REDC's Solar Food Preservation Facility

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Need or Problem

In order to survive, humans need food, preferably fresh nutritious food. Nutritious food is essential for the human body to develop properly. For millions of years humans have progressed from the hunter-gatherer, to agriculture, and finally to an industrialized stage of feeding ourselves. Even though many have progressed to the industrial stage, some have not. Today, many developing nations lack the ability to preserve nutritious foods short-term and long-term in rural environments. Not having the ability to preserve at the harvesting stage, processing stage and distribution stage many rural small-scale farmers cannot farm nutritious food as a business. Instead, small gardens of nutritious food are grown and consumed quickly before decomposition or rot begins. "Green Revolution" style farming practices are introduced to larger plots of land in order for farmers and their families to survive physically and financially year-to-year. "Green Revolution" farming practices focus primarily on boosting cereal crops such as rice, wheat, and grain in order to prevent increasing famine, but this style of farming leads to soil erosion, land degradation and deforestation. [1] Throughout the world, millions of small-scale farmers participate in these farming practices. [1] Small-scale farmers are able to store their supply of harvested crops long-term to feed their families and community members year-round and or sell the goods at the market for income. [2] Unfortunately, these types of crops lack the micronutrients growing body's require. [1] Globally, 2 billion people suffer from malnutrition. [3 (WHO)] Small-scale farmers in developing nations need a breakthrough in technology that will allow the short-term and long-term preservation of nutritious foods. Nutritious foods possess the micronutrients growing body's require, can be farmed in a sustainable manner, which doesn't contribute to soil erosion, land degradation and deforestation. If a business as usual, approach is the strategy for the agriculture industry in developing nations the small-scale farmer could find it very difficult to keep up with growing populations and the adverse effects of climate change.

For many developing nations, rural small-scale farmers are the backbone of the agriculture industry. [1, 2] Small-scale farmers help drive the economy a multitude of ways. [1] If the farmer is productive the benefits are widespread, if the farmer is not, it creates instability in the entire agriculture value chain. Many nations throughout sub-Saharan Africa (SSA) are utilizing unsustainable agriculture practices to feed their populations. [1] With populations expected to increase to 9 billion people by 2050 [1] more stress will be put on the agriculture industry especially in developing nations where the largest population increases are expected to take place. [1]

Cold storage helps small-scale farmers reduce the waste of nutritious foods and increase business profitability per hectare of land. During the harvest and post-harvest stages cold storage helps small-scale farmers preserve large portions of the food before distributing to his/her customers. Not all crops become ripe at the same time and having a refrigerated space when the crops enter the post-harvest stage is essential when farming any nutritious food. Storing nutritious food in cold storage immediately after harvesting also increases the shelf-life and reduces waste for food vendors, grocery markets, the food service industry and end use consumers. Annual business profits and household incomes increase when nutritious food has a longer shelf life.

Today throughout sub-Saharan Africa (SSA), fifty percent of fruits and vegetables are wasted before reaching consumers. [1, 4] Losses and waste occur at different stages during the journey from production to consumption. Ten percent of fruits and vegetables are lost during the agriculture production stage by accidental damage and premature harvesting. [4] During post-harvest stages, 8% of the fruits and vegetables are wasted due to spillage and degradation during the handling, storage, and transport of the produce. [4] Twenty percent of waste occurs at processing facilities when food handling mistakes are made or during the sorting process where produce is evaluated for imperfections and spoilage. While produce is on the shelf at wholesalers, supermarkets, retailers, and wet markets 10% spoils. [4] While in the consumers possession 2% goes to waste. [4]

Forty percent of the roots and tubers go to waste before reaching the distribution stage in SSA. [4] High temperatures and high humidity levels make roots and tubers especially vulnerable to loss and waste. Thirteen percent are lost during the agriculture stage, 16% are wasted at the post-harvest stage and 11% are wasted during processing. Two percent of the roots and tubers are wasted during distribution and 1% is wasted at the consumption stage. [4]

SSA has some of the highest loss and waste percentages when it comes to dairy. Twenty five percent of all dairy is wasted from production to consumption and 5% percent of dairy is wasted at the agriculture stage due to illnesses of the cow. 10% is lost or wasted at the post-harvest stage due to poor handling and lack of cold storage. 10% is wasted during the distribution stage due to lack of cold storage. None is wasted during consumption and processing doesn't take place.[4]

Twenty eight percent of all the meat in SSA experiences loss and waste. A majority of losses occur during animal production, 14% of losses are due to high rates of mortality caused by pneumonia, parasites, and digestive diseases. During the slaughter stage only .05% of meat goes to waste. Because almost all of the meat sold throughout SSA is sold warm, waste increases to 3% during processing stage and 5% is wasted when distributing the processed warm meat. Remarkably consumers waste a mere 1% the lowest percentage in the world.[4]

Without real cost-effective ways for small-scale farmers to preserve nutritious food long-term before crops decompose at the post-harvest stage, the business of farming nutritious food isn't maximizing its fullest potential. Long-term preservation of nutritious food is relatively non-existent throughout rural farming communities in developing nations. Long-term preservation helps small-scale farmers reduce waste and increase business profits further. Food that isn't of high enough quality for the farmer's customers can be used to create additional and or new profits that the small-scale farmer needs when farming nutritious foods.

