International Development Design Summit

KNUST, Kumasi , Ghana 2011

The Chargers:
Off-Grid Cell Phone Charging

Introduction

We advise villages on how to set up a cell phone charging system. Our clients are the 30% of Ghanaians (7.5 million) that have cell phone coverage, but do not have access to the national electrical grid.

The Team

AKINSHEYE: Born in the South Bronx and raised in the Virgin Islands. His name is from the Yuraba Tribe in Nigeria, but he has no contact with that country. Why? He is an aeronautical engineer, but never built planes. Why? He is not from Ghana but he travels there often. Why?

CHANTHAN: Born and raised in Phnom Penh, Cambodia, Chanthan is studying Electrical and Telecommunication Engineering at the Institute of Technology of Cambodia (ITC). Chanthan is also known to be very very handsome.

MARIANA: Mariana was born and raised in Brazil. She graduated from the University of Sao Paulo in 2011 in Electrical Engineer a couple of days before she went to Ghana for IDDS 2011. Thinks everything is NICE.

MENSAH: Born and raised in Wenchi in the Brong Ahafo region of Ghana. Had his basic and secondary education in Wenchi, continued at the Ghana Institute of Management and public administration to study ICT. Worked in the music industry for a while, and currently works with the Methodist Church Ghana. Hobbies: soccer and practicing to become Cambodian.

FABIANO: Technician in structural projects, Sao Paulo Brasil civil engineering student, president of NGO Familia Ines. Hobby: capoeira.

LAURA: Enjoys groundnuts, avocado, coconut and mangoes. Does not enjoy mosquitoes. Hopes one day to be as awesome as Chanthan.

OSCAR (MENTOR): Born in Barcelona, Spain, raised between Puerto Rico and Spain until he went to MIT in 1990 and stayed there for 13 years studying Electrical Engineering and Computer Science. He has been a professor at Olin College since 2005. He managed to not get bitten by any mosquitoes while in Ghana, and thoroughly enjoyed the night sky.

The Problem

In many rural villages in Ghana the access to cell phone coverage is outpacing the development of the national electric grid. Access to cell phones has driven the demand for cheap available power. Over 70% of Ghanaian villages do not have power, yet many of them are covered by the ever widening cell phone tower coverage.

In one village we spoke to people who are paying almost 8 times more on charging cell phones than they do for talk time.

Solution

Building on the ideas from villagers in Asampu, our team developed a cell phone charger which can be created and maintained in villages. The majority of the parts are available inside the village while the remaining parts (car phone chargers, 12-volt car battery) can be obtained in nearby towns. The charger uses power from a car battery that can be recharged using local transportation, such as partnering with tro-tro and truck drivers to swap batteries on a weekly basis. This solution frees villagers from the burden of traveling to another town to charge their phone and it will give them a safe option that will protect their battery from damage while saving money.

Needs Assessment

Cell phone charging

In Asampu. a village without electricity, there are three main ways that people charge their phones.

1. Send it to town to a friend who can charge it there. Cost: free
2. Pay the generator owner in the villager to recharge the phone. Customers are concerned that the irregular generator voltage harms their battery.
   Cost: 50p/charge
3. Use cheap D-cell batteries in series to recharge phone batteries. ~35p/charge

Cars at the village

One option for recharging car batteries is vehicles that visit the village. We saw 3 vehicles daily during our stay in Asampu: two trucks and one tro-tro, they all use 12-volt car batteries. (The trucks use 2 12-volt batteries in series.)

One of the trucks comes every day from Tuabodom, he stays near Asampu for about 6 hours, and then takes the tomatoes back to sell in the markets. The other truck comes from Inchira from Monday to Thursday. He buys yams and corn and take it to Kumasi.

The tro-tro comes every day from Monday to Friday. The driver/ owner lives nearby in Agena. He comes to Asampu in the morning, and takes passengers to Offuman or Techiman, depending on which market day it is. He returns in the evening around 5-6 pm.

We spoke to all three drivers to ask how much they would charge for recharging a car battery. We offered 3-5 cedis for a recharge, but they consistently insisted they would do it for free because they perceive the service is no extra cost to them.

Needs Assessment

Christina

Christina lives in Asampu, a village without electricity. She cooks breakfast to sell and she uses the lights from an LED flash light to work before the sunrise.

She charges her cell phone using D-cells. She has had her phone for one year now and charges it every 3 days.

Christina spends around 8 Ghana Cedis in talk time per year and around 37 Ghana Cedis to charge her phone.

Gordon

Gordon, who lives in the same village as Christina, builds has found one solution for charging cell phone batteries safely and conveniently. His solution, pictured above, uses locally available parts and is cheaper than other charging options.

His dream solution is a car battery with a cell phone connection adapter. He would charge the car battery in the nearest village with electricity for 1 Ghana cedi ($0.67 US).

Design Requirements

Customer need	What will you measure?	How will you measure it?	Good value	Better value
Price	Cost/ cell phone recharge	Charging price	50 p (standard charging price)	30 p (less than charging with D Cells)
Battery safety	Customer satisfaction with our system not harming their cell phone batteries	Interview customers and non-customers	People think our charging system is safer than using a generator	People think our charging system is safer than using D-cell batteries
Distance traveled	Distance from our charger to our average customer	Village size and location of charging station	Less than 30 min walking	Less than 10 min walking

