Innovative Energy Solutions In Paraguay

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Section I

A Theoretical Framework To Combat Energy Poverty

In the early 1990's, the advent of works by Amartya Sen and Mahbub ul Haq fueled a new international emphasis on sustainable human development. Their respective publications, Sen's, which offered freedom as both a means and ends to development, and Haq's, which spawned the Human Development Index, juxtaposed earlier adopted development strategies that promoted macroeconomic growth and one-dimensional income-based measures of poverty (42). This evolution in theory was especially promising for the world's 2 billion rural poor, whose dependence on biomass[1] energy often failed to register in formal economic statistics: "biomass in rural areas is collected at zero monetary cost, mainly by women and children, and so it falls outside national energy accounts, the result of which is that the issue renders itself invisible" (16). Human development challenged a macroeconomic approach that precluded interest and investment in biomass-related issues at a national and donor level; instead, it redirected focus towards individual capabilities and, in doing so, generated new avenues of visibility for the consequences of biomass use (7), (16). Elizabeth Cecelski captured this notion in her 1999 World Bank briefing paper for a meeting on Asia Alternative Energy Policy and Project Development Support, "Poverty and gender thinking prioritizes people, while energy thinking often prioritizes other objectives such as efficiency, or environment. The few attempts to view energy primarily through a poverty optic are quite startling in challenging us to alter our perspective." (7). With a broadened definition of poverty emerging, the impact of biomass use on health, the environment, productivity, and gender equality became more prominently discussed in the late 1990's development literature. (7), (18). Still, a growing acknowledgement of the correlation between energy and poverty failed to gain traction outside of the literature; energy policy, development, and research remained disproportionately focused on cutting-edge technologies that held little relevance to the worlds most impoverished. (18), (26). Even at the turn of the century, as human development seized the world stage following the adoption of the Millennium Development Goals (MDGs), not a single MDG mentioned energy.

In the years since, however, a multitude of reports and initiatives moved to concretely define the relationship between energy and modern multi-dimensional poverty. A 2005 report co-sponsored by the Millennium Project, United Nations Development Programme, and World Bank, recommended placing the issue of energy services on a par with other Millennium Development Goals, thoroughly implicating a lack of modern energy services as one of the leading barriers to accomplishing the Millennium Development Goals (36). The report went further stating, "one measure of energy poverty at the level of the poorest is the inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read, or for other household and productive activities after sunset." (36). In 2010, the World Energy Outlook, a report co-sponsored by the United Nations Development Programme and International Energy Agency, refined this definition, identifying two household indicators of energy poverty: lack of access to electricity and reliance on traditional biomass. The majority of the report though, outlined an ambitious goal to accomplish universal access to modern energy services by 2030, signifying the culmination of a

[1]Wood, agricultural residues and dung (http://www.sciencedirect.com.libproxy.tulane.edu:2048/science/article/pii/S1364032112006594?np=y)

decade-long effort to prioritize energy development in a modern approach to sustainable human development (14).

As policy becomes practice, recent research has focused on identifying a theoretical framework to contextualize the goals of energy development. In order to better understand and influence the processes that contribute to fuel transitions, specific emphasis in the literature has been placed on establishing a model to explain fuel choice at the household level (31), (21), (47). Historically, economic development was believed to drive the switch from biomass use towards modern energy services[2], which the 2010 World Energy Outlook defined as household access to electricity and clean cooking facilities (i.e. clean cooking fuels and biogas stoves) (14), (21). This is the foundation of the Energy Ladder Theory, which stratifies fuel options in a unidirectional linear progression from the least efficient, least costly, and most polluting fuels like dung and firewood, to transition fuels like charcoal, coal and kerosene, up to modern energy services like liquid petroleum gas and electricity[3]. The model is predicated on a socioeconomic desire and ability to transition up the 'ladder', whereby energy use is associated with class, and an inherent desire to improve socioeconomic status is powered by increases in household income. Although evidence exists to support the link between income and fuel choice, an abundance of research contradicts the Energy Ladder's core premise that income is the universal engine for an upward transition (31). Moreover, the Energy Ladder Model's unidirectional, linear transition, by which households abandon fuels altogether, is not empirically observed (31), (47). In just one example, a 2011, 16-village study conducted in rural Kenya, found that almost all surveyed households employed multiple fuel sources, with income being just one of several determining factors (47). A meta-analysis[4] of similar studies supported an alternative theoretical framework: Energy Stacking. The theory focuses on the many micro and macroeconomic factors that shape household decision-making, which ultimately result in an "ongoing transition process ... best described by multiple fuel use representing an energy portfolio." (31). These factors can be divided into two subgroups: endogenous factors, which encompass the microeconomic, social, behavioral and cultural characteristics of the household, and exogenous factors, which account for external conditions like the environment, government policy, energy supply, and energy device characteristics (29). Firstly, as previously established, the household decision making environment is largely influenced by income, which serves as the main means of access to the energy market. Irregular and variable income due to agricultural dependence and fluctuating employment rates, for example, inhibit stable access to modern fuels (31). Outside of the economic domain, gender, education, and information access all affect micro-decision making. Because women in poor rural families are typically tasked with firewood collection, having more females in a household

[2]'Services' is used as a broader term, encompassing not only fuels, but also the necessary capital (i.e. stoves and infrastructure) that facilitate and allow their use. Generally, more advanced fuels require the largest investments in capital at the household and national level, which is why the term 'modern energy services' is most often used to replace 'modern fuels'

[3]In this proposal, energy poverty is considered on a household level, so although electricity is not an energy source itself, it does satisfy household energy needs. On a national and even provincial level, however, effective energy development must prioritize the use of renewable and clean fuels to power electric infrastructure

[4]A method for systematically combining pertinent qualitative and quantitative study data from several selected studies to develop a single conclusion that has greater statistical power

generally impedes a transition away from biofuels. Higher education rates, however, drive households away from biomass by increasing the opportunity cost of fuel collection. Additionally, many of the drawbacks of biomass dependency, like increased risk of illness and lower energy efficiency, are not incorporated in the household decision-making process, as that information is often not disseminated or available to the rural poor (29). Culture and tradition should not be overlooked either; open fires can hold irreplaceable social value, while cooking techniques may also create a fuel preference. A Peace Corps study in Paraguay, for example, found that some women preferred cooking with wood because of its affect on the taste of food (5).

In regards to exogenous factors, climatic conditions, for one, influence the quantity of energy consumed. The high-energy demand caused by colder climates increases the cost of switching fuels. Subsidies, both from NGO's and the government, decrease the costs of certain fuels, which are important considering that modern fuels often require lump sum payments and thus become cost-prohibitive. Energy supply reliability and access are relevant in that they create transaction costs, like transportation and collection fees in reaching a market. Erratic supply can also decrease the attractiveness of an energy source and necessitate fuel diversification (31). Lastly, adopting modern energy services often requires a capital investment, as in cook stoves or electric infrastructure, which can also be cost-prohibitive (31).

Energy Stacking behavior serves to inform this project by defining the criterion for target, communities, markets and households, as well as shaping the structure of the proposed public health programs. These considerations will be more closely examined as they are explained within the overall structure of the project proposal. Furthermore, while this section briefly mentioned the negative effects of energy poverty on human development, the next section will dissect the direct impact a reliance on traditional biomass has on multidimensional development, as well as the opportunity costs that result from a lack of electric access. After which, an analysis of poverty in Paraguay will support the case to introduce charcoal micro franchises, public health education programs, and a clean charcoal cook stove distribution project in the rural part of the country.

Section II

Measuring Multi-dimensional Poverty

First and foremost, a holistic description of energy poverty's impact necessitates a method to assess and measure human development. While easily obtainable income and GNP statistics allowed the previously favored economic growth approach to benefit from a coherent union of theory and measurability, attempts to pair Amartya Sen's multi-dimensional, capabilities-oriented approach to development with a suitable metric have resulted in an evolving and ongoing process (46). Amartya Sen initially objected to the first of such efforts, the Human Development Index[5],

[5]The Human Development Index (HDI), currently employed by the United Nations Development Programme to measure fluctuations in development across the globe, consists of a health dimension determined by mean life expectancy at birth, an educational dimension quantified by mean years of schooling and expected years of schooling, and a standard of living dimension tallied by gross national income per capita. Each indicator is assigned a number, after which an indexed score that reflects a given country's

on the basis that it could not capture the complexity of his theory; however, Mahbub ul Haq, earned his support arguing, "We need a measure of the same level of vulgarity as GNP – just one number – but a measure that is not as blind to social aspects of human lives as GNP is." (46). Still, Sen recognized that a desire for simplicity was counterbalanced by a subsequent need to weight the importance of different capabilities. In order to evaluate which capabilities should be represented by the chosen dimensions of the metric, "Sen suggested focusing on dimensions that are of a) special importance to the society or people in question, and b) social influenceable– which means that they are an appropriate focus for public policy." (3). Although, the HDI has endured criticism for representing a limited scope of development in the years since, its dimensions of health, education, and quality of life have demonstrated impressive staying power, remaining the core focus of the Human Development Report (HDR) for more than a decade (46).

