United States Naval Academy
Multidisciplinary Engineering Design Program

Low-Cost Residential Power Generation System

Design and build a power generation prototype from cheap locally or readily-available materials

Students

Andrew Bergman	Mechanical Engineering
Hugh Ehrensbeck	Mechanical Engineering
Andrew Julius	Mechanical Engineering
Buba'A Norbert	Electrical Engineering
Gary Watson	Electrical Engineering

Faculty Advisors

LCDR Ethan Lust	EME
Asst. Prof. Hatem ElBidweihy	ECE
LT Jed Lomax	ECE
LT Cory McLaughlin	EME

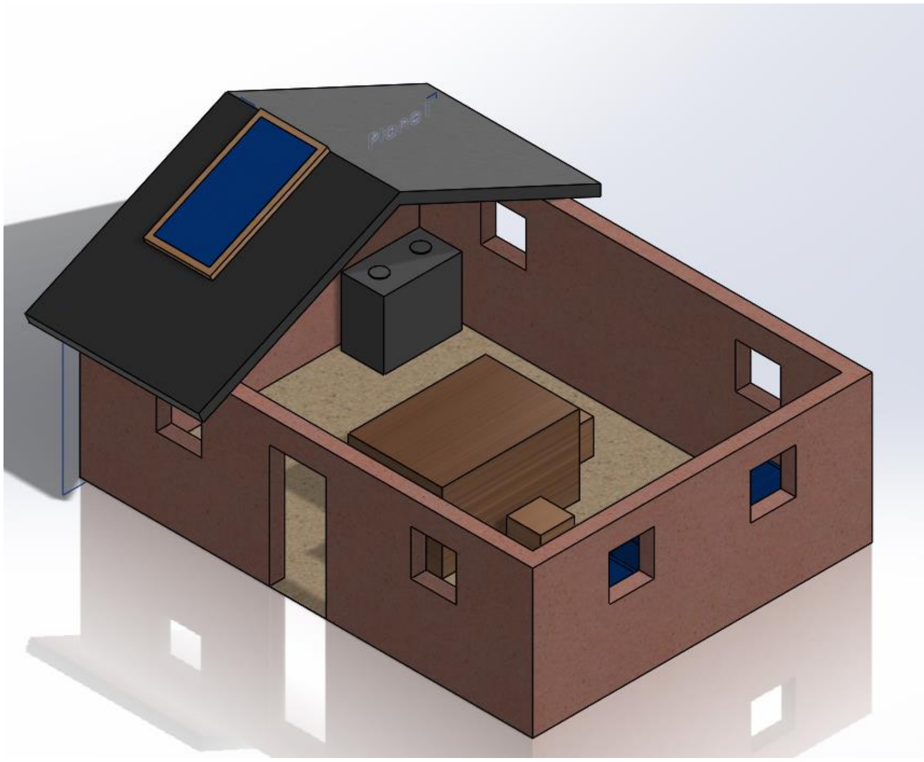
Introduction: As energy demand around the world increases, there is a growing demand for low-cost, locally-generated power. Small scale energy harvesting systems currently exist, however they are expensive, precluding wide-scale adoption in many regions throughout the world. Access to power has a direct impact on quality of life.

Problem Statement: Design and test a low-cost, renewable power system to provide residential power for households in Ile-a-Vache, Haiti. Specifically, the system should be capable of recharging two cell phones, and power four light bulbs for three hours per day.

The target cost is $36 for the entire system, equivalent to a monthly charge of $3 for the current system which features a central solar charging station and battery rental. Another goal for the project is that it should be the locus of an economically-sustainable business model with the potential to promote local manufacturing from local and imported materials.

