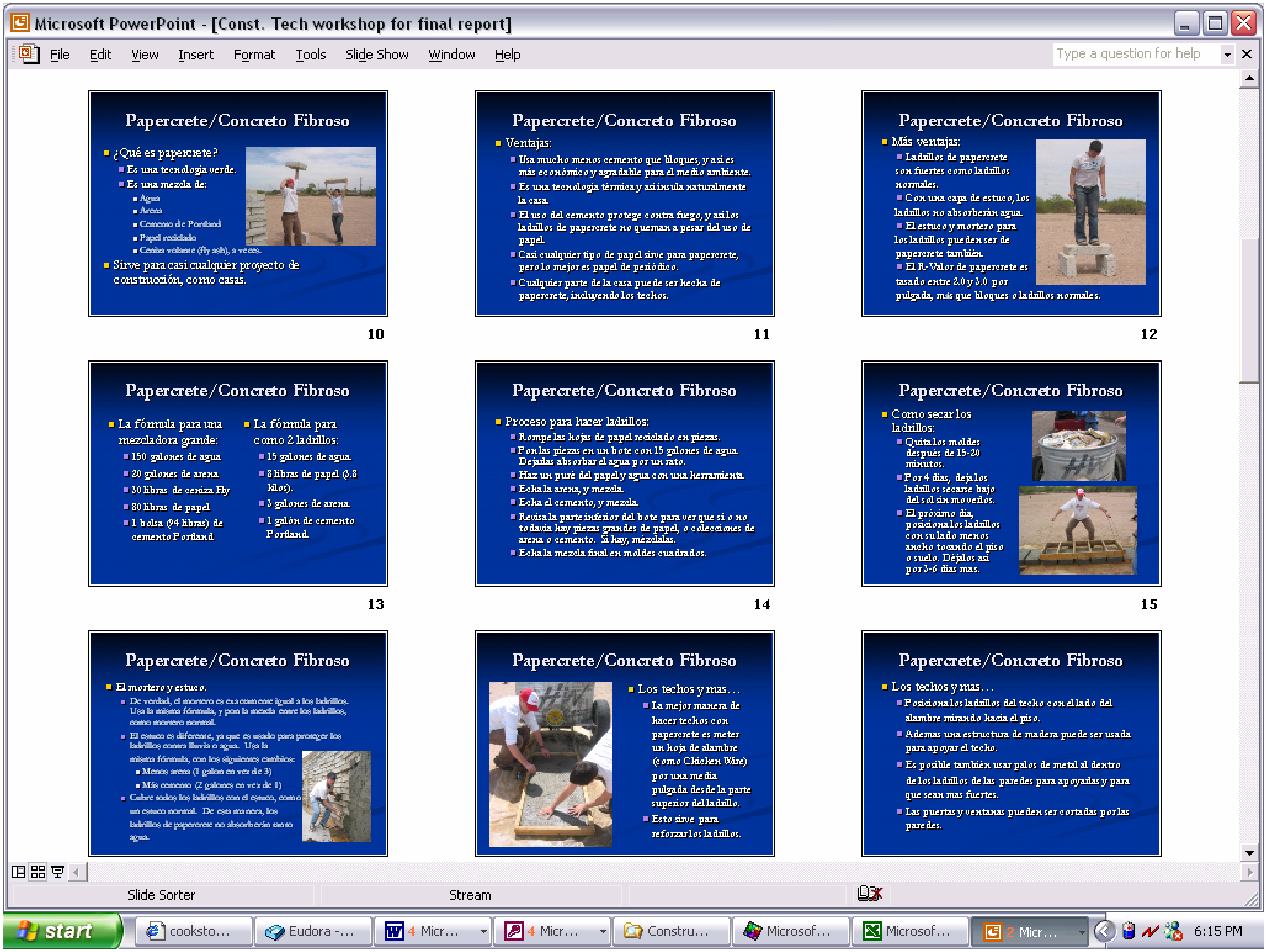
5:55 PM


Microsoft PowerPoint - [Const. Tech workshop for final report]
File Edit View Insert Format Tools Slide Show Window Help
Type a question for help
Papercrete/Concreto Fibroso
¿Qué es papercrete?
