Design for Emerging Markets Project
EDSGN 100- Section 022
Dr. Ritter
Fall 2015

SPIN STREAM
4½ Star Engineers

From Left to Right: Josh Lamond, Zeid Qubain, Jack Sheehan, Mohammad AlKhazraji
**Mission Statement:**

To design solutions and manufacture products or services that will provide energy to customers in need, especially in poverty stricken areas such as Sierra Leone. This first sentence is the mission statement for our company and what has driven our designs and actions as a project group. We were given the task to design an innovative method to charge a cell phone in areas that do not readily have access to electricity. Some requirements were that the product should be ruggedized to operate in harsh environments and also inexpensive at less than ten dollars per customer. The idea was to use some sort of alternative energy and find a process in order to be able to convert that source of energy into electricity that can charge a cell phone.

**Concept Development Summary:**

The first step was to research the area of interest that the team would be designing for. We decided to focus on Sierra Leone and we had a few main conclusions from our research. Arguably the most important part of our research was to confirm that this problem is prevalent enough to validate designing a solution to the problem. What we found was, according to the CIA World Factbook, Sierra Leone has around 4.8 million mobile phones, in other words 83 out of each 100 residents has a mobile phone (1). This, combined with the idea that their main source of fuel is biomass, proves there is an obvious power crisis. This was evidence enough for our team to continue designing a solution for consumers. Being that Sierra Leone was previously plagued with slavery our product could not be detrimental to the society surrounding it and the team would need to take extra care to design around this history. Other takeaways we obtained were that Sierra Leone as a country has an above average yearly rainfall as well as the geography of the land slopes down toward the Atlantic coast (1). Finally in researching different sources of alternative energy we found that solar energy was generally inefficient and this was confirmed
by experiments conducted in class. This research was something we kept in mind throughout the entire design process.

After analyzing the problem presented to us and researching Sierra Leone, we started brainstorming possible solutions to the problem. Shown in Figures one through three are some of our initial ideas. We then narrowed our broad selection of somewhere around twenty designs down to the three best options. This was achieved through group discussions in which we took into consideration the basic needs of the customer and what we felt were the best solutions to the problem. In Figures four through six are our three best solutions to the problem given. The alternative sources consisted of solar, hydroelectric, and kinetic energy. We then took our narrowed selection and completed a Design Selection Matrix, shown in Table 1 below, to determine how our ideas ranked against one another based upon customer criteria.

Figure 1: This pictures displays one of our fist sketches to capture the mechanical energy of a human riding a bicycle.

Figure 1: Shown here is the idea of capturing the mechanical energy a person uses when fishing through a gearing system attached to the fishing reel.

Figure 3: The above graphic shows a gearing system attached to the oars on a rowboat and the idea is capture some kinetic energy from the person in order to charge a cell phone.
Table 1: The table below shows the design selection matrix completed. “A” represents the weighted score given to each design on how well it would fulfill each criteria on a scale of one to six. We then multiplied this by the weighting we gave each criteria, also on a scale of one to six to obtain value “B”. The total weighted score is a sum of all of the “B” values across each row. What we then concluded from this matrix is that the solar station would have been the best solution to the problem we were given. However, as a group we decided that the hydroelectric

Figure 4: Shown is a drawing of a lamp post like figure with solar panels on top and charging phones on a lower shelf. This concept was for the charging station in the final product.

Figure 4: This is the first drawing of our final concept and shows a fan like blade that is powered by moving water. The energy captured would be converted into electricity to charge a cell phone.

Figure 4: This displays a bicycle with a gearing mechanism attached to capture some energy from the human riding it in order to charge a cell phone.
turbine was what we wanted to continue with and prototype. We overruled the matrix due to the idea that moving water has a lot of kinetic energy and the specific area we would be designing for contained numerous available waterways.

<table>
<thead>
<tr>
<th>User Need/Constraint (weighting)</th>
<th>Functional (6)</th>
<th>Durable (4.5)</th>
<th>Ease of Use (4)</th>
<th>Cost (5)</th>
<th>Efficient (4.5)</th>
<th>Cultural Acceptability (3)</th>
<th>Total (weighted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gearing on Bicycle</td>
<td>3/ 18</td>
<td>3/ 13.5</td>
<td>2/ 8</td>
<td>4/ 20</td>
<td>2/ 9</td>
<td>4/12</td>
<td>80.5</td>
</tr>
<tr>
<td>Solar Station</td>
<td>4.5/ 27</td>
<td>4/ 18</td>
<td>4/ 16</td>
<td>2/ 10</td>
<td>3/ 13.5</td>
<td>4/12</td>
<td>96.5</td>
</tr>
</tbody>
</table>

After completing the matrix and weighing in on all of our different design options, the matrix evaluated that the solar charging station was the best option to fit the consumer needs. Based on the matrix, our design team should have followed through with the design of a solar charging station. However, after reevaluating the matrix and the advantages and disadvantages it has, we decided as a team that the hydroelectric turbine would be the most suitable option for our customer. As a group we then continued with these 6 criteria to refine and improve our idea to further fulfill the customer needs.
Test Report Summary for Prototype #1:

Once we finalized our idea we began our first prototype. The team started drawing out general sketches to refer to in order to design the first model of the product shown in Figure 7.