In Ethiopia, 85% of the population (99 million [3]) works in the agriculture industry in some way and contribute to almost half of the nation's gross domestic product. [2] Small-scale farmers grow 94% of the food crops. In rural areas where almost 85% of the population resides, "Green Revolution" farming practices are a common way of life. The practices involve a high input, low output result and requires increasing the use of expensive chemicals and improved seeds, which both create additional costs to the small-scale farmer's business model. [1] These unsustainable farming practices contribute to soil degradation, deforestation and require the small-scale farmer to replace organic matter in the soils. [1] Organic matter helps sandy soils bind together, increasing nutrients and moisture in root areas. [1, 5] Without organic matter, sandy soils leach out nutrients and moisture, leading to fertility deficiencies.[5] Silty soils need space and air, organic matter allows this separation for the soil to properly drain, without it the silty soils can become water logged and dusty in dry conditions.[5] Clay soils rely upon organic

matter for separation needed for drainage and without it the soil becomes sticky when wet and bakes hard in high heats.[5] Organic based soils use water more efficiently due to better soil structure, experience less soil erosion, improve overall soil health and fertility, while providing a nutrient rich environment for healthy plant life. [1] If small-scale farmers do not replace organic matter the soil becomes useless. The farmer is left with two options, abandon his or her farmland in search of new fertile soils or relocate to urban environments for income. [1]

Almost all of Ethiopia's agriculture value chain depends on the climate and with the climate changing, the Ethiopian economy is at risk. [1] Reduced agriculture production, increased famine, lost wages and the displacement of entire communities are also consequences of climate change. [1] The agriculture dependent nation of Zambia is already witnessing the effects of climate change. [6] A Zambian farmer explained, "he is confused especially with the rainfall patterns, which are now unpredictable. He has resorted to conducting experiments by planting maize in stages so he does not lose out completely if he plants at the wrong time. He plants some of the maize at the beginning of the rain season, some more a few weeks later and so on, trying to assure himself a harvesting season. If the first planted maize dies he will still have the maize planted at later dates." [6] On top of this small-scale farmer guessing when the climate dependent rain-fed irrigation system will provide the planted crops with moisture, this farmer is investing more up-front costs in seed, labor and fertilizers (if he can afford it).

Drought reduces the supply of water, while demand increases for crops, livestock and humans. Grazing grass becomes dry and bare, leaving livestock without food or water and increases the incidents of livestock diseases and deaths.[1, 2, 7] Crops are stunted and or die, humans are forced to work harder, and take more trips (usually on foot) to gain access to fresh water in an attempt to save crops, animals and family members. [2, 7] In 2014 the earth experienced the hottest year recorded in modern history according to the National Aeronautics and Space Administration at Goddard Institute for Space Studies and The National Oceanic and Atmosphere Administration scientists. [8] October 2015 Meiso, Ethiopia began experiencing one of its worst droughts in a decade.[7] The lack of rain has dried irrigation ditches, corn is stunted, cattle are dying and farming communities are relocating.[7]

Heavy downpours cause soil erosion and flooding, the end results wreak havoc on farming communities; the farmlands can't absorb the larger amounts of rainfall in a shorter amount of time. [1, 9] Lives are threatened as floods tear through lower elevations, crops are water-logged at all elevations, [1, 9] fertile top soils are washed down-hill and down-stream and often entire farming communities are displaced.[9] In late June of 2015 cyclone Komer made landfall in Bangladesh and brought heavy rains with it to Myanmar. In total 122 lives were lost and 1.6 million were displaced. 525,330 hectares (1,306,791 acres) of farm lands were affected, particularly rice patties; 250,000 livestock (poultry, cattle, pigs, and goats) were killed; 30,000 hectares of fish and shrimp ponds were destroyed from flooding and fishing equipment such as boats, engines, nets and traps were destroyed or are now missing.[9]

Climate change will impact the economies of agriculture dependent nations and increase health issues for large amounts of people. [1,10] It is expected that countries with large populations who rely upon rain-fed irrigation sustenance farming will experience increased malnutrition. [1,10] Today 3 million children under the age of 5 die annually from malnutrition. [11] Lack of water and flooding will increase diarrhea deaths, which claim 1.5 million lives annually. [10] Warming will expand mosquito populations to higher elevations, transmitting new Dengue, Zika and Malaria cases. [10] Agriculture dependent farming communities will experience reductions in household incomes and increased costs for healthcare and repeated grade levels for children.

Seven hundred and ninety-five million people suffer from the lack of nutrition today. The vast majority, some 780 million reside in less economically developed countries.[1, 12] Undernourishment allows negative health conditions to persist such as underweight, wasting and stunting. The lack of a nutritious diet leads to malnutrition especially in children. North Africa experienced this exact situation; carbohydrate rich diets did not deliver the dietary quality that a developing body of a child requires and the region experienced a high rate of child malnutrition.[12] With populations steadily increasing and nations continuing to rely upon crops that lack the micronutrients growing bodies require to feed their nations, it is difficult to foresee any drastic changes in the future, especially in sub-Saharan Africa where populations are going to endure climate change head-on.