Importantly, more comprehensive alternatives to the HDI, like the Multidimensional Poverty Index (MPI) and Poverty Stoplight have emerged in recent years. The MPI, which is comprised of the same dimensions as the HDI, is distinguished by both its use of the household as the unit of analysis and larger collection of indicators; health is measured by nutrition and child mortality, education by years of schooling and school attendance, and quality of life by access to clean drinking water, improved sanitation, clean cooking fuel, electricity, and non-dirt flooring (3). Specifically, the metric is calculated as a mathematical aggregate of indicator specific determinations of poverty at the household level. For example, in regards to education, if at least one member of a household has completed five years of schooling, the household is considered not to be poor, or deprived, in the indicator of school attendance (3). Although the MPI presents a more individualized focus on poverty, its architects have always acknowledged that it, much like HDI, is limited in scope by a lack of data availability: "We very much wished the MPI to include additional vital dimensions. Unfortunately, we can state categorically that comparable data of sufficient quality are not available from the same survey in the public domain for 100+ less developed countries to consider any other dimensions, nor to include consumption data." (3).

The Poverty Stoplight manifests as a formidable compliment to MPI and HDI, given that it significantly more exhaustive, incorporating fifty indicators across six unique dimensions of poverty: 1) income and employment; 2) health and environment; 3) housing & infrastructure, education & culture; 4) organization & participation; and 5) interiority & motivation (40). The method collects data using a visual survey that allows households to self-identify as either extremely poor, poor, or not poor with respect to each indicator using photographs. The data is presented on a geographic mapping tool, with red, yellow and, green corresponding to the degrees of poverty. By identifying regional trends, the Poverty Stoplight can be especially valuable in mobilizing aid resources effectively and informing governmental and organizational policy. Still, because of the immense resource demand of continuously surveying an entire country by household, the Poverty Stoplight is limited in its ability to provide reliable and country-comparable macro information. Consequently, it currently does not, and may very well never, hold the international influence that HDI, and to an extent, MPI do.

level of development is calculated by geometric mean (23).

Analyzing the Impact of Energy Poverty

The following analysis of energy poverty's impact will be done using both the simple HDI/MPI dimensions and the comprehensive Poverty Stoplight metric. Firstly, because the dimensions of the HDI and MPI were chosen to be especially influencable by policy and are among the most universally discussed in development, the analysis will lead with an examination of how energy poverty affects health, education, and quality of life. The analysis of energy poverty's impact on quality of life will be conducted from an economic perspective, as the quality of life indicators included in MPI are either direct measurements of energy poverty itself or included in the Poverty Stoplight. After, the Poverty Stoplight will be used to conduct a more in depth treatment of energy poverty's impact on human capabilities, where important considerations like gender inequity and environmental sustainability will be discussed. The MPI and Poverty Stoplight's inclusion of access to clean cooking fuels and electricity as indicators of poverty serves to legitimatize one of the main conclusions of this section—that energy poverty is not only a leading inhibitor to human development, but also closely related with multidimensional poverty. The July 2011 report from the Oxford Poverty and Human Development Initiative (OPHDI) that introduced the MPI, highlighted the importance of indicators of energy poverty within Amartya Sen's theory: "Unlike income, which can serve an incredibly wide range of purposes ... [access to clean cooking fuels and electricity] are means very closely connected to the end (functioning) they are supposed to facilitate." (31).

The health risks associated with biomass use, especially indoors, take an unprecedented toll on global life expectancy. Acute respiratory illnesses from indoor air pollution are not only the number one cause of death in children under the age of five, but also the annual root cause of 3.8 million deaths worldwide from non-communicable disease (22). A meta-analysis of 26 studies, found that exposure to biomass fuels increases the risk of pneumonia nearly two-fold (32). Several studies have found a positive correlation between asthma and biomass smoke, one of which identified kerosene and wood stoves as the main cause of asthma in children under the age of five in Kuala Lumpur, Asia (27). Moreover, a 2006 World Health Organization (WHO) Household Energy and Health Report stated that women exposed to indoor smoke were more than 3 times as likely to suffer from chronic obstructive pulmonary disease, like bronchitis and emphysema, than women who used modern fuels (15). A large portion of the blame for these staggering statistics can be attributed to the toxic byproducts of incomplete combustion of biomass, which generally include carbon monoxide, particulate matter, hydrocarbons and nitrogen oxides (44). According to a study conducted in rural Kenya, burning just one kilogram of wood on a traditional three-stone cooking stove in a $40m^3$ kitchen produces carbon monoxide and particulate matter levels that exceed typical health standards by 15 and 33 times, respectively (49). Much of the biomass health burden quite literally falls on the shoulders of woman, who in countries like Nepal, risk back injury and their own safety walking up to 20 kilometers in search of wood (10). As for other vulnerable demographics, the well-documented health detriment to children who join their mothers in the kitchen may be worsened by strong evidence correlating fetal development with maternal exposure to sulfur dioxide and particulate matter. A community-based study of 74,671 women in Beijing estimated a 7.3 and 6.9-gram reduction in birth weight for each 100-$\mu g/m^3$ increase in sulfur dioxide and total suspended particles, respectively (48). Keeping the household energy transition process in mind, a 2005 joint study by the University of California

Berkeley and Harvard University estimated that in Africa alone, 1 to 2.8 million lives could be saved by the year 2030 if households transitioned from wood to charcoal for their energy needs. Conversely, households and communities in developing nations incur countless opportunity costs from a lack of electrification. Modern health services are almost entirely dependent on electric infrastructure, including but not limited to imaging equipment, medicine and vaccine distribution and storage, health monitoring equipment, sanitization equipment, and facility support functions like lighting and water pumps (1). On the same note, electricity increases quality of life and thus can help attract more trained health professionals to rural areas. Outside of health facilities, electrification provides access to information and communication technologies that play a pivotal role in the public health interventions that combat HIV/AIDS, malaria, and Tuberculosis (6). Lastly, by reducing the cost to boil and retrieve water, electricity can directly improve hygiene and sanitation.

Not surprisingly, the consequences of biomass use ripple into the education dimension as well. In addition to childhood respiratory illness being a major barrier to school attendance, girls are often removed from the classroom to abet family fuel collection (10). A study in Lucknow, India, a community in which 54% of households rely on wood for fuel, found a 14.5% prevalence rate of respiratory illness among 650 pre-school children. These illnesses, defined by runny nose, coughing, sore throat, breathlessness, and noisy respiration severely inhibit a child's ability to learn, let alone even attend school (4). Comparatively, improved household lighting due to modern fuel alternatives like electricity can add hours of productivity to a child's day, allowing for nighttime studying and homework completion (36). A study in rural Philippines found that "children from electrified households gained an additional two years of schooling compared to children from nonelectrified households." (6). Access to electricity and electric infrastructure are key pathways to enhancing quality of education as well as in-school productivity. Following electrification of several schools in rural Kenya, student achievement in science subjects increased, teachers enjoyed greater efficiency in administrative information processing, a variety of vocational classes were instituted, and standardized testing preparation improved (28).

Energy poverty's impact on economic growth is almost entirely composed of the opportunity costs incurred from using biomass as opposed to modern energy services. The continued use of less efficient biofuels not only curbs productivity, but also handicaps government and household expenditure. A data analysis of 1,989 families almost entirely dependent on fuel-wood in rural areas of Rajasthan, India reported a yearly productivity loss of 29 billion Rupees (33). Using an exchange rate of 44.08 Rupees to 1 US Dollar from May 2000 (20) when the study was conducted, this figure, aggregated by work days lost to fuel collection, costs of illness, and work days lost to illness, translates to over 657 million US Dollars. Studies in several South Indian villages found that families spent 2-6 hours traveling 4-10 kilometers each day to collect firewood—just one example of huge household productivity losses in the rural developing world (6). Moreover, cheap modern technologies powered by electricity like water pumps can reduce the strain of performing other manual household tasks, thus allowing for greater productivity in economic activities. Research in eastern Uganda uncovered that women spent an average of 660 hours per year, or 2 full months of labor, retrieving water for their households (24). Similarly, improved energy sources can increase agricultural productivity by opening access to more efficient technologies and techniques like irrigation, crop processing, and market transport (13). In another vein, countrywide health issues

caused by biomass stunt national economic growth, as government spending is redirected in subsidies to public health centers instead of expenditures with long-term capital returns.

