The VersaCook Stove

An Improved Cookstove for the Developing World

Hayden Fetter, *Project Manager*

Tatiana Sreenivasan, *Logistics Manager*

Ryan Flynn, *Financial Manager*

Wills Bird, *CAD & Manufacturing Engineer*

Tom Hart, *Test & Systems Engineer*

Dr. Paul Ibanez, *Director*

The Progress of Our Project

Around the world about three billion people currently rely on burning solid fuels like wood and agricultural byproducts for cooking and heat. Most consumers live in rural and low income areas, where typical cooking methods produce significant smoke, and in many cases very little ventilation is available. These conditions result in an estimated four million deaths per year from indoor air pollution. Additionally, traditional cooking methods do not use fuel efficiently, thus depleting the surrounding environment more quickly and costing the world over two trillion dollars per year in associated costs.

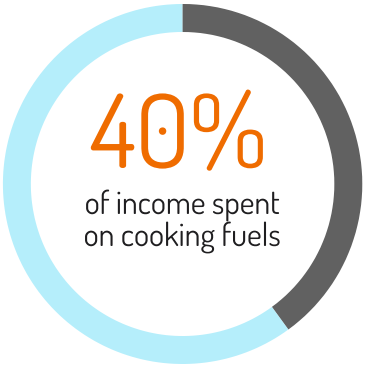
While many improved cook stove designs have been distributed throughout African and Asian regions, very few have made their way to Central America, where the majority of people also cook indoors. Most of the alternative stove designs marketed in these regions require batch loading, don't account for local cooking methods and foods, or produce excess emissions that pollute homes and the environment.This is why PurBurn developed the VersaCook stove.

The VersaCook Stove

- ✓ Reduces carbon emissions
- ✓ Griddle cooktop
- ✓ Adjustable airflow to combustion chamber
- ✓ Continuous fuel loading
- ✓ Chimney for ventilation
- ✓ Thermoelectric power generation

The Problem

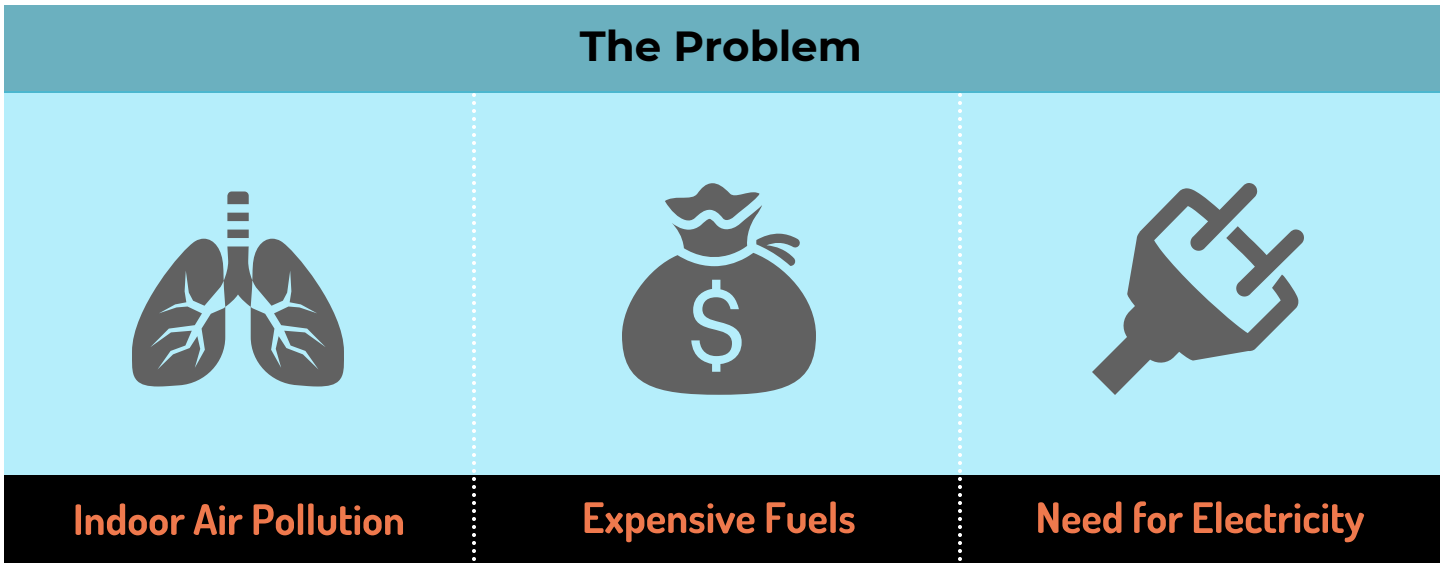
Indoor air pollution is a huge problem in the developing world, causing an estimated 3.8 million deaths every year that can be prevented. Traditional cooking methods and the popular alternative, rocket stoves, produce significant amounts of smoke and damage the health of users. Furthermore, women and children are disproportionately impacted. In Central America alone, 15.5% of children suffer from asthma and similar respiratory problems.