Es una tecnología verde.
Es una mezcla de:
Agua
Arena
Cemento de Portland
Papel reciclado
Sirve para casi cualquier proyecto de construcción, como casas.
10
Papercrete/Concreto Fibroso
Ventajas:
Usa mucho menos cemento que bloques, y así es más económico y agradable para el medio ambiente.
Es una tecnología térmica y así insula naturalmente la casa.
El uso del cemento protege contra fuego, y así los ladrillos de papercrete no queman a pesar del uso de papel.
Casi cualquier tipo de papel sirve para papercrete, pero lo mejor es papel de periódico.
Cualquier parte de la casa puede ser hecha de papercrete, incluyendo los techos.
11
Papercrete/Concreto Fibroso
Más ventajas:
Ladrillos de papercrete son fuertes como ladrillos normales.
Con una capa de estuco, los ladrillos no absorberán agua.
El estuco y mortero para los ladrillos pueden ser de papercrete también.
El R-Valor de papercrete es tasado entre 2.0 y 3.0 por pulgada, más que bloques o ladrillos normales.
12
Papercrete/Concreto Fibroso
La fórmula para una mezcladora grande:
150 galones de agua
20 galones de arena
30 libras de ceniza Fly
80 libras de papel
1 bolsa (94 libras) de cemento Portland
La fórmula para como 2 ladrillos:
15 galones de agua
8 libras de papel (3.8 kilos).
3 galones de arena
1 galón de cemento Portland
13
Papercrete/Concreto Fibroso
Proceso para hacer ladrillos:
Rompe las hojas de papel reciclado en piezas.
Pon las piezas en un bote con 15 galones de agua. Dejadas absorbar el agua por un rato.
Haz un puré del papel y agua con una herramienta.
Echa la arena, y mezcla.
Echa el cemento, y mezcla.
Revisa la parte inferior del bote para ver que si o no todavía hay piezas grandes de papel, o colecciones de arena o cemento. Si hay, mézclalas.
Echa la mezcla final en moldes cuadrados.
14
Papercrete/Concreto Fibroso
Como secar los ladrillos:
Quita los moldes después de 15-20 minutos.
Por 4 días, deja los ladrillos secarse bajo del sol sin moverlos.
El próximo día, posiciona los ladrillos con su lado menos ancho tocando el piso o suelo. Déjalos así por 3-6 días mas.
15
Papercrete/Concreto Fibroso
El mortero y estuco.
Menos arena (1 galon en vez de 3)
Más cemento (2 galones en vez de 1)
Papercrete/Concreto Fibroso
Los techos y mas…
La mejor manera de hacer techos con papercrete es meter un hoja de alambre (como Chicken Wire) por una media pulgada desde la parte superior del ladrillo.
Esto sirve para reforzar los ladrillos.
Papercrete/Concreto Fibroso
Los techos y mas…
Posiciona los ladrillos del techo con el lado del alambre mirando hacia el piso.
Ademas una estructura de madera puede ser usada para apoyar el techo.
Es posible también usar palos de metal al dentro de los ladrillos de las paredes para apoyadas y para que sean mas fuertes.
Las puertas y ventanas pueden ser cortadas por las paredes.