While these consequences are certainly condemning in their own right, they have overlooked perhaps one of the greatest detriments of energy poverty: the environmental impact. In 2006 the WHO estimated that 2 million tons of biomass were combusted everyday to support worlds energy needs (45). This is primarily problematic, as firewood harvesting for direct household use and charcoal production is one of the main global causes deforestation. Moreover, shrubs, roots, branches, and even crops when all else is unavailable are often burned for fuel in the developing world, depleting both agricultural resources and ecosystems. (45), (2). Such unsustainable harvesting can have an impact beyond just deforestation, contributing to land degradation, erosion, desertification, and depletion of soil and water resources (17). Haiti, a tropical country that is facing near complete deforestation from charcoal demand, serves as a sobering case study. Decreased soil retention potential and soil erosion, two local environmental consequences of deforestation, have caused Haiti's rivers to resemble torrents (34). The result is higher incidences of flooding and deadly landslides, deterioration of farmable land, loss of utilizable water sources, and ironically, an intensified rate of charcoal production (35). The income and employment, health and environment, housing and infrastructure, and education and culture dimensions of the Poverty Stoplight register many of these environmental repercussions of biomass use. Indicator 2; stable income, indicator 3; having more than one source of income, indicator 5; household savings, and indicator 9; nutrition, are all affected by uncertainty in agricultural production and food security. Indicator 7; potable water, and indicator 10; personal hygiene and sexual health, are affected by runoff pollution of water sources and environmental degradation. Indicator 16; having a safe home, and indicator 24; road accessibility during adverse weather, are affected by flooding, landslides and amplified affects of storms due to soil erosion and poor soil water retention. Lastly, Indicator 36; value of cultural traditions and heritage, is affected by the destruction of culturally valuable environmental resources, which is especially relevant for indigenous communities. It is also again important to note that although replacing household energy needs with modern energy services would mitigate many of these consequences and cause improvements across a multitude of indicators, governmental and private sector policy must emphasize the implementation of renewable energy infrastructure, so these impact are not merely redirected to other areas and peoples.

Equally important, and evident from some of the earlier cited research from the health and education dimensions, energy poverty creates gender inequity and inhibits the development of women and their capabilities. In rural areas women are disproportionately tasked with retrieving biomass and water, which negatively impacts their physical health and safety. Furthermore, because women in the developing world are often responsible for a majority of the daily time-consuming domestic tasks, they cannot enter the workforce, and thus loose economic, and subsequently social, power, as well as the ability to pursue leisurely activities. Not only that; because women and girls are quite often the ones tasked with cooking in the developing world, they account for a disproportionate amount of biomass-related respiratory illnesses (10). Electric access can significantly decrease the time demand and health burden of these activities, helping to keep girls in school, and provide them means to be economically autonomous. These impacts are accounted for in the income and employment, health and environment, education and culture,

organization and participation, and interiority and motivation dimensions. Indicator 1; income above the poverty line, indicator 2; stable income, indicator 4; family savings, indicator 5; having more than one source of income, indicator 8; monetary access to health centers, indicator 9; nutrition, indicator 10; personal hygiene and sexual health, indicator 11; eye and dental health, and indicator 22; basic comfort, are all affected by women's' limited participation in formal household economic activities and subsequently worsened family monetary poverty. Indicator 6; personal identification, indicator 40; ability to influence the public sector, indicator 42; being registered to vote and participate in elections, and indicator 50; ability to make decisions and be autonomous, are all affected by social and legislative gender inequity perpetuated by energy poverty's social and economic consequences. Indicator 25; security and indicator 48; physical safety, are impacted by the daily long trips women take to secure firewood, risking physical attack and rape, as well as the previously mentioned rigid socioeconomic power structures that create cultural acceptance or taboo of acknowledging violence against women (10). Lastly, indicator 35, access to entertainment and leisure, is limited by the daily time-consuming domestic tasks women in the developing world are often burdened with.

Section III

Background and Project Justification

Paraguay is landlocked country located in South America, bordered by Argentina, Brazil and Bolivia. Classified as a developing country by the 2012 Human Development Report, Paraguay ranked 111 out of 187 countries with an HDI of .669 in 2012, a significant rise from .549 in 1980. Although it has made significant improvements in the education and health dimensions, GNI per capita, adjusted to 2005's purchasing power parity (PPP), has remained relatively constant, increasing slightly from $4084 in 1980 to $4497 in 2012. For comparison, data collected from 2002/2003, indicates that 13.3% of the population lives in multi-dimensional poverty as measured by MPI, while an additional 15% are vulnerable to multiple deprivations[6] (23). According to the World Bank 41% of the population is rural, 32% of which live below the national poverty line. (51). Notably, the International Agricultural Fund for Development (IAFD), an agency of the United Nations, considers some of the main contributors to poverty in rural Paraguay to be: "1; poor access to land, markets, and financials services, 2; deterioration of natural resources and soil fertility, 3; insufficient productive assets at the farm level, and 4; high levels of dependency on commercial agricultural and agribusiness" (43). Increases in the number of people employed and higher earnings among those employed are the two main drivers in removing families from extreme poverty. Still, more than two-thirds of families trapped in extreme rural poverty are self-employed in agriculture, an extremely volatile economic sector susceptible to market shocks (18).

In Paraguay 2.8 million people rely on biomass for their energy needs, which translates to 42% of the population. The average country in Latin America has 14% of its population relying on

[6]All members of a household are considered to be multi-dimensionally poor if, after the 10 indicators are weighted, the household is more than 33% deprived. All members of a household are considered to be vulnerable to multi-dimensional poverty, if the household is between 20% and 33% deprived.

biomass (12). Interestingly, 99% of the population in Paraguay has access to electricity, which is almost entirely powered by hydroelectric plants (9). In the last decade, the IDB and World Bank have made significant investments in both rural and overall electric infrastructure. In 2007, the IDB approved funding for a National Rural Electrification Program, while the World Bank approved a $100 million loan in 2010 to satisfy rapidly rising electric demand, increasing the quantity and quality of national electric supply (37). The disparity between electric access and biomass use can largely be attributed to many of the factors involved in energy stacking behavior, including the economic convenience and access of biomass, as well as a still at times unreliable rural electric infrastructure.

Continued reliance on biomass and reluctance to adopt electricity also restrict the development of women in Paraguay. A 2011 USAID Gender Assessment of Paraguay reported that one of the country's main gender gaps was the time constraint imposed on women as economic actors, caregivers, and community members. The time demand of domestic tasks are huge barriers to female participation in the labor force; as of 2012, only 57.9% of eligible females were employed compared to 86.3% of males (23). The USAID report explained that laborsaving technologies like dishwashers, washing machines, and stoves could reduce the burden of household responsibilities. Additionally, improving forest management, including land protection and reducing deforestation, was part of a key set of recommendations to promote women's integration into the economic sector (39).

Furthermore, while Paraguay is known to have an abundance of biomass resources, a 2013 University of Maryland study of Earth observation satellite data identified the Chaco Woodlands that overlap Paraguay, Bolivia, and Argentina as having the highest rate of deforestation in the world (19). The country enacted The Land Conservation Moratorium for The Atlantic Forests of Paraguay in 2004, which bans deforestation in protected areas, and recently extended it to 2018 (38). Regardless, Paraguay's continued reliance on biomass energy and agriculture present enormous obstacles to environmental protection.

Given the above considerations, energy development initiatives are widely needed in Paraguay in order to promote household transitions from biomass to modern energy services. Continued land degradation from over farming and deforestation, as well as the inevitable economic and health limitations synonymous with biomass use, function as incredible obstacles to human development. Especially because electricity is already nearly ubiquitously available, projects must incorporate energy stacking behavior to understand and adapt to the regional-specific factors that are currently inhibiting a transition. Additionally, the countries environmental situation demands aggressive and innovative projects to ensure sustainability. Not only that, but, access to improved energy sources will facilitate the development of women.

Project Introduction

In this section, a project proposal to implement environmentally sustainable charcoal producing micro franchises, public health education programs, and an improved charcoal cook stove distribution program will be specifically outlined. This project will benefit Paraguay by fitting within a larger nationwide effort and need to reduce the impact of energy poverty. Many of the project's activities, which will be discussed with greater detail in the next section, target biomass's health,

educational, economic, environmental, and gender impact in rural Paraguay.

Project Management and Implementation

> ***Mission Statement:***
> *We seek to reduce the frequency and severity of preventable disease originating from indoor cooking fires, provide a paradigm to diminish deforestation rates in Paraguay's endangered Chaco, reduce the gender inequities perpetuated by biomass use, and eliminate extreme financial poverty by partnering with La Fundacion Paraguaya to introduce environmentally sustainable charcoal briquette micro franchises, biomass public health education programs, and an improved charcoal cook stove distribution initiative. We aim to measurably limit the cyclical nature in which energy poverty inhibits human development.*

This mission statement is constructed around one main goal of restricting energy poverty's impact on sustainable human development in Paraguay. The following project proposal, which will fit within a long-term nationwide effort, is composed of seven unique objectives to be carried out over the span of 18 months. These objectives are organized into 4 phases, and ultimately will fit within La Fundacion Paraguaya's work to eliminate multi-dimensional poverty in Paraguay. The first phase includes objectives one and two and spans the first three months; the second phase includes objective three and spans three to five months from the project's start; the third phase includes objectives four, five, and six and spans five to eight months from the project's start; the fourth phase includes objective seven and spans eight to eighteen months from the project's start.