Even in the developing world, fuel for cooking does not come cheap. Fuel costs range from $50 to $70 a month. A typical family can spend up to 40% of their income on cooking fuel. Because of the high costs, families will often choose to gather their fuel instead, but this burdens many women and children with hours of additional preparation for each meal. This lost time reduces productivity and exacerbates the inequality women in these regions face. It is also common for children to drop out of school at a young age in order to help with these chores, directly contributing to a cycle of poverty. Despite education being compulsory and provided free by the government in Guatemala, students spend only **4.1 years in school** on average.

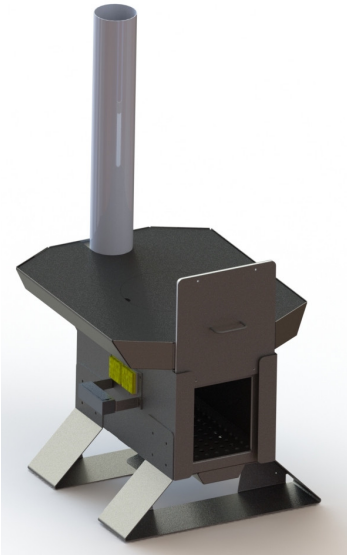
The need for physical labor isn't the end of it. While more than 80% of the global population has access to power on a regular basis, Central America is prone to cyclones and extreme weather conditions – both of which compromise electricity infrastructure. Central America's Atlantic coast saw 30 named storms, 13 of which were hurricanes, within the past year. Reports from these storms show **80% of electricity infrastructure was damaged**. These weather conditions can easily cause power outages and problems for those who cannot afford a generator. As a result, there is a demand for off-the-grid electricity production.

In the Clean Cooking Alliance Catalog, there are 452 stoves on the market, however, only 43 household-sized, wood-fuel, improved stoves are available in select parts of Latin America. In our countries of interest – Guatemala, Honduras, and Nicaragua – there are zero gasifiers, zero stoves with thermoelectric power generation, and only a handful with a griddle cooktop. Gasifying stoves perform best for reducing indoor air pollution, though they are not readily available to the communities in Latin America that need them. According to the Clean Cooking Alliance Catalog, even if they were able to import a stove from another country, there is not a single gasifying, griddle stove on the market in the world. The people in these countries don't want to change the way they cook. They need a stove that will improve their health, save them money, and provide electricity without having to forfeit their traditions of cooking family meals on a griddle cooktop.



Our Solution

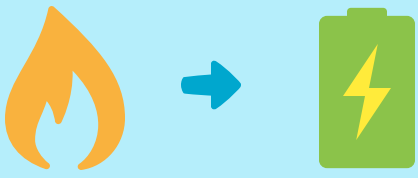
The VersaCook Stove



The VersaCook would be the first **gasifying griddle stove** on the market. Through gasifying fuel in a two step process, the stove significantly reduces both fuel consumption and harmful emissions. By burning fuel in a limited oxygen environment, a regulated flow of combustible gas is produced. This gas joins with a separate stream of fresh air above the fuel – here the two streams are mixed and fully combusted. Gasification yields high fuel efficiency because the controlled production of wood gas prevents the mixture from becoming too fuel rich. This process also means the VersaCook emits significantly fewer particulates and harmful gases when compared to traditional stoves. With the addition of a chimney the combustion emissions can be directed outside the home, thus **reducing indoor air pollution**.

Existing improved cook stoves utilize a batch loading technique where additional fuel cannot be added once the stove has started. The VersaCook has removed this problem by implementing a sliding door at the front of the stove which enables **continuous fuel feed** into the stove without having to interrupt the cooking process. As a result, women can begin cooking with a smaller amount of fuel while children gather more, saving time on fuel collection. Additionally, the griddle surface allows users in Central America to continue cooking their traditional meals with established techniques. Additionally, the VersaCook **produces electricity** using two thermoelectric power generators (TEG) mounted to its side.

How does a TEG work?



They convert waste heat from the stove into usable electric power with the Seebeck Effect.

The VersaCook Stove has prioritized a simple manufacturing and assembly process. All of the components for the inner and outer stove body are constructed of sheet metal with as few bends as needed. The chimney is composed of off-the-shelf vent piping that can easily be customized for each user's home. The chimney in our prototype is straight up for ease of emissions testing. The stove our consumers would receive with be fit with a flexible chimney for seamless integration into their homes. The only components that require machining are the TEG electronics housing parts which can be produced on a basic 3-axis mill.