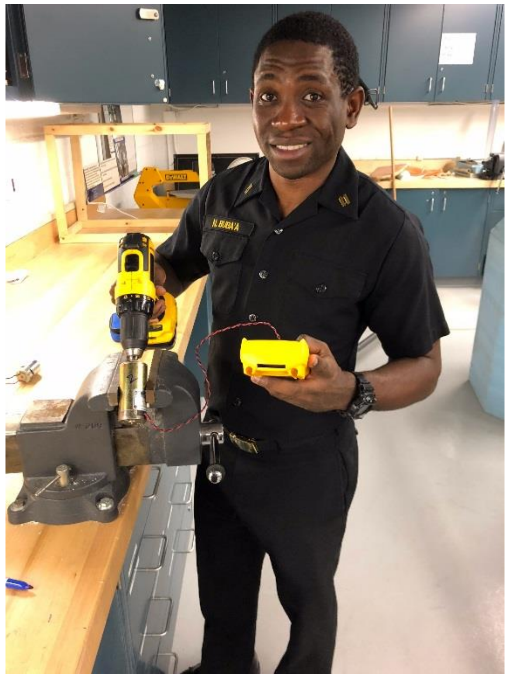
Progress to Date: The team has interviewed Mr. Jean-Patrick Lucien, the founder and director of the EDEM Foundation in order to define the customer. The team originally developed and modeled two design concepts for power generation systems: a solar photo-voltaic and a wind turbine power generation system. Market competitors for each of these systems were purchased and tested in order to attain realistic target values for system performance as well as to provide detailed, accurate lists of necessary components.

After significant testing, modeling, and analysis, the team decided to focus on the solar photo-voltaic design in the coming semester, specifically on how panels can be manufactured simply and cheaply from a minimum number of imported components.



Solar panel design on typical home in Ile-a-Vache, Haiti.

The team will be constructing and testing a standard, flat, 1.5 m^2 solar panel design. A set of component tests and integration tests have been developed to test the effectiveness of the solar panel design. A computer-aided design (CAD) rendering of the system on a typical house in Ile-a-Vache is shown above.



Wind turbine generator testing.

The team (from left to right):
Norbert Buba'A, Andrew Bergman, Andrew Julius, Gary Watson, and Hugh Ehrensbeck.

United States Naval Academy
Multidisciplinary Engineering Design Program

Sustainable Farm Power
Convert Resources Available from Agriculture
to Cooking Fuel for a Farm on the Island of Ile-a-Vache, Haiti

Team Members

MIDN 1/C Aidan Ball	Mechanical Engineering
MIDN 1/C Colin Ball	Mechanical Engineering
MIDN 1/C Logan Dyer	Systems Engineering
MIDN 1/C Paco Figueroa	Mechanical Engineering
MIDN 1/C Ace Padilla	Mechanical Engineering
MIDN 1/C Nik Schaeffer	Mechanical Engineering
MIDN 2/C Katie Wesdyk	Mechanical Engineering

Faculty Advisors

LCDR Ethan Lust	Mechanical Engineering
Prof. Patrick Caton	Mechanical Engineering

Customer/Sponsor

Amazal Jean Yvres	Mayor, Ile-a-Vache, Haiti
Jean-Patrick Lucien	Director, EDEM Foundation

Introduction: Ile-a-Vache is a small island inhabited by approximately 15,000 people off the southern coast of Haiti (Figure 1).

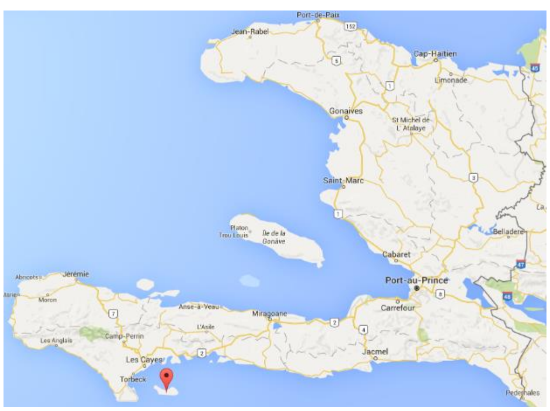


Figure 1: The location of Ile-a-Vache, Haiti (marked with the red indicator).[1]

[1] Google Maps.

Like many communities in the developing world, food security is a critical issue. USNA is currently partnering with the EDEM Foundation (www.edem2.org) to provide technical assistance to the mayor of the island of Ile-a-Vache, Haiti, Mr. Amazal Jean Yvres. One of the many efforts of the mayor with assistance from the EDEM Foundation is to provide food security for the island through the development of sustainable agriculture. The Foundation currently operates one two-acre farm on the island (Figure 2) that grows a variety of dietary staples including beans, peppers, and plantains. The Foundation also has several livestock operations including cows and chickens which contribute greatly to local food security and economic development on the island.