The first objective is to successfully adapt and test the *Fuel from the Fields* charcoal briquette making method developed by the Massachusetts Institute of Technology's (MIT's) D-Lab. The method utilizes low-cost, easily accessible technology to convert agricultural waste[7] into charcoal, which can in turn be cheaply shaped into sturdy briquettes. Furthermore, because of its income-generating ability and applicability to highly deforested regions, *Fuel from the Fields* was one of 22 winners in the 2007 World Bank Development Marketplace Competition. The method's only required inputs are agricultural waste, cassava[8], a 100-gallon steel drum, a 2" x 2" wood block, and a small metal press that can easily be welded from scrap metal. In Haiti, where over 1000 artisans have been trained in the method, the start-up equipment can be obtained for $25 (the press is $2) and distributed in the form of small business loans, which are typically paid back in less than one month (8). Charcoal is produced by burning agricultural waste in the metal drum using a technique called pyrolysis, which decomposes organic carbon rich matter in the absence of oxygen. The resulting brittle charcoal pieces can then be pulverized and mixed with cassava powder and water, before being pressed into briquette form. The briquettes must dry in the sun for 3-10 days depending on the climate and are very sturdy. Figures 1-16, seen in the appendix, elucidate the method in greater detail. For the purposes of this project, each micro franchise will

[7]More than 8 types of agricultural wastes can be used, including sugarcane, corn cobs and stalks, banana leaves, vetiver, sorghum stalks, coconut husks, cassava flour, millet stalks (8)

[8]A starch-based fruit easily often grown and accessible in the developing world. It can also be pulverized and sold in powder form.

receive four drums, one wooden table to replace the individual wood blocks that eject briquettes, five presses, a tarp, and a metal mesh sifter to separate ash and charcoal. This additional input capital will increase the productivity and thus profitability of the micro franchises. Three sets of input materials will be purchased or produced using open source designs provided by MIT's D-lab, which should not take longer than 3 weeks. Additionally, at the outset of the project 45 Prakti single burner charcoal stoves (15 for each micro franchise community) will be ordered for a clean cook stove distribution initiative that will occur simultaneously with micro franchise implementation. The Prakti stove, which was named "Best Charcoal Stove 2010" by USAID costs $40 and not only reduces fuel consumption by 47%, but also reduces toxic emissions by 60% (25), (11). This particular stove was selected because it was the only charcoal cook stove available on the Global Alliance for Clean Cook Stoves' Clean Cooking Catalog that fit the criteria of being cheap, available in Latin America, third-party tested, and easily locally assembled. Immediately after the method input materials and Prakti stoves have been acquired and assembled, the project implementers will quantitatively and qualitatively test the briquettes against available market charcoal according to the following criteria: 1; time to ignite briquettes, 2; difficulty igniting briquettes, 3; time briquettes maintain peak temperature, 4; time briquettes emit heat, 5; amount of smoke produced by burning briquettes (qualitative), and 6; briquette durability[9]. Additionally, the respective charcoal fire temperatures can be plotted as a function of time on Microsoft Excel and integrated with the SumFunction calculating tool to compare the total energy produced by each form of charcoal[10]. Because the briquettes will ultimately be sold at the market as well as to local Prakti stove owning households, these tests will be conducted using both a Prakti stove and typical Paraguayan charcoal brazier (5). Pending the results of these tests, the ratio of adhesive to charcoal can be adjusted to increase the briquettes' energy content and/or central holes inserted to decrease the briquettes time to ignite. The trials are also important to understand the best method to use the briquettes, in regards to how to position them for maximum efficiency and ignite them effectively. Furthermore, conducting trials with rural cooks will bring any necessary improvements or cultural barriers to light before the micro franchises begin distribution.

The second objective is to identify three unique communities and fifteen unique households (five households per one micro franchise) to implement charcoal micro franchises and distribute Prakti cook stoves, as well as respective markets for each micro franchise to sell briquettes. The project implementer will first cooperate with La Fundacion Paraguaya, specifically its regional microfinance manager, in order to select at least five candidate communities. The candidate communities will be surveyed by both the regional micro franchise manager and project implementer and ranked according to the following criteria: 1; percentage of households that cook indoors, 2; percentage of households that have unventilated cooking areas, 3; percentage of households in which children are consistently around indoor cooking fires, 4; percentage of households that rely on charcoal/biomass for energy, 5; average community income, 6; level of deforestation in surrounding area, 7; average time spent retrieving biomass daily, 8; community education level, 9; availability of cassava/agricultural waste, 10 proximity to charcoal market. In order to maximize the public health, economic, and environmental benefits of the project, the

[9]Although impractical because of budgetary and resource limitations, it would be very useful to know the amount of carbon monoxide and particulate matter our briquettes produced compared against market charcoal.

[10]The sum function formula is as follows: fx =SUMPRODUCT((x3:xn - x2:xn-1)*(y3:yn + y2:yn-1)/2)

ideal community will have a high prevalence of unventilated indoor cooking fires with children present, high percentage of its households depending on biomass and charcoal for energy, low average community income, high level of deforestation, high average daily time spent collecting biomass, low community education level, both agricultural waste and cassava readily available, and access to a nearby charcoal market.. Potential household micro franchise participants will be interviewed and selected using the following criteria: 1; level of interest in participation, 2; number of eligible members unemployed, 3; numbers of members able to work at micro franchise, 4; use of biomass/charcoal for energy, 5; stability of income, 6; net income, 7; level of education, and 8; ability to cooperate and work collaboratively. In order to maximize the micro franchises impact on multi-dimensional poverty, an ideal household will have a very high interest in participating, multiple unemployed members, a low and unstable income, rely mostly on biomass, and be capable of learning business principles and cooperating with other families. Each household will contribute one full-time worker; however, additional part-time work will be available for other family members as necessary. While the review of candidate communities and households will necessitate an in-person surveying process, the Poverty Stoplight map can provide valuable information and geographically advise a search of potential communities. Specifically, because indicator 1; income above the poverty line, indicator 2; stable income, indicator 3; access to credit, indicator 4; family savings, indicator 5; having more than once source of income, indicator 30; having knowledge and skills to generate income, and indicator 31; ability to plan a budget are all expected to be positively affected by the micro franchises, initial low scores for candidate households would maximize the projects impact. It is important to note that much, if not all of the criterion for target communities and households have a theoretical grounding in the Energy Stacking Theory. Furthermore, in the same community a charcoal micro franchises is implemented, fifteen Prakti charcoal cook stoves will be "sold". The stoves will be sold to fifteen unique households at a significantly lowered price than originally purchased in order to ensure participant accountability and interest. Households will pay 3-5% of their monthly income for three months to gain ownership of the stove. An ideal participating family will have the long-term financial means to both pay for the stove and charcoal, high interest in using the stove and/or transitioning from biomass to charcoal, and a large number of young children to benefit from a less polluted environment. Additionally, many of these determining factors carry trade-offs that must be considered and weighed. For example, the community health public health education programs, which will occur in the same communities as the charcoal cook stove distribution initiative, are most beneficial to households using biomass; however, distributing charcoal cook stoves to a community entirely reliant on biomass would almost certainly prove ineffective as it would not address the factors that have previously inhibited a transition to charcoal. Similarly, the areas most affected by deforestation are likely to have high unemployment as well as low and unstable income; therefore, the free time gained by using charcoal wouldn't necessarily translate to economic opportunity. Consequently, although distributing cookstoves to households and communities already employing charcoal rather than biomass might not be as beneficial, it may be more effective. Lastly, although the charcoal cook stove distribution project will help create demand for the micro franchises, supplementary markets for each micro franchise will also be identified. An ideal market will sell charcoal at a high price (low supply, but high demand), be of close proximity to the participating micro franchises, and have a high demand for briquette charcoal as opposed to wood charcoal. Depending on the micro franchises proximity to the chosen

market, La Fundacion Paraguaya could assist with transportation.

The third objective is to hire and train two charcoal micro franchise officers in teaching a general tri-facet training module and role-specific training program to all fifteen participating micro franchise households. First, the project implementer and La Fundacion Paraguaya's regional microfinance manager will collaborate to hire two charcoal micro franchise officers. Given La Fundacion Paraguaya experience with microfinance, the organization should have general criteria available for hiring employees. Still, as it relates to this project, candidates must be proficient in Spanish and Guarani[11], knowledgeable about microfinance, and willing to travel often. The hired employees will be trained in teaching both the general training module and role-specific training. Their success will be monitored and evaluated with practical and knowledge-based exams. Having the hired micro franchise officers train the future micro franchise participants as opposed to the project implementer will help establish a professional and authoritative relationship. Regardless, the project implementer will oversee the training of micro franchise participants to ensure all information is covered appropriately and effectively. The general tri-facet training module will encompass foundational information, small business and financing skills, and a tutorial on the briquette-making method. The module will take approximately three weeks, and because many of the households cannot afford to lose wages for such a long duration, one full-time worker from each participating household will be paid to attend. During the foundational portion, participants will learn why the charcoal briquettes are a unique and important product, specifically how they are a healthier, economical, and environmentally sustainable alternative to biomass. This information is valuable as it will serve to include participants in their own development and provide a purpose to the micro franchise beyond just increasing household income. The small business and financing skills will not only provide participants the capabilities to run a business, but also supply knowledge that can be applied to future household activities and decisions like saving money, managing credit, and formulating a budget. Because La Fundacion Paraguaya already operates micro franchises and small business, educational materials should be should readily available. Finally, an in depth informational and practical training on the *Fuel from the Fields* briquette-making method will conclude the general training module. Overall success in the training module will be monitored and evaluated with practical and knowledge-based exams. Next, the individual duties of each full time worker will be differentiated and role-specific training will take place over the course of one week, with workers again being paid for participation. Two workers will specialize in briquette production, one in marketing and packaging, one in selling, and one in financing. Although the roles may be fluid, as certain jobs require more or less work, they will help instill accountability for each step in the supply chain. The project implementer will design and develop the curricula for the general training module and role-specific training, working with La Fundacion Paraguaya to ensure each is culturally appropriate and understandable.