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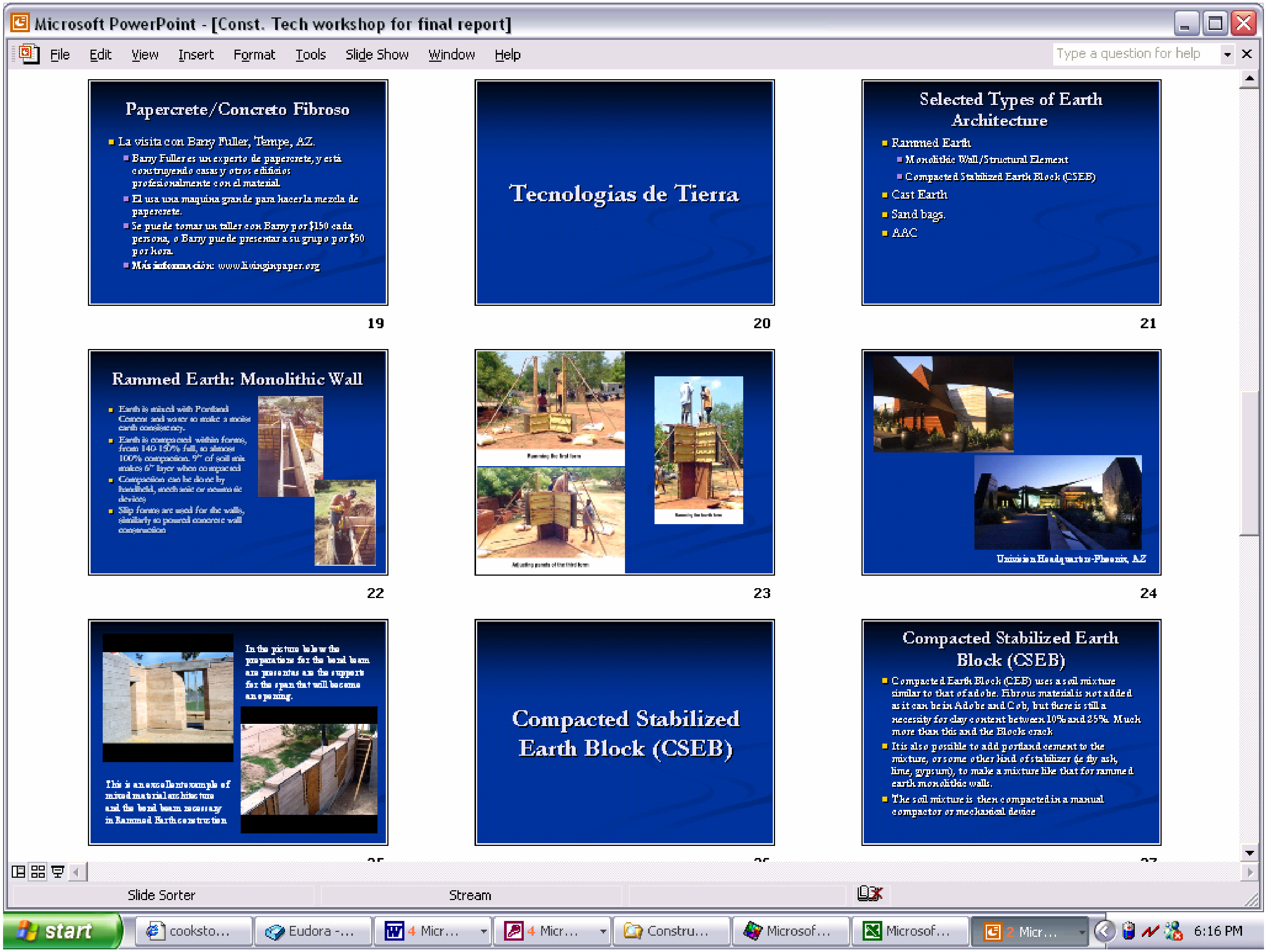
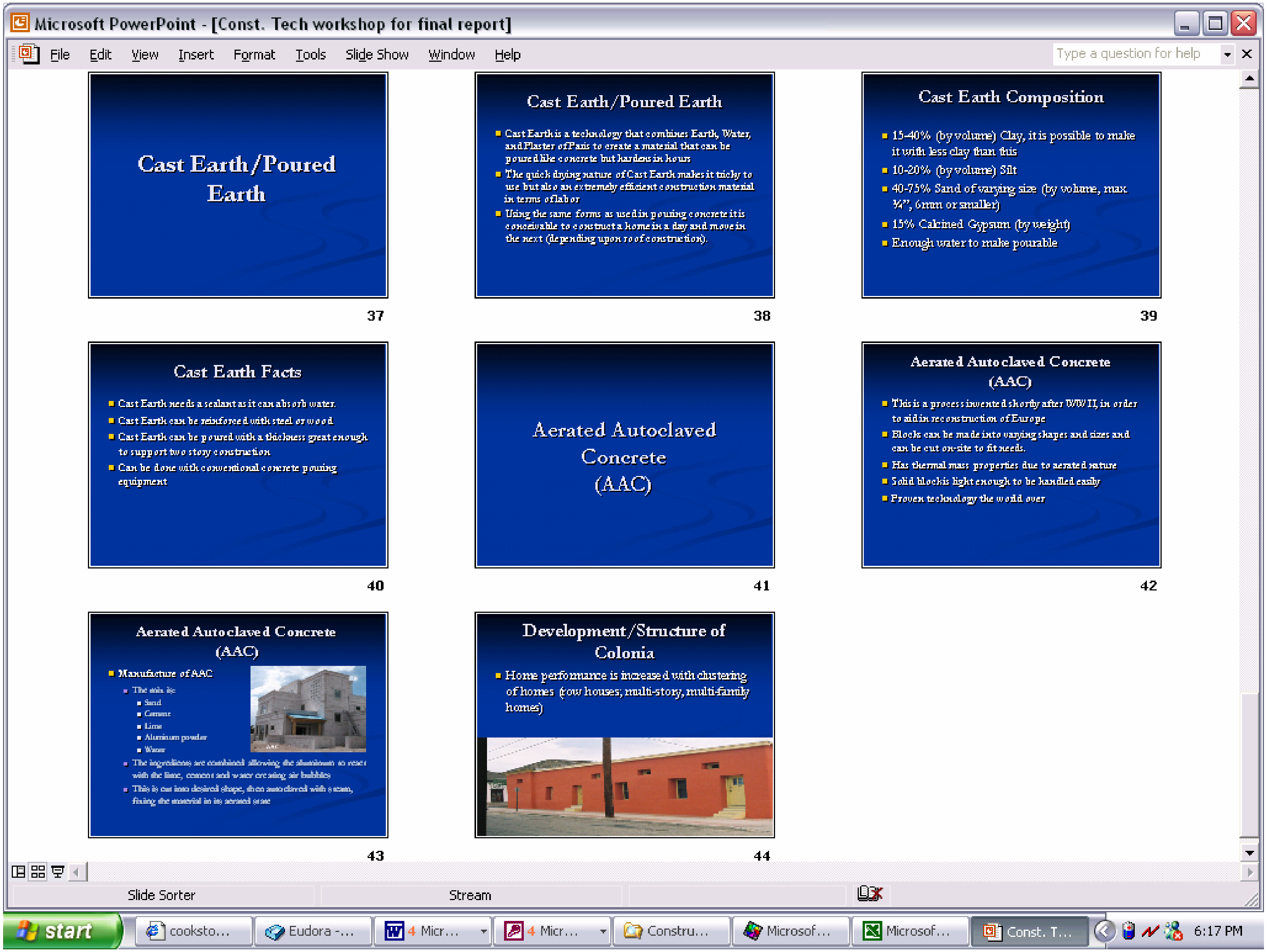
start
6:15 PM



Microsoft PowerPoint - [Const. Tech workshop for final report]
File Edit View Insert Format Tools Slide Show Window Help
Type a question for help
Papercrete/Concreto Fibroso
La visita con Barry Fuller, Tempe, AZ.
Barry Fuller es un experto de papercrete, y está construyendo casas y otros edificios profesionalmente con el material.
El usa una maquina grande para hacerla mezcla de papercrete.