Table 1: This table organizes the criteria testing and results that occurred for prototype one.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Test</th>
<th>Result</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality (blades turning)</td>
<td>Test if the blades would turn. Turning with minimal friction was considered passing.</td>
<td>The blades turned with minimal amount of energy input.</td>
<td>Pass</td>
</tr>
<tr>
<td>Durability</td>
<td>Drop the prototype at 6 feet (almost 1.8 meters).</td>
<td>Some of the blades became disabled when the prototype was dropped.</td>
<td>Failure</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>Determine if classmates could understand how the product generally operated.</td>
<td>Asked to rate from 1-5 how easy the product is to understand. Average= 4.53</td>
<td>Pass</td>
</tr>
<tr>
<td>Cost</td>
<td>Research if the product meets the &lt;$10 goal.</td>
<td>Product was found to be well less than $10 *</td>
<td>Pass</td>
</tr>
<tr>
<td>Efficient</td>
<td>Conduct research to determine energy efficiency. Goal was 95% efficiency.</td>
<td>The product could not reach that minimum value.</td>
<td>Failure</td>
</tr>
<tr>
<td>Culturally Acceptable</td>
<td>Obtain a 90% acceptance rate.</td>
<td>100% of those interviewed accepted product. *</td>
<td>Pass</td>
</tr>
</tbody>
</table>

* Error margin necessary or possibly misleading. Explained in testing report.
Afterwards we continued with the criteria listed earlier to evaluate our first prototype in its effectiveness at meeting these criteria. The results shown in Table 1 were promising. They allowed us to conclude that the graphics, shown later in Figure 10, along with the prototype itself, were beneficial in explaining the product. The results marked with asterisks in the table are possibly misleading as there is a difference between the audience interviewed and the targeted consumers. Overall this testing helped the group identify the advantages and disadvantages of the first prototype.

From this stage of prototyping we needed to conduct research as to whether this first prototype would be substantial enough to meet the energy needs of our potential customers. We found that a typical dam can produce 3,000,000 kWh per year. A typical phone such as the Nokia 3210 uses 0.444 kWh to charge per year, if the user charges it 8 times per month, this means that our product would need to produce six millionths of the power that an average dam does (2,3). Based on the calculations that we have, this would be feasible for our final product but not the first prototype. The changes made from the first prototype to the final product will be displayed and explained later. At this point we knew that the first prototype was not substantial enough for our customer in many ways.

Further research was done to begin formulating what the actual product could be constructed of as scrap wood, cardboard and hot glue were obviously just for display purposes. The spin-stream’s base frame would be made out of cottonwood and red mangroves trees which are naturally light and therefore buoyant as well. Those components are found in Sierra Leone which means that they will be inherently resistant to local weather patterns in the area. This will provide a more durable product and also increases the length of life cycle of the product.
Moreover, the other parts would be imported to the location that the people live in. It is cheaper for these specialized parts to be imported because the materials are more easily accessed and manufactured in other countries. The product would be durable and lightweight to make assembly and transportation of components easier. The method of construction for the frame would depend on the users’ preferences. It could be latched together using rope or bolted together using power tools. This would give customers options in buying to either have the product be more durable or less expensive. Overall the first prototype was successful to convey the general idea and allow for more progression. Throughout the rest of the project there were still many changes and improvements that needed to be implemented.

**Concept Refinement Summary:**

After presenting our first prototype, the design team was reminded to always consider the customer needs in the design process and this is what drove the changes from prototype one to two. The main difference being that prototype two had curved metal blades which created a larger surface area to contact the water and therefore increase the efficiency of the turbine (4). In addition, the base logs were made to be round as it more correctly displays the final proposal of the product and is more applicable in this manner. To try and saw a round log in half, vertically, to obtain a flat side is difficult in general. To achieve this in a majority of targeted customer regions would be an extreme challenge and only increase costs. Another important issue was the charging station; the first prototype lacked a certain level of safety for the customer phones and protection from the outside environment. The second prototype provided shelter from environmental factors by providing cover from above and concealment for each charging socket. This adds the benefit of protecting a user’s phone from being stolen as well. The new design of
the charging station allowed for the internalization of all wiring and electronics which is an obvious improvement as electronics degrade quickly when exposed to the environment. These improvements amplified the efficiency, lengthened the life cycle, and enlarged the applicability of the product.

**Test Report Summary for Prototype #2:**

The main advantage of the second prototype would be the increased efficiency of the system as this was one aspect of concern in the first prototype. An aspect to consider in the blade design is its resistivity to rotate. With the blades being constructed of lightweight aluminum or plastic on top of now having a curved blade, the system will easily revolve from the power associated with the water current. Additionally we lowered the connection point of the blade spindle on the upright beams to effectively lower the center of gravity and make the assembly more stable in the water. This again increases the amount of area of the blade that comes in contact with the water. The next refinement came in the charging station positioned on land. The first design lacked certain safety measures for the cellular devices against the natural environment and theft. The refined prototype included slots for cellular devices to be housed in and could be

*Figure 6:* This picture shows the initial stage of our second prototype. It displays the main frame the assembly will float on as well as the refined blade design.