The fourth and fifth objectives will mostly occur simultaneously and are respectively, to implement one charcoal micro franchises and distribute fifteen Prakti cook stoves in each target community. All fifteen households in the micro franchise program will participate in the previously described month-long training process. After which, each micro franchise will be launched consecutively in one-week intervals with the initial loan of input materials. After the first month, the micro

[11]An indigenous language to Paraguay often spoken, at times predominantly, in rural Paraguay

franchises will pay 10% of profits per month to pay back the start up loan, until the initial $150 loan is paid back. The micro franchise officers will stay in the community, using the one-week start-up time as an observatory period to ensure every worker understands his/her role and that there are no major issues. If electric infrastructure permits, the worker responsible for financing will receive a tablet computer to enter data that can be monitored by the micro finance officers weekly. At the same time, the officers will distribute the Prakti charcoal cook stoves to selected households and collect the first payment towards its eventual purchase. Each of the households participating in a charcoal micro franchise will also receive a cook stove and notebook for data recording. A member from every household will participate in one of two nighttime training sessions explaining its operation, troubleshooting, and the benefits of the stove. The charcoal cookstoves will create demand for the charcoal micro franchises, while also providing benefits for households in their own right.

The sixth objective is to teach three community health education seminars to a total of 100 household representatives in each respective community where a micro franchise is being initiated. Once the micro franchises have been successfully initiated, the project implementer will train the micro franchise officers to lead the seminars, which are aimed to mitigate the risk of indoor cooking fires and provide important information that is overlooked in the household energy decision making process. Specifically, the education seminars will focus on reducing childhood exposure to indoor air pollution from cooking fires, motivating families to cook outdoors or ventilate indoor fires where possible, explaining the economic, health, educational, and environmental benefits of transitioning to charcoal, and providing relevant health information, including how and when to seek help for biomass caused illnesses. These sessions also provide a valuable opportunity to explain the local purpose of the charcoal micro franchises, so that families can understand their positive community impact. It will also be important for La Fundacion Paraguaya to collect feedback and understand how and where participants need help making positive changes in response to the other information provided. One potential follow-up project could be the administration of microloans for households to implement adequate indoor ventilation.

The seventh and final objective is to remove the fifteen participating micro franchise households from extreme poverty, at least as measured by indicator 1; indicator income above the poverty line, indicator 2; stable income, indicator 3; access to credit, indicator 4; family savings, indicator 5; having more than once source of income, indicator 30; having knowledge and skills to generate income, and indicator 31; ability to plan a budget. Additionally, although the charcoal cook stove distribution initiative will at the very least positively impact the environment, household health, and household spending, it is, for reasons that will soon be explained, difficult to define these expectations in terms of the Poverty Stoplight. Regardless pre and post-surveys combined with participant interviews, which will be discussed in the monitoring and evaluation section, can provide insight into the cookstoves impact.

These objectives are designed to function collectively and create a comprehensive community impact. By not just focusing on one dimension of poverty or method of development, but instead creating a multi-faceted project, each objective will benefit from an amplified community focus on energy poverty.

Project Organization

The projects organizational structure, which can be seen in the appendix, is headed by an institutional partnership between the project implementer and La Fundacion Paraguaya, a self-sustaining non-governmental organization that aims to eliminate multi-dimensional Poverty in Paraguay. Although the charcoal cook stoves will be purchased from Prakti, a cook stove developer, manufacturer, and distributer, Prakti will have no functional role in this project. The project implementer is responsible for overseeing, implementing, and evaluating the project until it is progressively absorbed into La Fundacion Paraguaya's microfinance program. The regional microfinance manager will operate as the effective face of La Fundacion Paraguaya for this project. He or she will initially cooperate with the project implementer to find training and testing sites in Paraguay, as well as help lead the search for target communities, households, and markets. The two micro franchise officers, once hired, will assume the role of cooperating with the project implementer to facilitate the project and report to the regional micro franchise officer. They will be trained by the project implementer, and then in turn train the micro franchise participants along with the project implementer. The officers will also be responsible for monitoring and evaluating the micro franchise during their implementation, conducting the nine total public health seminars across the three target communities, conducting and collecting feedback on the six total Prakti cook stove nighttime education programs, and performing monthly evaluations of both the micro franchises and cook stove distribution initiative. Both officers will work and learn in tandem for a majority of the project; however, with sufficient experience, the monthly community evaluations can be performed individually. It is important to note that after phase three of the project is completed, the micro franchise officers role will be limited to conducting monthly community evaluations and creating weekly micro franchise productivity reports. The project implementer will remain involved by serving as the main informational resource for the micro franchise officers, as well as training the officers to conduct the public health seminars. The project implementer will also conduct formal monitoring and evaluation of the project at 13 and 18 months, which includes interviews, focus groups, surveys, and data collection and analysis. Lastly, the micro franchises will be broken down into the previously described roles of production, marketing and packing, selling, and financing. Financial and production information will be reviewed at weekly meetings and entered into an online Google Document database for constant external monitoring by the micro franchise officers. Participants can also propose suggestions and questions to each other at these meetings.

Beyond this organization structure, additional human and informational resources may be required. Depending on the project implementer's proficiency of Spanish and Guarani, translators may be hired. Also, in order to properly develop curricula for the micro franchise general training module, role-specific training, and public health seminars, the project implementer may seek external expertise. This may manifest as a collaboration with universities, La Fundacion Paraguaya, other Paraguayan organizations, or local health centers. The project implementer will also require a basic technological background to create a functional database and train micro franchise officers and participants in its operation. Furthermore, as funding for the project is determined, additional partnerships may be necessitated.

Budgeting

The budget can be seen in the appendix and provides an overview of the costs associated with implementing this project. The total cost of the project is $11971; however there are several caveats that must be considered. First, these are very rough values, as it was difficult to find specific estimates for Paraguayan labor and rent in the non-profit sector. Before moving forward with this project or seeking funding, implementers must collaborate with La Fundacion Paraguaya to obtain accurate estimates. Secondly, many of the largest expenditures are overhead costs associated with transportation, labor and office space. If La Fundacion Paraguaya were to incorporate these costs into their microfinance program and budget, the project would become significantly cheaper to implement. Thirdly, the actual cost of raw materials for the charcoal micro franchises and Prakti cook stoves is incredibly low, especially considering many of these initial costs will be repaid in the form of loans. The expenditure of acquiring raw materials for the micro franchises will be entirely repaid in the form of loans, while approximately $358 of the original $2025 spent on cookstoves will be repaid. The latter estimate assumes forty-five households will pay 5% respectively of their monthly income for three months and given the Poverty Stoplight measures the extreme rural poverty line at $53 per month, the total cook stove returns would be $358. Lastly, the public health education seminars, which when combined with appropriate community action have an enormous impact, only compose a minimal portion of the budget. They will only require two weeks of labor and transportation. The costs of the project are divided into four phases that span eighteen months, although the majority of spending will be incurred in the first eight months.

Monitoring and Evaluation

In order to properly gauge the projects effectiveness, each objective has been equipped with a monitoring and evaluation plan, which can be seen in the appendix. Successful application of the *Fuel from the Fields* method will be quantitatively measured using the previously described scientific testing of available market charcoal and the briquettes. Moreover, trials conducted with rural cooks will provide valuable qualitative comparisons. These assessments are important to both determine the necessity of possible adjustments to the briquettes and inform a marketing strategy.

The initial training of both micro franchise officers and participants will be evaluated with practical and knowledge-based tests. Furthermore, the project implementer and regional micro franchise manager will conduct bimonthly job performance evaluations for the first two months after the micro franchise officers are hired. Because the officers will work closely with the project implementer, his or her observations will provide a bulk of the evaluation. During the month-long training of the micro franchise participants, both the project implementer and micro franchise officers will collaborate to test and evaluate the performance of the micro franchise participants in training. The ending of this two-month period will coincide with the implementation of the charcoal micro franchises and distribution of charcoal cookstoves. While the project implementer will assist in the execution of these objectives, the micro franchise officers will be expected to perform the weeklong observation period and nighttime cook stove education programs autonomously. The project implementer will use this period to evaluate the officers one final time before they are absorbed into La Fundacion Paraguaya's organizational structure and exclusively

report to the regional micro finance manager. Although the project implementer will later train the micro franchise officers in teaching the public health programs, the regional micro franchise officer will attend the presentations and qualitatively evaluate the officer's performance. Assuming the project implementer is foreign, his or her attendance may serve as an obstacle to honest discussion and the effective dissemination of information.