Millions of Ethiopians, young and old, rely upon the at-risk supply of grains and cereals for food. The high carbohydrate, low protein, and low in nutrient diet leads Ethiopians to micronutrient malnutrition, and they pay the price physically, financially and mentally. Undernourished Ethiopian children between the ages of 0-5 experience higher risks of anemia, diarrhea, fever, infections, and 28% of all child deaths in Ethiopia are related to undernutrition and are reducing Ethiopia's workforce by 8%. [13] Healthcare costs associated with malnutrition put financial strains on already struggling families and the health care system. Malnourishment increases the risk of diseases such as malaria, dengue, and cholera. In 2009 Ethiopian families paid 1.8 billion Ethiopian Birr (ETB) (77,356,386 million USD) in medical expenses related to malnutrition, which 90% was covered by families and the remainder by the health care system. [13] Two out of five children are stunted and 68% of the Ethiopian adult population is stunted. [13] Stunted children are more prone to repeat grade levels, therefore affecting families and the educational systems financially. In 2009 17.4 million Ethiopian children attending school were stunted. [13] Stunting reduces brain development and reduces lean body mass, reducing the stunted individual's ability to perform both non-labor and labor intensive jobs. In 2009 the total costs associated with a nutritionally deprived population were estimated at 55.5 billion ETB (2,385,155,235 billion USD), 16.5% of Ethiopia's total GDP.[13] A malnourished population costs a nation in many ways; a population with the proper nourishment only increases the nation's ability to succeed. Ethiopia has the largest population of youth in all of Africa today and a young, strong, healthy and educated workforce will be much more productive.

As small-scale farmers continue to feed increasing populations with grains, rice and cereals, crop production will continue to decrease, soils and populations will remain undernourished, deforestation and erosion will remain, and business of farming will continue to suffer. Without arming small-scale farmers with the needed tools for long-term nutritious food preservation and sustainable farming practices to prepare them for increasing droughts, extreme heats and heavy downpours, the already struggling small-scale farmers will be forced into submission. Nations with large populations dependent upon the small-scale farmer's productivity could be teetering on the brink of disaster if nothing is done. Time is running out, [1] swift action is needed. Urban environments are not prepared for the migration of large amounts of poverty-stricken families [1] in search of food, income, and shelter.

Small-scale farmers throughout the world are in need of a low-cost clean energy technology that provides food preservation short-term and long-term, which does not require access to electricity. Preserving nutritious crops at the harvest and the post-harvest stages allows the farmer to maximize productivity per hectare and diversify crops within the rain-fed irrigated lands, while supplying community members with a nutritious supply of food year-round. Introducing an inexpensive food preservation facility for small-scale farmers benefits the entire agriculture value chain. Diversifying crops and turning normally wasted crops into profits makes the small-scale farmer's business model more productive, profitable and, in turn, stimulates the local economy. Vendors and supermarkets benefit from the locally produced, low-cost fresh produce, its longer shelf life and repeat customer business. Fresh nutritious food promotes a healthier lifestyle, increases household family incomes and allows small scale-farmers to play an integral

role in supplying quality food for a nation in need. Crop diversification provides inside and outside community members with the nutrition needed to reduce child mortality, malnutrition, health issues related to malnutrition, and stunting, while increasing job performance and national growth. The diverse supply of green crops gives the small-scale farmer the ability to now compost, so that he or can replace organic matter, which is needed to continuously produce the high quality and quantities of crops that the customer requires. The healthy soils help the small-scale farmer prepare for a changing climate, while reducing soil degradation. A low cost food preservation facility that provides short-term and long term preservation will help small-scale farmers lead a new Sustainable Organic Food Industry that can benefit many developing nations today and well into the future.