The VersaCook can be assembled with a series of tack welds along each seam to ensure a sturdy and reliable product. The exterior of the stove receives a coat of high temperature paint to reduce the likelihood of rust and corrosion and to extend the products lifespan. An initial prototype has been produced by ProtoCase and members of PurBurn on CU's campus. Moving forward, the team plans to work with non-governmental organizations, such as Stove Team International, to begin manufacturing in Central America. Utilizing manufacturers local to our customers will help to stimulate their economy and greatly reduce import and shipping costs.

The VersaCook's robust but simple to manufacture design will ensure a well functioning product for years to come.

Market Opportunity

The largest hurdle for our competitors is getting their potential customer to know about their product. Our competitors mass produce their stoves and do their best to market their products – a strategy that does not advantage communities in the developing world. This is why the VersaCook Stove is composed of **100% sheet metal** parts. The materials to build the stove can be easily sourced and manufactured, this allows us to hire manufacturers in many different cities. This, in turn, leads to word-of-mouth marketing, turning PurBurn into a household brand.

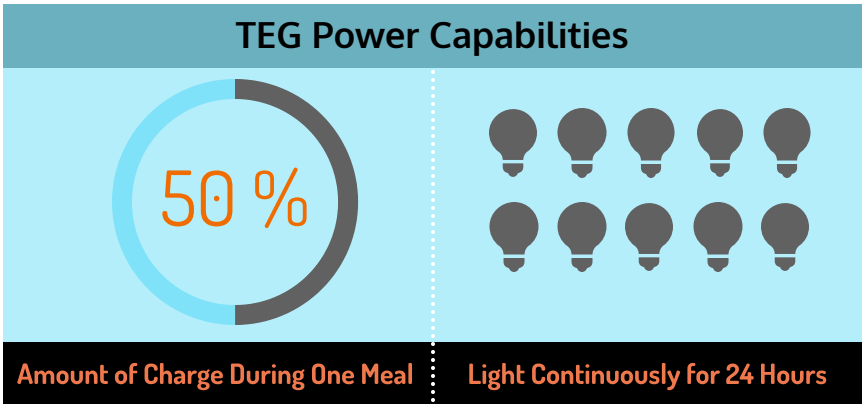
Nearly four billion people worldwide rely on open fires or inefficient stoves to cook their meals everyday. These practices use solid fuels that are not burned efficiently which risks the health and safety of women and children when they cook. PurBurn is targeting remote and isolated communities in Central America – specifically, **Nicaragua, Honduras, and Guatemala** where the average household income is $12.50 USD per day. This region has an untapped market for improved cook stoves (ICS), and a large percentage of the population is affected by household air pollution. Due to the high number of people that rely on solid fuel cooking and the lack of distributed ICS, there is a niche for the VersaCook Stove with room to grow beyond the specified target countries.

A projected unit cost of $175 and assuming 10% market penetration.

Our Users

Based on the product unit cost, $175 USD, and the average household in our target countries, $12.50 USD daily, PurBurn will establish as payment plan with Stove Team International to help our potential customers afford their VersaCook stove. The plan will feature seven payments of $25 USD, allowing the stove to be fully paid off in just six months.

Furthermore, the VersaCook stove offers users the ability to charge devices or power lights with off-the-grid electricity – an increasingly important utility for families in Central America. In 2020 alone, 13 hurricanes hit the Atlantic coasts of Central American countries and reports claim that 80% of electricity infrastructure was damaged. Through utilizing waste heat from the combustion chamber, the TEG mounted to the VersaCook stove is expected to output a steady five volts. This power can be used to charge a phone or power several small LED lights.



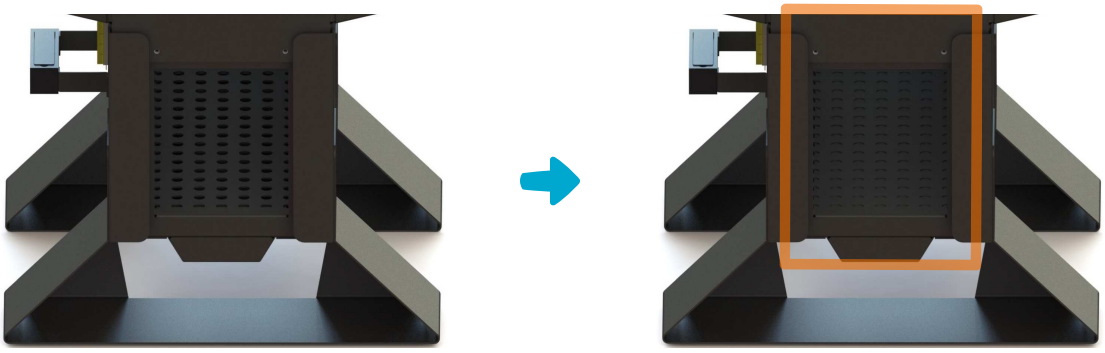
Testing Highlights & Key Findings

After initial assembly, the team embarked on a rigorous testing procedure which evaluated key performance metrics of the stove including combustion emissions, boil time, maximum temperatures, and combustion efficiency. Several pseudo-user tests were also performed to collect qualitative data including ease and intuitiveness of use, which were paramount to the goals of the design.