In regards to the actual implementation of the charcoal micro franchises, three phases of evaluation will be used to ensure a successful operation. First, the immediate one-week observatory period conducted by the micro franchise officers will guarantee that the training effectively translates to action. This period will allow the officers to provide additional in-person training where necessary and advise workers if queries arise. Upon completion of this phase, officers will conduct monthly in-person performance evaluations of the micro franchises to further ensure continued success. Loan repayments will be collected during this time; however, if electric infrastructure and Internet access permit, weekly online submitted financial reports will keep officers consistently informed on each micro franchises progress. Important information will include the selling price of charcoal at the market/in the local community, the amount of charcoal being sold at the market/in the local community, and total profits. The in-person evaluations will allow officers to empirically confirm progress, and provide additional opportunities to train and advise workers. Finally, the project implementer will conduct two in-depth evaluations five and ten months after each micro franchise's initiation. These will be discussed in greater detail in a few paragraphs, as it relates to the accomplishment of objective seven.

The cook stove distribution initiative evaluation strategy is very similar to that of the micro franchises. Initially, monitoring attendance at each nighttime education session will be vital, as attendance is a prerequisite to receive a stove. During each monthly micro franchise evaluation, officers will also conduct household surveys on the cook stove program to collect loan repayments, answer any user questions, and ensure proper usage. Sample questions during these household visitations would include: is the "cook stove functional?", "have you encountered problems with it?", and "how often and when is it used?". Data will be collected on user issues as well as how and when the cook stove is used to create further training materials in the short-term. Unlike the micro franchises, this part of the project does not include an objective to remove families from certain dimensions of poverty as it relates to the Poverty Stoplight because it is difficult to explicitly predict the Prakti cookstoves impact. For example, it is likely that the Prakti stoves increased efficiency will reduce household spending on charcoal; however, without regional specific information on charcoal price fluctuations and household charcoal usage, a reliable estimate on the exact amount of those savings cannot be made. Similarly, although Prakti cook stoves reduce toxic emissions by 60%, many factors determine indoor air pollution's effect on health and other dimensions of poverty (25). For example, although the Prakti stove's impact of improved air quality would seem to definitively affect indicator 19; unpolluted environment, moving to the yellow region specifically requires "the family lives in a somewhat clean environment that is contaminated, but does not put [their] health at risk" (41). However, indoor cooking fires, albeit with reduced toxicity, still put health at risk. Regardless, the project implementer will comprehensively evaluate the project's impact at thirteen and eighteen months. Household surveys and focus groups will be used to obtain information on specifically how and when families used the stove as well as attitudes about the project's perceived impact. Further analysis will incorporate reevaluating

stakeholders in the Poverty Stoplight to see if specific trends can be identified. Simultaneously evaluating a control population of fifteen households in the same communities that did not receive cook stoves will improve the reliability of obtained information. Specific considerations will include the cook stoves impact on household health and pollution. For families who transitioned from biomass to charcoal with the Prakti cook stove, potential productivity gains and improved school attendance among resident children will also be discussed.

Evaluating the public health education programs will involve an immediate and postponed assessment. First, taking attendance at the sessions will provide an overview of the reach of the program. Additionally, because the programs, are intended to provoke community discussion and action, the amount of feedback and community interest will also be qualitatively assessed. It will be important to hear from households and learn what factors are inhibiting households from employing safer cooking methods like cooking outdoors and ventilating kitchens, if not simply a lack of knowledge. This information can inform future interventions and draw community interest and leadership in such action. Secondly, the programs are also designed to motivate households to immediate action. The program consequently will also be evaluated by the amount of households who made changes to accommodate the programs recommendations. Micro franchise officers will conduct community surveys after one and two months to collect data on the percent of attendees that in response to the program 1; ventilated their kitchen, 2; increased the frequency with which they cook outdoors, 3; made an effort to keep children away from indoor air pollution, and 4; transitioned or became highly motivated to transition away from biomass.

Finally, in order to evaluate the projects efficacy in removing households participating in micro franchises from multi-dimensional poverty as measured by the Poverty Stoplight and outlined in objective 7, the project implementer will conduct an in-depth evaluation at five and ten months from the initial loan. It will begin with an examination of each micro franchises credit and loan repayment history. The percent of successful repayments will serve as indicator of the micro franchises ability to generate stable profit. The weekly financial reports will also be used to understand trends regarding the amount of briquettes sold at each market and time of year as well as how profit margins continuously changed. This information will not only determine the effectiveness of the micro franchises, but also advise possible necessary changes in marketing or location for future micro franchises. Furthermore, steady growth could indicate that a micro franchise might be ready for another loan. The micro franchise officers will examine the job performance review trends during these evaluations to understand the working dynamic of the micro franchise. This will identify possible explanations for why a given micro franchise failed or succeeded. Focus groups and participant interviews will also be conducted in order to gain insight to the project's perceived impact. Lastly, and most importantly, the Poverty Stoplight survey will be re-administered to participating micro franchise households as well as a control group to verify accomplishment of objective seven.

Anticipated Outcomes and Conclusions

In Paraguay, especially rural regions affected by deforestation, energy poverty is a main inhibitor to alleviating multi-dimensional poverty. This project is intended to help facilitate one step in the household energy transition process, and in doing, abet alleviate the economic, educational,

health, environmental, and gender consequences of energy poverty. The government of Paraguay has made great investments to expand electric access and infrastructure; however, many rural communities are still reliant on biomass for energy. In the short-term, projects like this one are needed to both address the many energy stacking factors that inhibit household transitions of energy and create more realistic intermediary goals in community energy development.

The charcoal micro franchises directly serve to economically empower families, but in the process provide avenues of eliminating many aspects multi-dimensional poverty. The training required, for example, can be applied to many household activities like budgeting and financing, while income increases can be applied to healthcare access or school supplies. Furthermore, on a community-wide level, using charcoal made from agricultural waste will decrease the environmental burden imposed by wood-based charcoal. The micro franchises also offer a new variation of implementing the *Fuel from the Fields* technology that can be introduced in other development settings.

The Prakti charcoal cook stove distribution initiative will also function to help eliminate the symptoms of multi-dimensional energy poverty. Although their impact has been less clearly outlined in terms of the Poverty Stoplight, the stoves' increased energy efficiency and lower toxicity will surely improve household health and lower household energy costs. Equally, important this initiative will also create charcoal demand for the charcoal micro franchises, thus helping overall project success.

Finally, the public health education programs are designed to have an impact on the entire community. By leveraging simple information dissemination and promoting easy risk-reducing activities, the impact of energy poverty can be severely reduced. These education sessions also provide an opportunity to engage the community as a whole and identify further development needs.

On the same note, this project has been engineered to create a community-wide emphasis on eliminating energy poverty. By implementing a project with unique objectives, all under the umbrella of energy development, each respective activity will benefit from increased community action and focus. It is important to attack energy poverty from several different directions, and consequently this project has incorporated microfinance, technology, and education to maximize the overall impact.

The greatest obstacle to this project success remains the complexity of energy stacking behavior. Although extensive community and household evaluations will incorporate many elements of the household energy decision-making process, ignoring just one vital factor can have an extreme negative impact. In order to minimize the threat, both pre-implementation community analysis and a comprehensive monitoring and evaluation strategy will provide opportunities to adjust the project with new information.

Conclusion

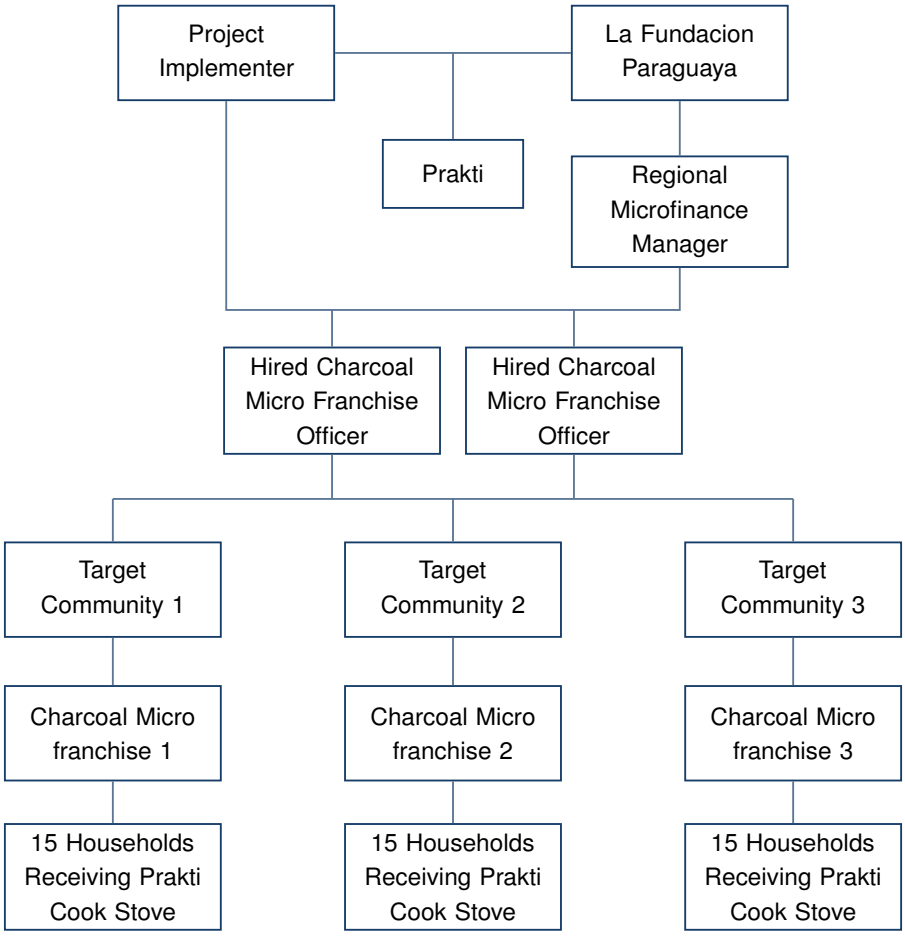
The conclusion of 2015 coincides with the expected completion of the Millennium Development Goals. As it remains, the international community still faces significant obstacles in accomplishing these goals. However, with an increased global emphasis on eliminating energy poverty, future

goals and efforts should be grounded in a more comprehensive understanding of energy's impact on development.