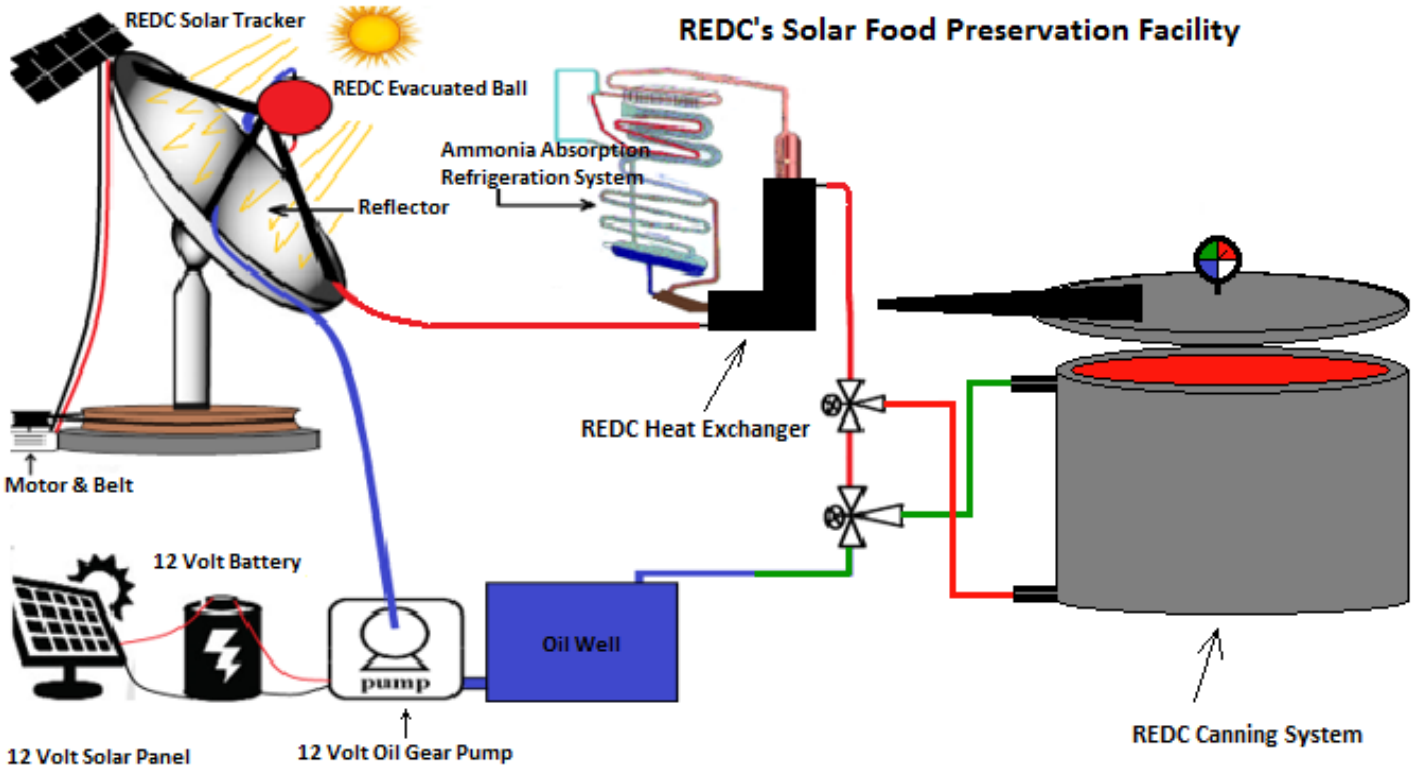

Fig. 1

Renewable Energy Design Concepts Llc. (REDC) clean energy technology allows small-scale farmers the ability to preserve food short-term and long-term for a low up-front cost. REDC's Solar Food Preservation Facility uses the thermal energy from the sun as the energy source. A tracking system made up of photovoltaic solar cells, a D/C electric motor and belt position a reflector directly on the sun at all times. When the sun moves left or right of the center of the solar tracking system, the motor adjusts the reflector left or right. When the tracking system is centered on the sun, current stops flowing to the motor and focuses the sun directly on the middle of the reflector. The rays are reflected and intensified onto an oil filled solar evacuated ball. Oil conducts the intensified rays' energy and the oil is circulated by a small D/C gear pump powered by a 12 volt battery and small photovoltaic solar panel. The oil travels through a

closed loop insulated piping system. The oil is heated to extreme temperatures inside the evacuated ball and fills REDC's Heat Exchanger with hot oil from the bottom-up. The heat exchanger covers ammonia filled piping on a continuous-cycle double effect ammonia absorption refrigeration system. The submerged ammonia-filled pipes transfer the heat from the oil to the ammonia, the ammonia liquid boils into gas and the cooling process begins, thus allowing small-scale farmers to preserve nutritious food short-term through cold storage preservation. Because not all of the energy is exhausted out of the hot oil by the refrigeration system, the hot oil can be used for REDC's Canning System when needed. The double walled canning container fills with the hot oil between the two walls from the bottom up and the inside wall transfers heat to water until it boils. The boiling water allows farmers to perform warm bath canning and/or pressure canning techniques for long-term preservation of nutritious foods.

A root cellar works alongside our refrigeration system. While the refrigeration system keeps meat, fish, dairy products, eggs, fruits and vegetables at constant temperatures below 4.4^{o}C, the root cellar provides a cool area below 15.5^{o}C for roots, tubers, grains, rice, cereals and canned goods. The root cellar uses the earth to keep the storage area at a constant temperature. REDC's refrigeration system and root cellar together help small-scale farmers preserve and store a wide variety of nutritious foods short-term and long-term. Immediate preservation and storage allows vendors, grocery markets, and food distributors a local supply of fresh nutritious food with a long shelf life at a lower cost than imported nutritious foods.

REDC's Solar Canning technology gives small-scale farmers the ability to store nutritious foods long-term by canning leftover foods not sold to vendors or grocery markets. Before any fruits, vegetables, roots, tubers, fish, meats eggs and/or dairy products spoil in the short-term refrigeration system or root cellar they are preserved and stored long-term by canning. The canned goods are stored in a cool, dry, and dark space in the root cellar until they are sold to local or outside community members.

REDC creates and provides a workforce development program for the youth to lead a new Sustainable Organic Farming Industry. The youth benefit from the new hands-on and classroom training program. Young men and women are trained how to generate business between farmers and vendors. They learn how to install and maintain REDC's Solar Food Preservation Facility, educate small-scale farmers about the operations and maintenance procedures, payback periods as well as the additional benefits the technology and business model provides small-scale farmers and community members. Finally, the young workforce educates small-scale farmers how to incorporate sustainable farming practices that help retain soil fertility, generate high quality and quantities of crops annually, and prepare the small-scale farmers property for a changing climate.