During initial tests, the stove was slow to start because there was not enough fuel in the combustion chamber – this was increased and yielded positive results. After start-up, the stove emitted low emissions and little particulate matter. Small puffs of smoke were emitted each time the door was opened to reload fuel, however clean operation resumed quickly after. We also observed changes in particulate emissions with adjustments in the airflow tray, with the cleanest burn achieved at the most restricted setting, as intended.

Relatively little charcoal was left in the fuel chamber at the end of operation thus, the stove was achieving gasification, but not as successfully as intended. Too much intake air was coming in direct contact with the fuel. Feedback from experts in the field of improved cookstove development and testing helped the team identify several changes which would ultimately improve the performance of the stove. To protect the company's intellectual property, the specifics of these changes will not be discussed here.

Leaks between the panels at the bottom of the stove were found to prevent complete air cutoff to the fuel, resulting in a large portion of the charcoal burning during operation. After modifying the assembly to tighten these gaps, minimum airflow was achieved, resulting in the wood remaining as charcoal throughout cooking. Small gaps that remained in the airflow tray itself prevented charcoal from extinguishing after gasification was completed, meaning the stove required two hours to cool down fully. An additional plate was placed directly underneath the fuel tray, cutting off all primary airflow; this enabled burning fuel to be quickly extinguished leaving large amounts of unburned charcoal from the stove.



Without Plate

With Plate

After adding the solid plate under the fuel, combustion stopped almost immediately, but residual heat in the stove caused the fuel to release wood-gas for several minutes. Attempts to reignite the gases above the fuel were unsuccessful. We believe this is due to the **secondary combustion zone** – the area above the fuel – being too large and resulting in the gas flow not being concentrated enough for reliable combustion. Currently ignition of the wood-gas relies on primary combustion inside the fuel, which results in increased particulate emissions. Implementing this design change would be extremely straightforward, but would require remaking the combustion chamber wall panels.

Ryan Flynn

Financial Manager

Ryan is graduating with a BS in Mechanical Engineering. With a passion for auto racing, he has several years experience fabricating custom parts and building cars. Ryan also has internship experience in plastic injection molding and ADAS vehicle diagnostics.

Tatiana Sreenivasan

Logistics Manager

Tatiana is graduating with a BS in Mechanical Engineering. She will be working toward a PhD in Education and Psychology with the goal of impacting her local government through educational policy and curriculum reform. She is a practicing yogi, an avid rock climber, and has a passion for helping people.

Hayden Fetter

Project Manager

Hayden is graduating with a BS in Mechanical Engineering, a certificate in Engineering Management, and a minor in Philosophy. Hayden has two years of experience in forensic mechanical investigation at Jensen Hughes. After graduation, Hayden will be pursuing a MS in Forensic Investigation at Cranfield University in England.

Tom Hart

Test & Systems Engineer

Tom is graduating with a BS in Mechanical Engineering and a minor in Electrical Engineering. He is passionate about design and sustainability, and is experienced with SolidWorks and Fusion 360 CAD packages, as well as several programming languages. He also has experience working as a machinist at an aerospace contractor.

Wills Bird

CAD & Manufacturing Engineer

Wills is graduating with a BS in Mechanical Engineering. He is a certified SolidWorks Associate with internship experience at a small manufacturing facility. He has additional experience rebuilding engines and working on motorcycles. Wills is very passionate about engineering and has a deep love of all things outdoors.

Looking Forward

We aimed to produce an improved cook stove that was unique, inexpensive, efficient, easy to use, reduced emissions, and generated electricity. Preliminary tests show that we have successfully reached all of our goals. The VersaCook will be one of the few griddle gasifiers on the market and the only one that incorporates a TEG for power generation. The flat cooktop provides our customers in Central America with a familiar cooking experience – ensuring that the stove is easy to use. With a well-designed sheet metal construction, the VersaCook can enter the market at a competitive price point. Additionally, the increased efficiency compared to traditional cooking methods can save families $400 per year on fuel costs.

PurBurn will soon complete testing our first prototype and our primary goal moving forward is to iterate upon and refine our current design.

Our Ask

PurBurn is a team devoted to making an impact on the lives of Central Americans and are seeking to make connections and build relationships in the countries of interest. If you would like to know more about how our product can make an impact or if you or someone you know could help us take our product to the next level please reach out to Ryan Flynn.

ryan.j.flynn@colorado.edu