This paper is useful in many domains of international development. The theoretical framework and analysis of energy poverty's impact are intended to inform professionals and agencies involved in international development. The knowledge is relevant and applicable across all frontiers of development. Moreover, the project proposal in section three provides one paradigm to measurably reduce energy poverty at the community and household level. Still, this effort and future reproductions must fall within a national effort to eliminate energy poverty.

Appendix

Organizational Structure



Monitoring and Evaluation Plan

Objective	Monitoring Strategy	Indicator (How it will be measured)	Methods	Who	When	Where
Objective 1: Successfully adapt and test MIT briquette making method in Paraguay **Activities:** 1.Develop 3 sets of production materials (drum, steel press, block stand) using measurements provided by MIT's D-Lab 2.Create and quality test charcoal briquettes 3.Compare briquettes against available market charcoal 4. Order and assemble 45 Prakti charcoal cookstoves	We will quantitatively and qualitatively measure the briquettes produced	**1)** a. Number of of sets of production materials developed **2)** a. Number of briquettes produced b. Time to ignite briquettes c. Difficulty igniting briquettes (qualitatively rated on 1-10 scale)* d. Time briquettes maintain peak temperature* e. Time briquettes emit heat* f. Smoke produced from burning briquettes* g. Percentage of trial users reporting no difference or improvements as compared to market charcoal/firewood h. Briquette durability (qualitatively rated on 1-10 scale)* **3)** Same indicators as 2 Note: Although impractical because of budgetary and resource limitations, it would be very useful to know the amount of carbon monoxide and particulate matter our briquettes produced compared against market charcoal **4)** a. Number of Prakti stoves received and assembled	Counting numbers of production materials developed Counting number of cookstoves received and assembled Scientific experimentation and observation Community trials and subsequent surveys	Project Implementer	First 3 months of project	Rural setting near Asuncion

Objective	Monitoring Strategy	Indicator (How it will be measured)	Methods	Who	When	Where
Objective 2: Identify 3 target communities to establish micro franchises and distribute Prakti cookstoves, as well as markets where each micro franchise will sell briquettes **Activities:** 1.Identify at least 5 candidate communities to start micro franchises 2. Rank all candidate communities and choose 3 (deciding factors: incidence of indoor cooking fires, dependence on firewood/charcoal, average community income, scores on relevant Poverty Stoplight indicators) 3. Rank all candidate households for micro franchises and choose 3 in total 4. Rank all candidate households to receive Prakti cookstove and choose 45 in total (15 per community) 5.Identify at least 2 potential markets for each respective business to sell briquettes, 1 of which will be chosen for each (deciding factors: local price of charcoal, proximity to target community, supply and demand of charcoal, value of briquettes vs. wood charcoal)	We will quantitatively measure the number of communities and markets both identified and chosen, as well as the statistical and qualitative fit for each	**1)** a. Number of candidate communities identified b. Number of target communities chosen **2)** a. Number of candidate markets identified **3)** a. Number of households chosen **4)** a. Number of households chosen **5)** a. Number of target markets chosen decided by: -Local price of charcoal -Distance to target community -stability of supply and demand of charcoal (qualitatively rated on 1-10 scale) -Value placed on briquettes vs. wood charcoal (qualitatively rated on 1-10 scale)	Counting number of candidate/target communities identified/chosen Door-to-door community surveys Poverty stoplight data aggregation Market surveys/analysis	Project Implementer/ Regional microfinance manager	First 3 months of project	Rural communities in Paraguay

Objective	Monitoring Strategy	Indicator (How it will be measured)	Methods	Who	When	Where
Objective 3: Develop and train 2 microfranchise officers in teaching a general tri-facet training module (public health, small-business financing/management, and briquette-making method) and role-specific training program (production, marketing, selling, finances) for future microfranchise stakeholders **Activities:** 1. Interview potential microfranchise officers through La Fundacion Paraguaya and hire 2 candidates 2. Train new micro franchise officers with training module 3. Hold knowledge and practical tests for hired workers following training 4. Develop program curriculum and educational materials with new employees, emphasizing culturally appropriate and relevant strategies (i.e. videos, handouts, tests)	We will quantitatively measure our success in hiring employees and creating educational materials and use both qualitative and quantitative measures to analyze each employee's training	**1)** a. Number of workers successfully interviewed/hired **3)** a. Percentage of questions answered correctly on knowledge tests for hired workers b. Performance on practical exams c. Scores on weekly job performance evaluations for first 2 months **4)** a. Number of documents, materials created for education b. Quality of documents, materials created for education	Counting number of employees hired/interviewed Pre-training test/post-training testing Weekly job performance evaluations Counting number of documents/materials created Focus groups to test quality/efficacy of education materials	Project Implementer, Regional Microfinance manager, Hired microfranchise officers	3-5 months from project start	Asuncion Paraguay, rural communities

Objective	Monitoring Strategy	Indicator (How it will be measured)	Methods	Who	When	Where
Objective 4: Implement 3 charcoal briquette micro franchises within the first year **Activities:** 1. Train participants with general tri-facet training module, paying them for participation 2. Differentiate participant roles in microfranchise (briquette production, packaging, marketing, selling, finances) and hold individual training for respective role 3.Initiate micro franchises consecutively with initial loan and week-long observation period 4. Perform bimonthly visits and evaluations and monitor financial reports 5.Collect monthly loan repayment installments constituting 10% of microfranchise profit	We will quantitatively and qualitatively examine the efficacy of our training programs as well as the performance of the workers and micro franchises overall	**1)** a. Percentage of questions answered correctly on knowledge tests b. Performance on practical exams c. Percentage of household participants attending each training session **3)** a. Number of micro franchises operating after week long-observatory period **4)** a. Percentage of micro franchises successfully implemented b. Net income per month of each microfranchise c. Net profit per month of each microfranchise d. Percentage of loan repayments successfully completed e. Price/Kg briquettes at market f. Total Kg briquettes sold g. Kg briquettes sold monthly/seasonally **5)** a. Percentage of monthly loan payments successfully completed	Counting number of micro franchises implemented Pre-training test/post-training testing Stakeholder focus groups to identify areas where improvements/adjustments/additional training is needed Data analysis Performance evaluations of participants	Project Implementer, Hired microfranchise officers, charcoal micro franchises	5-8 months from project start	Rural communities in Paraguay

Objective	Monitoring Strategy	Indicator (How it will be measured)	Methods	Who	When	Where
Objective 5: Distribute 45 Prakti charcoal cookstoves to 45 households in three communities 1. conduct two nighttime educational programs in all 3 communities, one of which must be attended by a household representative 2. collect monthly loan repayments constituting 5% of family income. 3. Perform monthly household visits to evaluate cookstoves (is it functional, how often is it used, when is it used) 4. At 13 months conduct in-depth surveying (is it functional, when is it used, how often is it used, did family's maintain financial access to charcoal throughout 5 months, do families use less charcoal than with previous stove, do families report less polluted household, redo PS survey and ask families why changes occurred)	We will qualitatively and quantitatively evaluate the effectiveness of the cookstove program through different surveying methods and household loan repayments	**1)** a. number of participants at each nighttime education session b. number of participants responding with feedback (i.e. questions or ideas) c. Percent of households receiving cookstove that attended **2)** a. Percent of households paying each monthly loan **3)** a. Percentage of households reporting successful use at each monthly survey questions: -is cookstove functional? -have you encountered problems with it? -how often is it used? **4)** a. Percentage of households with improvements in relevant Poverty Stoplight indicators b. Percentage of interview respondees reporting less polluted indoor air environment c. Percentage of interview respondees reporting using less charcoal than previous cookstove d. Percentage of households with positive feedback regarding use of Prakti cook stove	Counting number of participants at education sessions Counting number of households paying back loans Surveys Participant focus groups Poverty Stoplight resurveying and analysis	Project Implementer, Hired microfranchise officers, Households receiving cookstoves	5-8 months from projects start	Rural communities in Paraguay