Liquid petroleum gas (LPG) can be used as the primary fuel source for our entire system. This approach does not align with REDC's mission and is not financially feasible for the small-scale farmer's business model over time. LPG is stored on site (underground) and used as a back-up fuel source in the event of equipment failure and or prolonged cloudy days to protect the farmer's investments during the harvesting and post-harvest stages.

Technical Overview of REDC's Solar Food Preservation Facility

Utilizing the sun's rays to heat isn't a new concept. Solar "flat plate" and "evacuated tube" collectors are designed to absorb shorter wavelengths of sunlight. Heat wavelengths are captured inside of open loop or closed loop collectors. Open loop systems heat potable water directly in environments which don't experience freezing weather and closed loop systems use a heat transfer fluid (distilled water or propylene glycol) inside of piping and transfer the collected solar energy through a heat exchanger to the potable water. Today, many countries utilize a flat panel style solar thermal heating systems. These stand-alone

systems exchange heat to swimming pools, radiant heated flooring, wall mounted radiators, and or hot water tanks. Other countries prefer solar evacuated tube heating systems. Evacuated tubes retain heat better than flat panels, operate better in colder and cloudy climates, and don't collect dust or snow due to their circular shape. Evacuated tubes are made of Borosilicate glass 3.3 and the inner tube is coated with an absorptive coating made of Al/N/Al. Tubes are fused together at the ends and a vacuum is created. The vacuum process causes a silver barium layer and if the vacuum loses its seal the glass will turn white. The vacuum chamber between the inner tube and the outer tube reduces heat transfer. The Al/N/Al coating allows the inner tube to conduct heat to high temperatures. Even though the inner tubes reach extreme temperatures, the outside tube remains cool to the touch. [14]

In some concentrated solar systems, solar evacuated tubes are used. The sun's rays are intensified with parabolic reflectors, dishes, or Fesnel collectors which increase the intensity of the ray. In larger concentrated solar thermal systems oil or molten salt is heated to temperatures up to 400^{o}C utilizing solar evacuated tubes and reflectors.[15]

Ammonia absorption refrigerators use natural substances to refrigerate. [16] Ammonia, hydrogen gas, and water (NH_3-H_2O) [16] are the three natural substances inside an ammonia absorption refrigeration system. Unlike other refrigerants, if ammonia were to leak humans notice its odor quickly and it does not have a negative effect on the ozone.[17] The closed loop system is pressurized to the point that the ammonia is a liquid. The partial pressure hydrogen is used to regulate the total pressure of the hydrogen and ammonia in order to regulate the boiling point.[16]

With no moving parts, ammonia absorption systems experience less down-time. Ammonia absorption systems don't require electricity and if coupled with an inexpensive heat source the reliable ammonia absorption systems allows quality refrigeration at a lower cost over time. Ammonia has excellent heat transfer properties over other refrigerants, allowing for a lower heat transfer area. It's one of the most efficient refrigerant systems on the market today. The United States of America's Environmental Protection Agency has identified ammonia as an excellent replacement refrigerant for chlorofluorocarbon and hydrofluorocarbon, which are ozone-depleting refrigerants.[17]

The root cellar protects fruits, vegetables and canned goods by keeping them cool in the warmer months and preventing freezing in the cooler months. Wide varieties of produce can be stored in a root cellar and kept fresh. For example; cabbage, celery, endive, onions, parsnips, peppers, potatoes, pumpkin, squash, root crops, sweet potatoes, tomatoes, apples, grapefruit, grapes, oranges, pears, dry beans and other harvested crops all remain fresh much longer with a root cellar than without. [18]

The canning process allows long-term preservation of nutritious food. Heat is needed to boil water for both warm bath and pressure canning. Warm bath canning is completed by placing fruit or tomato filled jars in 100^{o}C water for variable times. Warm bath canning is only for fruits and high acid tomatoes and not vegetables or meats. Pressure canning is used to preserve low acid vegetables and meats which require temperatures at 115^{o}C in order to kill botulism spores that enjoy low acid environments and other bacteria that may be present in the nutritional food. Canning allows the farmer to process and preserve a wide variety of nutritious foods at the harvest stage. For example, water bath canning allows the farmer to preserve apples, apricots, berries, cherries, figs, currants, fruit juice, nuts, peaches, pears, plums, fruit preserves, rhubarb, tomatoes, tomato juice, stews, and pre-cooked or leftover meals. Pressure canning allows the farmer to preserve meats, fish, and vegetables.[18]

Benefits of REDC's Solar Food Preservation Facility and Sustainable Business Model

REDC's Solar Food Preservation Facility helps small-scale farmers be responsible for healthy future generations. Newborns (0-5 years old) are impacted significantly. After the implementation of REDC's Solar Food Preservation Facility, immediately newborns will begin to benefit from our system. They will ingest the micronutrients their growing bodies require for full development year-round and reduce their chances of death. Family members and government funded healthcare programs benefit from the reduced healthcare costs that result from malnutrition. With widespread implementation of our technology Ethiopia's workforce will be stronger mentally and physically. The costs associated with a malnourished and stunted population will allow Ethiopia to operate more efficiently.