*Figure 7:* This picture displays our second stage of prototype two. This is more closely related to what the final product will consist of.
locked additionally if theft was of concern to the customer. The charging station would further be tested against the different weather patterns that are common to areas we have interest in selling. As far as Sierra Leone is concerned, the prototype would be matched against humidity, heat, and high winds. Considerations will be made for the summer, monsoon, season when heavy rains fall spanning from May to December (5).

**Cost Analysis:**

What we’ve determined as a project group is that our product could be scaled to fit the needs of any customer. It could be built to the size of an Alaskan fish wheel or to the size of a laptop. For analysis purposes we will discuss a larger scale project, which we estimate will be more expensive per family than a smaller installment. This means that the cost will vary depending on the situation it is to be instituted in. On a large scale product the wood that will be used for the design will be brought from the area’s natural growing trees. This is cost effective due to the use of natural resources available and also reduces import costs. On a smaller scale project more plastics will be used to construct the product and it would be sold in its entirety. In addition, we will be using aluminum for our blade design which is priced at $0.70 per square foot (6). When considering the amount of material and labor required it would cost around $201.60 for the blade assembly.

Another perspective of the labor cost is the installment team. The majority of the labor will be provided by people of the tribe with the guidance of a small group of experts. This will again reduce costs for our consumer. Experts will receive $50 a day for food on top of the costs for their sleeping arrangements. We estimate they will need to be on site for 3-4 days which results in around $1000. As for the blade construction we will outsource the machining and then
import the parts to the site. Outsourcing manufacturing will help to reduce the cost of labor and will increase our company’s flexibility (7). The size of the product as a whole will be very customizable according to what the users need and can afford. For our current customers (Village of Mende Tribe) the total cost of constructing the blades is about $300-400. In addition, we would also need a generator which will be $349 for a 4,400 Watt generator that would convert the energy gathered into electrical energy.

Lastly the shipping of the product to Sierra Leone would be the part that is most expensive. According to our calculation using a rate calculator from parcelbound.com, shipping will cost $1,400 to Sierra Leone. The numbers were calculated by inputting the weight and the dimensions of the product that will be shipped and the program determined the shipping costs. For larger shipments shipping would be cheaper to reserve a large metal shipping container on a cargo ship to import a large amount of product. However, overall the shipping would be the largest expense for the company per product.

The village that we will be focusing on consists of 100 families which correlates to a maximum of $1000 the customer will spend based upon the $10 criteria set for the project. Our product as a whole would cost more than that limit at around $2500 total; however, there are possibilities to make the product cheaper which will be discussed later in the report. On average the cost has been estimated to $17/ family. As stated previously the cost will vary depending on the actual power output of the product which determines the number of customers it can support. Finally the price to the customer will vary depending on how many consumers can access the product in a given area, and for the same reason this could increase or decrease the price per family.
User Guides:

The users of the product will be given Figure 10 as a drawing to help them understand how the product will fit into their society. In the graph the users will have a reference to how the product would be placed; in addition, it also shows general concepts of operations and context for the product. Another important aspect of the informative guides for the customers will come in the form of a team of experts on site to manage construction of the product. Representatives from our company will give specific instructions to ensure it is built correctly and to proportion in order to satisfy the customer needs. Accompanying this team will be a translator, if needed, to enable locals to clearly understand instructions given from our team. In total we will have verbal, visual, and in person methods of communication to convey the idea to the customer. This protects against excess misunderstanding and failure to express our message appropriately.

Re-Design Ideas/Thoughts:

One of the important ways that we can improve upon the second prototype is to use cheaper materials that would still output the same amount of power. Furthermore, we can decrease the number of blades which will decrease the cost of our product. Possibly construct the blades in a sturdier manner which will consequently increase the output of power even with fewer blades. The HESE students gave feedback more in the form of questions than direct changes we could make to the design. As a team we were asked how our product will be...
specifically anchored in the water as well as how reliable the water flow is in the country. From this we could further define our product by adding posts that could be driven into the riverbed or eyelets on the upright beams that could be tied off to both banks. Both options would effectively prevent the product from floating downstream and being destroyed. Additionally we would need to conduct further research to analyze the fluctuation of water flow throughout the year. If the fluctuation is large enough the installment may call for a battery to store energy that can be tapped into when the water flow is below par.

Overall we valued the education from working on a project like this. It provided us a good opportunity to start working as a team early on in our collegiate careers. We do have a few critiques for the project. We would’ve liked to have been given the final report rubric early on so we could’ve collected more information and stored it for the final report along the way. This would’ve allowed for an easier compilation of the progress throughout each step of the process and documentation could have been taken as well. In addition we would have liked more time to prototype our first physical concept as it was slightly rushed which is understandable as there is a lot of curriculum to get through. Overall we felt the project was a beneficial way to learn the design process and it was something that could potentially be implemented through HESE as well which was a good collaboration.

References:

   <https://www.cia.gov.html>

   <http://www.indiabizclub.com>