Figure 2: The EDEM Farm on Ile-a-Vache (photo: LCDR Lust).

Background: A variety of products and materials must be imported to the island, including fuel and charcoal. These are typically delivered to the island via small, open boat and once on the island over unimproved roads. It is a labor-intensive logistical process. Lessening the associated burden by using resources available on the island could potentially provide a significant improvement to local quality of life. To that end, Mr. Lucien would like to explore options for power production using locally-sourced, renewable resources.

In addition to the need for power, there is also a need to provide improved sanitation services, both waste management and sewer. Biodigestion, or the conversion of organic materials into methane gas, is a potentially suitable option providing both cooking gas and waste management.

Objectives: The goal of this project is to design, test, and implement a biodigestion system to serve as a testbed to build local familiarity with the technology and assess the feasibility of implementing such a system on a wider scale. The system is to be installed at the EDEM farm using agricultural waste as well has household waste and sewer from the farm workers.

Progress to Date: After speaking with the customer, Mr. Lucien, the developed a list of customer requirements, which were translated into measurable or observable engineering characteristics by which to assess system performance. Gathering information about the technology, the team, shown below in Figure 3, first met with local experts at the Beltsville Agricultural Research Center (BARC).

Figure 3: The Watts to Do Team at the BARC

The team will conduct both lab and field-scale testing. Figures 4 and 5 show team members cleaning and preparing the lab for upcoming experiments. Lab-scale experiments will be conducted to familiarize students with the process of making, monitoring, and handling biogas.

Figure 4: Ace in action in the lab

Figure 5: Paco in action in the lab

Field-scale experiments will be conducted on an existing system, shown in Figure 6. These experiments will provide the students with familiarity with the system. They will include a measurement system to verify product performance. The ultimate goal of field-scale testing is to provide plans and a bill of materials for a low-cost system to be implemented on the farm in Ile-a-Vache.

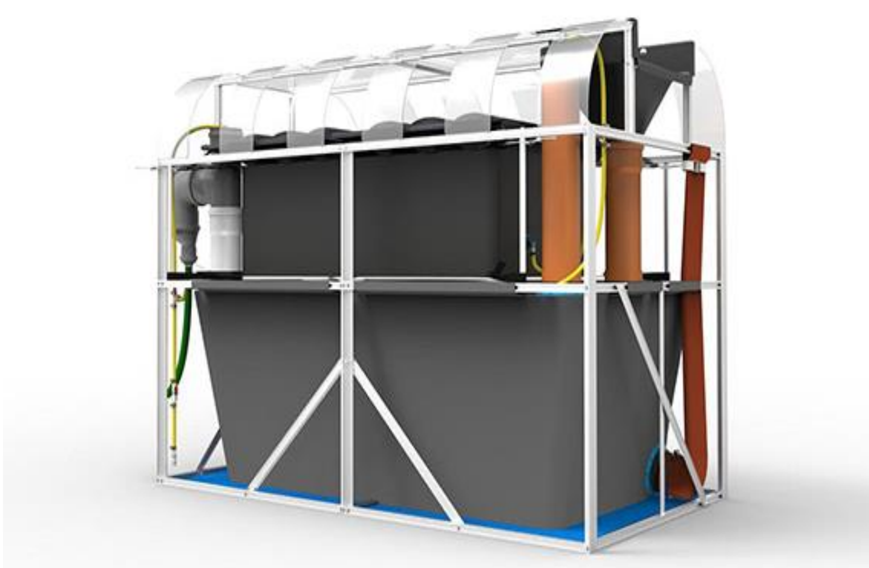


Figure 6: HomeBiogas system[2]

[2] https://homebiogas.com/shop/buy-the-homebiogas-system/

United States Naval Academy
Multidisciplinary Engineering Design Program

Improved Cinder Block Press
Increase production rate and decrease effort in making concrete masonry units for Ile-a-Vache, Haiti

Students

Samuel Davis	Mechanical Engineering	Purchaser
Luke Dodds	Mechanical Engineering	Technical Support Detachment
Connor Mcnerney	Mechanical Engineering	Safety Officer
Blake Stanford	Mechanical Engineering	Team Leader
Taylor Yohe	Mechanical Engineering	Design Communication Editor

Faculty Advisors

LT J.M. Olson	Mechanical Engineering	Civil Engineer
Prof. R. Link	Mechanical Engineering	Mechanical Engineer

Introduction: Ile-a-Vache is a small island of approximately 15,000 people off the southern coast of Haiti. USNA is currently partnering with the EDEM Foundation (www.edem2.org) to provide technical assistance to the mayor of the island, Mr. Amazal Jean Yvres. One of the many efforts of the mayor, with assistance from the EDEM Foundation, is to provide an improved means of cinderblock production.