Ninety percent of Ethiopians use biomass for cooking and heating [1] even though 26% of the population has access to electricity.[2] Seventy-eight percent of the biomass used in Ethiopia is woody biomass. [1, 2] This contributes to negative environmental impacts; deforestation, land degradation, desertification and air pollution, all results of massive populations using biomass as a primary fuel source for cooking and heating. With the removal of each tree less CO_2 is removed from our atmosphere and the fertility of soils are reduced.[1,] Poet Walt Whitman once said "The earth itself is something of a compost pile. It gives such divine materials to men, and accepts such leavings from them at last. Long before there were people around to observe it, composting was going on in every forest, every meadow, every swamp, and bog, and prairie and steppe in the world". [19] Richard Langer said "composting is a natural process that began with the first plants on earth and has been going on ever since". [19]

Today the financial costs associated with unsustainable farming prevent 85% of Ethiopia's population of 99 million from progressing and eradicating poverty. While farmers continue to degrade soils and community members shrink forest cover, eventually the steadily increasing population will dissolve some of Ethiopia's most important natural resources. With widespread implementation of REDC's Solar Food Preservation Facility and business model, Ethiopian soils can retain the required organic matter to remain productive farmlands year after year. Forests can continue to naturally compost and remove CO_2 from the atmosphere. Ethiopians can experience an increased supply of nutritional food, better health, increased household incomes, and increased levels of education and training, all of which help reduce the odds of remaining in poverty. The bottom-up approach empowers and expands the backbone of the agriculture value chain and allows Ethiopia to transition out of an unsustainable agriculture industry into a sustainable farming industry that helps Ethiopia sequester more carbon in the future.

LPG has additional benefits. The LPG business model provides a door to door fuel delivery service to their clients. The on-site large LPG tank allows community members access to a local supply of fuel that can be used for cooking and heating immediately. Trees, shrubs, and bushes can remain in place to remove carbon from our atmosphere and help Ethiopian farming communities reduce pollution, deforestation and land degradation. The small-scale farmer's business model benefits from the additional income and reduced practices of using trees to cook and heat with. In the future the farmer will invest into modern farming equipment to increase profits further. LPG can power irrigation pumps, tractors, light-duty trucks and other equipment. A supply of LPG on site that is filled by the supplier entices small-scale farmers to purchase cleaner burning LPG farm equipment versus higher polluting diesel fueled equipment as expansion occurs.

REDC's Solar Food Preservation Facility and sustainable business model promotes gender equality. In Ethiopia, the workload in the farming industry is equally distributed amongst men and women, [2,] but very few women are small-scale farmers. [2] Usually small-scale farmers grow crops, transport the crops long distances by truck, horse, mule and or on the backs of humans to sell the goods at markets. [1, 2, 20]

Compensation for travel expense doesn't exist.[2, 20] After traveling long distances the small-scale farmer is at the mercy of "market prices". With fluctuating market prices daily, small-scale farmers travel with their crops and make the decision to sell the crops at the current market value upon arrival. Women rarely ever make the trek to markets to sell crops. Long trips away from the home are frowned upon, so, mothers stay close to the home. [2] Quite often, women who own farm land rely upon others (usually men) to make these important business decisions. [2] Grocery stores in populated areas rely upon imported fruits, vegetables, roots and tubers for their customers during non-harvesting periods. With REDC's Solar Food Preservation Facility and sustainable business model women can now play a major role as small-scale farmers. Food vendors, supermarkets and small grocery stores travel out to farming communities to purchase the locally grown year-round fresh nutritious food and the farmer sets his or her price for their food supply. The tradition of rural community members traveling to outside communities for nutritious food during non-harvesting periods sends hard earned money out of the community. Our approach creates business-to-business relationships that drive money into the rural farming communities and keeps locally generated revenue inside of the community. The result: expanding farming business, more jobs, reduced healthcare costs, increased household incomes and a stronger, healthier community.

Project Design/Technical Approach

REDC has already began designing, fabricating, and testing our proof of concept prototype ahead of schedule. REDC has paid for all of the equipment, labor, and travel costs associated with our prototype's research & development up to this point. With excellent test results already, REDC is confident that our next steps will produce a cutting edge, reliable, clean energy technology. Over a three-year period, we will continue testing, make the system more robust, design REDC's Solar Food Preservation Facility scaled to size for our rural small-scale farming community, implement that technology in a developing country, and document all of the results.

During the first year REDC will develop our full-time working group and complete research, finish prototype designs, and construct a more robust prototype. During the harvesting season our team will travel to our selected farming community in Ethiopia in order to document the already-in-place small-scale farmer's business model, community health, jobs, education level of family members, the number of homes in the community, combined household incomes and how many children are under the age of 14.