Objective	Monitoring Strategy	Indicator (How it will be measured)	Methods	Who	When	Where
Objective 6: Teach 3 community health education seminars to a total of 100 household representatives in each community where a microfranchise is being implemented within 3 months of business implementation **Activities:** 1. Develop specific public health training program 2. Train microfranchise officers in health detriments of indoor cooking fires and ways to mitigate risk (having locals teach provides important local context), evaluating them with knowledge and practical exams 3. Conduct 3 community education sessions per community (i.e. reducing childhood exposure to cooking fires, promoting ventilation of fires/cooking outdoors, replacing firewood with charcoal where possible, knowing when to seek medical help for common illness, investing in alternative cooking methods like solar cookers and more efficient cook stoves) 4. Collect feedback from community on ways to improve information dissemination/abet them make positive changes 5. Evaluate behavior changes one month later	We will use qualitative and quantitative measures to gauge the effectiveness of training and education sessions	**1)** a. Number of educational materials created for training program b. Quality of educational materials created **2)** a. Percentage of questions answered correctly on knowledge tests by trained educator b. Performance on practical exams by trained educator **3)** a. Number of programs successfully held b. Attendance per education session c. Percentage of attendees immediately reporting usefulness of information d. Percentage of attendees reporting continued lifestyle/behavioral changes one month after session e. Receptiveness/Participation of audience (qualitatively rated) f. Performance evaluation of presenter g. sex/age of household representative **4)** a. Number of attendees offering feedback on session **5)** a. Percent of families reporting keeping children away from cooking fire b. Percent of families who cook outdoors more often c. Percent of families who ventilated cooking area d. Percent of families who switched cooking fuels or are now trying to	Counting number of educational materials produced Focus groups to determine quality of education materials Pre-training/post-test training Performance evaluations Counting number of attendees/attendees offering feedback Registering attendees upon entrance Focus groups Community surveys Individual participant interviews	Hired microfranchise officers, Community health educators, Project Implementer	5-8 months from project start	Rural communities in Paraguay, Asuncion Paraguay

Objective	Monitoring Strategy	Indicator (How it will be measured)	Methods	Who	When	Where
Objective 7: Remove 15 households from extreme poverty within one year of business implementation **Activities:** 1. Monitor income changes of participating households 2. Consider additional loans with promising microfranchise growth 3. Monitor indicator changes in Poverty Stoplight	We will quantitatively compare income growth from charcoal micro franchises against Poverty Stoplight data and use a comprehensive evaluation to consider eligibility for additional loans	**1)** a. Percentage growth in household income compared against pre-project income b. Percentage of households alleviated from extreme poverty as determined by indicator 1 of Poverty Stoplight **2)** a. Percentage of loan repayments successfully completed b. Number of consecutive months completing loan repayments c. Comprehensive micro franchise evaluation by hired micro franchise officer (interviews, credit, performance evaluations) **3)** a. Poverty Stoplight scores before and after	Data analysis Focus groups Interviews Performance evaluations	Project Implementer, La Fundacion Paraguaya, Hired microfranchise officers, Charcoal Micro franchises	8-18 months from project start	Paraguay

Budget

Item	Unit	Cost Per Unit	Amount	Total
Phase 1 (First 3 months)				
Prakti Cookstove	45	$45	N/A	$2025
Production materials (4 100-gallon steel drums, 1 wood table, 5 steel press, 1 tarp, 1 metal mesh sifter)	3	$200	N/A	$600
Office Space	1	$30/month	3 months	$90
Round trip flight to Paraguay	1	$850	N/A	$850
Labor to create production materials (welder, wood cutter)	1	$15/day	3 days	$45
Market wood charcoal	4	$1.50/Kg	1 Kg/bag	$6
Experimentation materials (lighters, notebook, pencils)	1	$20	N/A	$20
Charcoal brazier	1	$10	N/A	$10
Round trip bus tickets to candidate communities	20	$5/ticket	N/A	$100
Round trip bus to candidate markets	10	$5/ticket	N/A	$50
Translator	1	$15/day	18 days	$270
				Net Total:$4066
Phase 2 (3-5 months)				
Office space	1	$30/month	2 months	$60
Job opening advertising (fliers, newspaper publications)	1	$30	N/A	$30
Micro franchise officer salaries	2	$500/month	2 months total	$1000
Educational materials (paper, printing, pencils)	1	$50	N/A	$50
				Net Total: $1140
Phase 3 (5-8 months)				
Office space	1	$30/month	3 months	$90
Micro franchise officer salaries	2	$500/month	6 months total	$3000
Round trip bus tickets for officers to communities	6	$5/ticket	12 tickets total	$60
Round trip bus tickets to training for micro franchise participants	15	$5/ticket	20 tickets/participant	$1500
Micro franchise participant salaries	15	$20/week	4 weeks/participant	$1200
Educational Materials (paper, printing, pencils)	1	$50	N/A	$50
Classroom Rent	1	$30/week	4 weeks	$120
Officer housing/meals in target communities	2	$15/day	21 days	$630

Item	Unit	Cost Per Unit	Amount	Total
Input Material/Stove Transports	3	$50/transport	N/A	$150
Financial recording materials (notebook, pencils)	1	$15	N/A	$15
First monthly Prakti cook stove loan repayment	45	-$3		-$135
				Net Total: $6680
Phase 4 (8-18 months)				
Office space	1	$5/day	half-day/week x 40 weeks	$100
Round trip bus tickets for monthly evaluations	3	$5/ticket	3 tickets total	$15
Micro finance officer salary	2	$15 day	5 days total/month x 10 months	$750
Monthly Prakti cook stove loan repayments	45	-$3/month	90 months total	-$180
Micro franchise loan repayments	3	$200/micro franchise total	N/A	-$600
				Net Total: $85
All Phases				**Net Total: $11971**

Fuel From the Fields Method

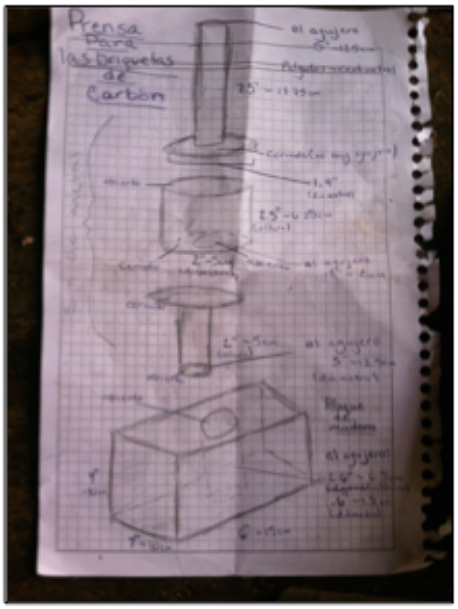


Figure 1: Drawings and diagrams based off of MIT's open source designs used by students to weld and cut the press.



Figure 2: The four parts of the press, as replicated by students at La Escuela San Francisco de Cerrito



Figure 3: One of the students cutting holes in the drums using electric tools



Figure 4: The finished drum with a square opening cut on top and seven holes on bottom



Figure 5: The drum placed on three stones with a stick going through the center bottom hole. The drum has been filled with agricultural waste.



Figure 6: Easily ignitable agricultural waste placed into the six circumferential holes on the bottom of the drum



Figure 7: As the waste protruding out of the bottom of the drum was ignited, a thick white smoke billows from the top of the drum



Figure 8: After about three to five minutes the smoke combusted burning clearer and cleaner.



Figure 9: After an additional five minutes, the top was placed on and the stones were removed using a stick for support



Figure 10: Sand was placed around the edges of the bottom and top of the drum to seal out oxygen



Figure 11: A charcoal yield from one burn. Most of the agricultural waste had successfully carbonized



Figure 12: A lump of dough from the mix of water, cassava powder, and pulverized charcoal in the white bucket being placed in the press

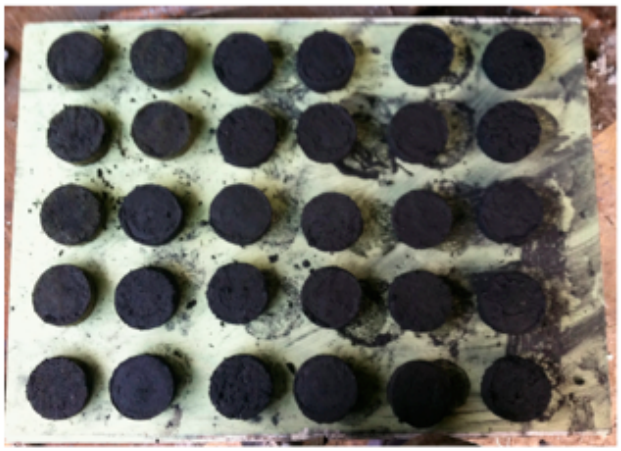


Figure 13: A tray of moist briquettes ready to dry in the sun. Charcoal is generally black in color, while ash is greyer; therefore, darker briquettes are desired



Figure 14: In the left column are briquettes made with banana as an adhesive and in the right column are briquettes made with cassava as an adhesive. In the first row are solid briquettes and in the second row are briquettes with holes in them



Figure 15: Our burning location with dry agricultural waste on the left and charcoal on the right



Figure 16: Briquettes made with cassava as an adhesive burning

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