Background: During a recent hurricane, Hurricane Matthew, many homes on the island of Ile-a-Vache were damaged or destroyed. As with many places in the developing world, dwellings are often made of earthen bricks. The current method of creating these earthen bricks or concrete masonry units (CMUs) as they are sometimes called, is slow and “back-breaking” according to Jean-Patrick Lucien, the founder and director of the EDEM Foundation and the client for the project.

Improved methods and devices currently exist but are typically either 1) powered by an external source such as a generator, which is undesirable due to the difficulty of getting fuel to the island, or 2) only produce one block at a time. For reference, it takes between 800-1200 bricks to make a home - clearly a very time-intensive process. The goal of this project is to design and develop a cinderblock production device or system that reduces the required labor to make bricks, improves production rate, and improves brick quality.

Progress to Date: The team interviewed Mr. Lucien, in order to create a list of customer requirements for the design. These requirements include a specified minimum strength of the bricks, that it be human-powered, that it produces bricks efficiently, that it not be a burden on the user’s back, that it be weather-resistant, and that it be usable with no training required.

Each member of the team developed a design concept using a variety of design methods and from those a single design was selected. A computer-aided design (CAD) rendering is shown in Figure 1. Material is shoveled into the CMU molds, shown in the lower portion of Figure 1a and pressed, as shown in Figure 1b. The CMUs exit the mechanism from beneath and the whole system is wheeled backward, leaving the newly-made CMUs to dry in preparation for the process to start again.

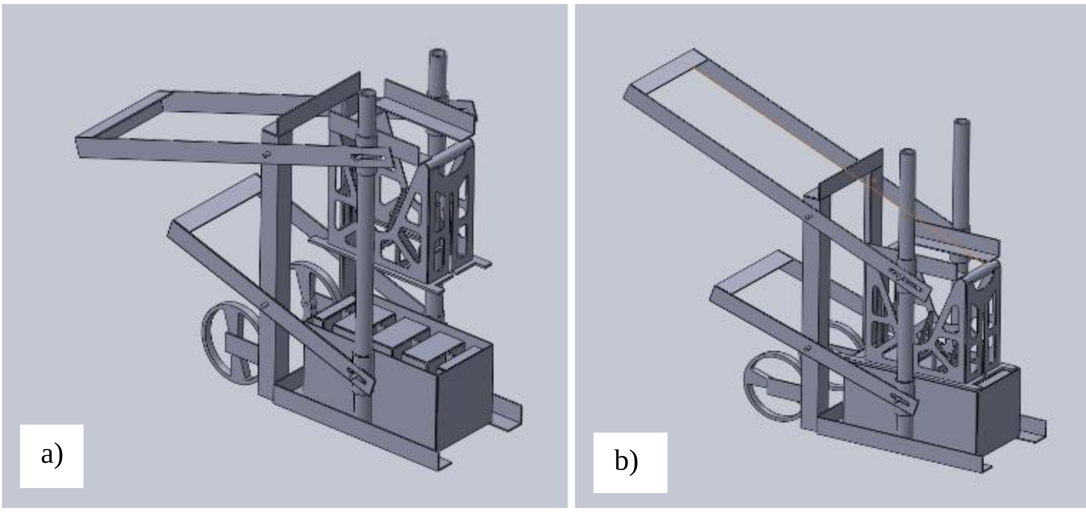


Figure 1: a) the system in loading configuration, b) the system in compression configuration.

Over the next several months a number of tests will be conducted including component and integration testing of the system itself as well as testing of brick composition and strength. The results of initial CMU manufacturing tests are shown in Figure 2.

Figure 2: Familiarization testing of CMUs.