Entering the second year our group will begin to design REDC's Solar Food Preservation Facility to scale. Utilizing the information gathered in the developing nation about the small-scale farmer's plot size(s) (potential co-op system), and the predicted quantities of food produced each harvesting period, our design team will design a system and estimate those costs those costs accordingly. Vendors who possess the proper equipment, skills and abilities to implement REDC's technology scaled to size will be asked to submit a cost proposal based on designs provided by the REDC group. REDC will select vendors, coordinate travel arrangements and implement REDC's Solar Food Preservation Facility. Our group will deploy to Ethiopia for a period of one month. Individuals will make up five teams consisting of Sustainable Farming, Business, Cold Storage, Solar Heating and Root Cellar. The entire group will provide training to the small-scale farmer(s) participating in our project. The farmer(s) will be educated, trained and supplied with a reference guide that explains how to maintain and operate the entire preservation system, how to implement new composting practices and planting techniques, execute new business-to-business relationships and how to track and relay information about the business model back to REDC effectively. While in country we will make contact with food distributers, vendors, and grocery markets for the farmer and discuss the new preservation abilities of the small-scale farmers and how those abilities benefit their business models.

In the third year REDC will monitor the progress of the operations through scheduled weekly/bi-weekly communications with our farmer(s). To understand the benefits of REDC Solar Food Preservation Facility and sustainable business model we will compare the incoming data to our survey results. While gathering results REDC will begin to deploy our second project and prepare for widespread implementation.

Six months into the third year of operations REDC will conduct a site visit during the harvesting period and document the results of our first installation. Finally, REDC will utilize all of our gathered data about REDC's Solar Food Preservation Facility and sustainable farming business model to develop a vocational trade program that educates and trains the youth for a Sustainable Farming Industry.

REDC does not foresee any social, economic, environmental, legal, or regulatory complications when introducing our Solar Food Preservation Facility. For example, when REDC targets Ethiopia, the agriculture industry is shared by men and women equally and our education and training program will conform to the standard practices in place today. The nation of Ethiopia owns all of its land and leases their land as a source of income. This business model is unsustainable due to a majority of Ethiopia's farming industry depending upon "Green Revolution" farming practices. Almost half of Ethiopia's fertile soils have been subject to degradation, erosion and rendered useless. [20] Ethiopia can expect more land to be rendered useless if nothing is done. Our approach creates a sustainable business model for Ethiopia's Land Lease Program. New sources of revenue are generated and continuously grow as the farmer's business expands in the future. Ethiopia's valuable soils and revenues are protected; soil degradation, erosion and deforestation is reduced with our sustainable business model, even while facing the impacts of a rapidly changing climate and increasing populations.

Business/Financial Viability

REDC's Solar Food Preservation Facility and sustainable business model can revolutionize the current "Green Revolution" farming industry in Ethiopia. Millions of small-scale farmers provide 95% of the agriculture in Ethiopia today,[2] making up 47% of the country's gross domestic product.[2, 20] Our technology and business model will help small-scale farmers become more productive and profitable. Small-scale farmers understand the farming business and will understand the advantages our technology and business model brings to his/her farm. The technology is reliable, simple to operate, and increases the profitability of the farmer's already in-place business, thus motivating the farmer, non-government organizations (NGO's) and financial lending institutions to invest into REDC's technology. Helping farmers preserve and store food short and long-term, incentivizes financial institutions to finance our technology to small-scale farmers who cannot afford to pay for the installation and equipment costs up-front. A financing program allows the farmer to transition into growth without feeling the costs associated with the installation and technology in the early stages of implementation. As production increases the costs associated with the technology will be minimal to farmers. With widespread implementation of our technology a new financing opportunity for banks is created.

REDC's Solar Food Preservation Facility benefits those nations and NGOs who provide humanitarian assistance for nations in need. NGO's such as United Nations, Food and Agriculture Organization, World Health Organization, World Food Program, International Fund for Agriculture Development and many others all benefit. These are our customers and billions of dollars (USD) are spent fighting the world's most pressing issues each year. In 2015 the United Nations introduced the Sustainable Development Goals (SDGs) for the world, which focus on completing the 17 SDGs by the year 2030. REDC's Solar

Food Preservation Facility, sustainable business model, and workforce development training program help our customers reach 11 of the 17 SDG's. More developed nations spend billions of dollars annually in humanitarian aid. REDC's Solar Food Preservation Facility and sustainable business model helps developing nations reduce their dependency on foreign aid. A report by the Business and Sustainable Development Commission concluded that the Sustainable Development Goals open up $12 trillion (USD) by 2030 for the private sector and potentially 2 to 3 times more. Four target markets were discussed; energy, cities, agriculture, and health. REDC's Solar Food Preservation Facility and sustainable business model aligns well with these investments. [21]

REDC's Sustainable Food Industry Workforce Development Program was designed to mimic a successful business model and company, Kirby Vacuums. In the United States Kirby Vacuum sales reps traveled door to door marketing their company, selling their products and educating their customers about the benefits of their vacuums. Our Sustainable Food Industry Workforce Development Program mimics this same door-to-door business approach. Our workforce travels out to the rural farming community to market, sell and educate our end use customer about the benefits REDC's technology provides his/her community versus waiting for the customer to travel to a store is a much better business approach. The door-to-door approach helps REDC reach our end use customer direct, it quickly generates income for our workforce and it reduces warehouse and retail store costs, which increase the up-front costs of our technology to the small-scale farmer. The targeted market approach also helps REDC reach widespread implementation much faster, thus generating large amounts of revenue in a shorter amount of time. As the business of farming expands and begins to turn a substantial profit the business owner can now invest into irrigation and other farming tools that boost agriculture production even more. Our workforces trusted relationships won't be forgotten and REDC will again benefit from the fast paced growth of its Sustainable Farming Industry.