Se puede tomar un taller con Barry por $150 cada persona, o Barry puede presentar a su grupo por $50 por hora.
Más información: www.livinginpaper.org
19
Tecnologias de Tierra
20
Selected Types of Earth Architecture
Rammed Earth
Monolithic Wall/Structural Element
Compacted Stabilized Earth Block (CSEB)
Cast Earth
Sand bags.
AAC
21
Rammed Earth: Monolithic Wall
22
23
Unision Headquarters-Phoenix, AZ
24
In the picture below the preparations for the bond beam are presentas are the supports for the span that will become an opening.
This is an excellent example of mixed material architecture and the bond beam necessary in Rammed Earth construction
Compacted Stabilized Earth Block (CSEB)
Compacted Stabilized Earth Block (CSEB)
Compacted Earth Block (CEB) uses a soil mixture similar to that of adobe. Fibrous material is not added as it can be in Adobe and Cob, but there is still a necessity for clay content between 10% and 25%. Much more than this and the Blocks crack.
It is also possible to add portland cement to the mixture, or some other kind of stabilizer (ie fly ash, lime, gypsum), to make a mixture like that for rammed earth monolithic walls.
The soil mixture is then compacted in a manual compactor or mechanical device
Slide Sorter
Stream
start
6:16 PM


Microsoft PowerPoint - [Const. Tech workshop for final report]
File Edit View Insert Format Tools Slide Show Window Help
Type a question for help
Left and bottom left, modern mechanically compacted stabilized Earth Block structures
Below, old hand packed earth block home
28
CSEB are mortared together with a soil mixture similar to the composition of the block but with more water, standard masonry mortar can also be used.
Can be plastered over – as with all Earth based non autoclaved building materials, plaster or stucco needs to be able to 'breath'
With modern machines, both hand powered and engine powered, blocks can be made into different shapes including those with holes.
CSEB can be as thin as 1 2" and maintain both structural and thermal mass qualities
29
CSEB Compacting Machines
Two examples of manual earth block compacting machines in use.
30
31
Sandbags
32
Emergency Sandbag Shelter
33
Slide Sorter
Stream
start
6:16 PM


Microsoft PowerPoint - [Const. Tech workshop for final report]
File Edit View Insert Format Tools Slide Show Window Help
Type a question for help
Cast Earth/Poured Earth
37
Cast Earth/Poured Earth
Cast Earth is a technology that combines Earth, Water, and Plaster of Paris to create a material that can be poured like concrete but hardens in hours
The quick drying nature of Cast Earth makes it tricky to use but also an extremely efficient construction material in terms of labor
Using the same forms as used in pouring concrete it is conceivable to construct a home in a day and move in the next (depending upon roof construction).
38
Cast Earth Composition
15-40% (by volume) Clay, it is possible to make it with less clay than this
10-20% (by volume) Silt
40-75% Sand of varying size (by volume, max ¾", 6mm or smaller)
15% Calcined Gypsum (by weight)
Enough water to make pourable
39
Cast Earth Facts
Cast Earth needs a sealant as it can absorb water.
Cast Earth can be reinforced with steel or wood
Cast Earth can be poured with a thickness great enough to support two story construction
Can be done with conventional concrete pouring equipment
40
Aerated Autoclaved Concrete (AAC)
41
Aerated Autoclaved Concrete (AAC)
This is a process invented shortly after WW II, in order to aid in reconstruction of Europe
Blocks can be made into varying shapes and sizes and can be cut on-site to fit needs.
Has thermal mass properties due to aerated nature
Solid block is light enough to be handled easily
Proven technology the world over
42
Aerated Autoclaved Concrete (AAC)
Manufacture of AAC
The mix is:
Sand
Cement
Lime
Aluminum powder
Water
43
Development/Structure of Colonia
Home performance is increased with clustering of homes (row houses, multi-story, multi-family homes)
44
Slide Sorter
Stream
start
6:17 PM