Ninety three percent of Ethiopia's population is below the age of 54.[3] Forty four percent are below the age of 14 [3] and are the future of Ethiopia. It's this generation who will become the engine and workforce that drives REDC's Solar Food Preservation Facility towards widespread implementation. Women and men will learn a new trade: REDC's Sustainable Food Industry. Students will learn the importance of the agriculture value chain, food preservation, sustainable farming practices, as well as how to market, sell, install, maintain and repair REDC's Solar Food Preservation Facility and finally earn a living wage to escape poverty. REDC will provide each of our in country non-profit organizations with the tools needed for educating and training our workforce. The tools will consist of educational material about the technologies that make up our technology, proper installation procedures, the tools and equipment needed for repetitive assembly of our technology and eventually the clients in need of our systems. As students and faculty become confident with the topics covered in REDC's Sustainable Farming Industry Workforce Development Program, students will begin classroom education and hands-on training. After confidence is built through analysis, design, and development, students then move to outside the classroom training to practice implementation. Interaction between the client and student will take place in order for the student to get a grasp of how to transfer their learned knowledge to the farmer such as, how to operate REDC's Solar Food Preservation Facility, benefits of the technology, new farming practices to preserve lands, and how to expand business operations. The hands-on learning approach along with inside and outside classroom training will prepare the young tradesmen and women for widespread implementation of our technology.

Educating and training a workforce is a key component to the long-term success of an industry. By developing a young workforce that understands the market, the technology, the technology's payback periods and advantages the technology brings to the entire agriculture value chain is crucial.

For years REDC has had to conduct research and development without the proper staff or funding. For the past 7 years REDC has conducted research, developed new clean energy technologies and demonstrated their proof of concept with very limited resources and help.

The total estimated costs associated with the research and development of REDC's Solar Food Preservation Facility and Sustainable Food Industry Workforce Development Program is $1,000,000 USD. The funds will provide 4 qualified individuals to be hired by REDC full-time to accomplish our tasks set in our technical approach. Funding will also pay for REDC's corporate and state taxes (depending on final location of REDC's corporate headquarters), corporate liability insurance, employee health insurance, business needs (patent, trade marking, office space, office equipment, telephone, internet, internet security, website, and legal fees), travel to and from Ethiopia (all employees), room and board (1 month), food (1 month), in country travel (1 month) and any other costs associated with the three year project and the start-up business needs of REDC.

Organizational Capacity

Kelly Fetters is a clean energy visionary and entrepreneur. He's the founder and owner of Renewable Energy Design Concepts Llc. (REDC). Kelly invents clean energy technologies and business models that create a new Sustainable Food Industry for many developing nations throughout sub-Saharan Africa and South Asia. He attended Centralia College in Centralia, WA and finished his education at The Evergreen State College in Olympia, WA where he researched, tested, developed and authored The Evergreen State College "Bamboo Hydropower Project". While completing the scientific project he invented the bamboo coupling (allows bamboo to be coupled together for miles if needed), bamboo light stick (flashlight), and flange that allows a low-cost centrifugal pump to become a Micro-hydropower turbine. He is the Author of the "Solar Food Preservation Facility" and inventor of REDC's Solar Food Preservation Facility and sustainable business model; REDC's heating technologies, REDC's Hydrokinetic Prime Mover and REDC's Safe Drinking Water Distribution System.

REDC is a for profit social enterprise. REDC manufactures and distributes our clean energy technologies to our workforce distribution centers that reside in those developing nations who participate in our Sustainable Food Industry Workforce Development Programs. REDC's brand-new clean energy technologies and ground-breaking business models create healthy, farming communities for developing nations. The benefits are immense; jobs are created that help the youth and small-scale farming community's climb out of poverty, while malnourishment, health care costs associated with malnutrition, stunting, hunger, food insecurity, soil degradation, pollution, deforestation and unsafe drinking water are reduced.

REDC separates itself from competitors with our workforce and business model, but REDC takes it one step further. REDC rewards its customers for using technologies that benefit the environment. REDC's volunteer Renewable Energy, Energy Efficiency and Carbon Sequestering Credit Program offer a simple solution for any entity wanting to offset their carbon footprint. Governments, NGOs, non-profit organizations, and for profit corporations can all offset their carbon footprint, while benefitting humanity at the same time. Participating entities sign legal contracts, purchase credits, and REDC disperses the funds to the owner of REDC's clean energy technologies (banks, NGO's and/or the small-scale farmer) annually. The program helps reduce financing risk, reduce pay-back periods for equipment, installations and maintenance, it helps expands the small-scale farmer's business model quickly and it entices developing nations and investors to support energy technologies and farming practices that benefit the environment.

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