The Product:
Car Battery Phone Charger

The Charger

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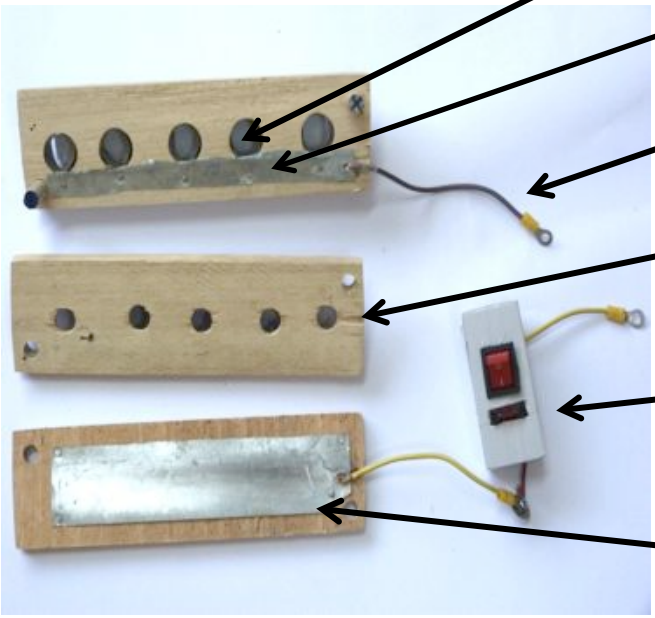

Each hole has metal inside that connects to the negative metal strip.

Negative metal strip. A small piece of roofing tin works well.

This wire connects negative metal strip to the negative side of the car battery.

Protective layer of wood that separates the positive and negative metal strips.

15 amp car fuse and switch connected in series. The wire connects to the positive side of the battery.

Positive metal strip inside on the bottom of the charger.

The System

The holes are sized to fit a car charger. Car chargers can be purchased in town for 1-2 Ghana cedis each.

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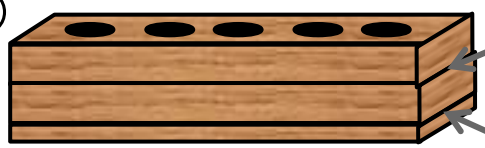


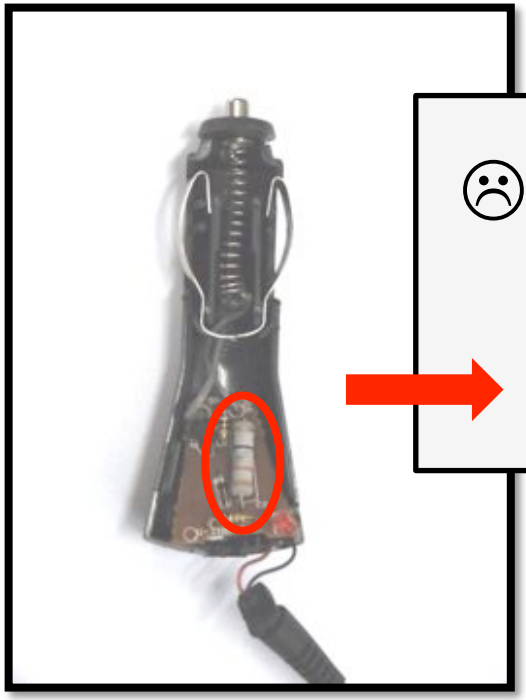
Negative metal strip inside

Positive metal strip inside

This piece of metal must touch the negative metal strip.

This piece of metal must touch the positive metal strip.

Types of Car Adaptors



☹ This type of car adaptor usually heats up when in use. It has a big resistor in the circuit board.

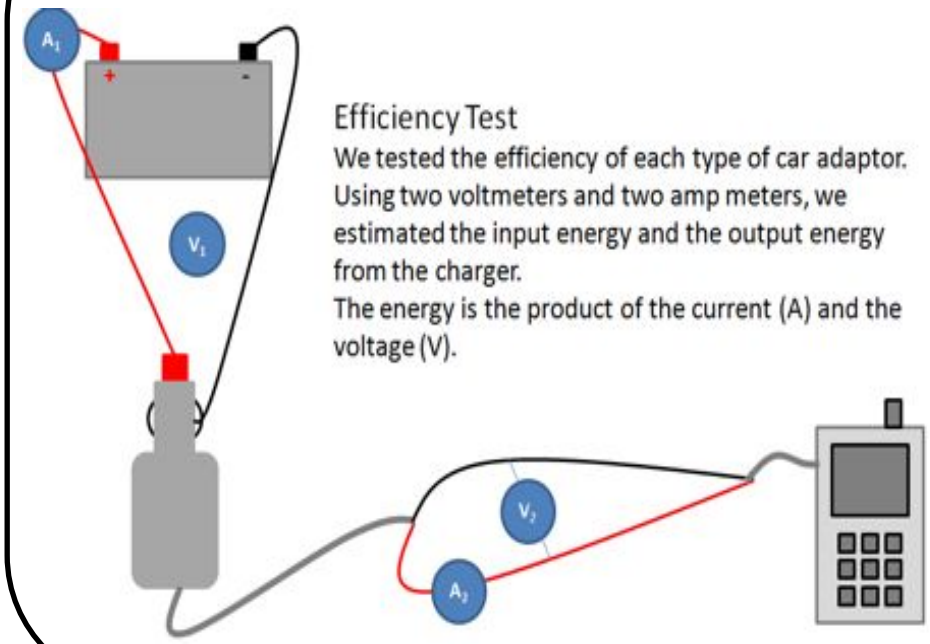
☺ This type of car adaptor doesn't heat up and has a black, square micro chip in the circuit board.

The Product - Testing

1 - Problem

There are mainly two types of car adaptors in the Ghanaian market (see previous page). One type wastes a lot of energy and will use up a car battery faster.

2- Test



Efficiency Test

We tested the efficiency of each type of car adaptor. Using two voltmeters and two amp meters, we estimated the input energy and the output energy from the charger.

The energy is the product of the current (A) and the voltage (V).

3 - Results

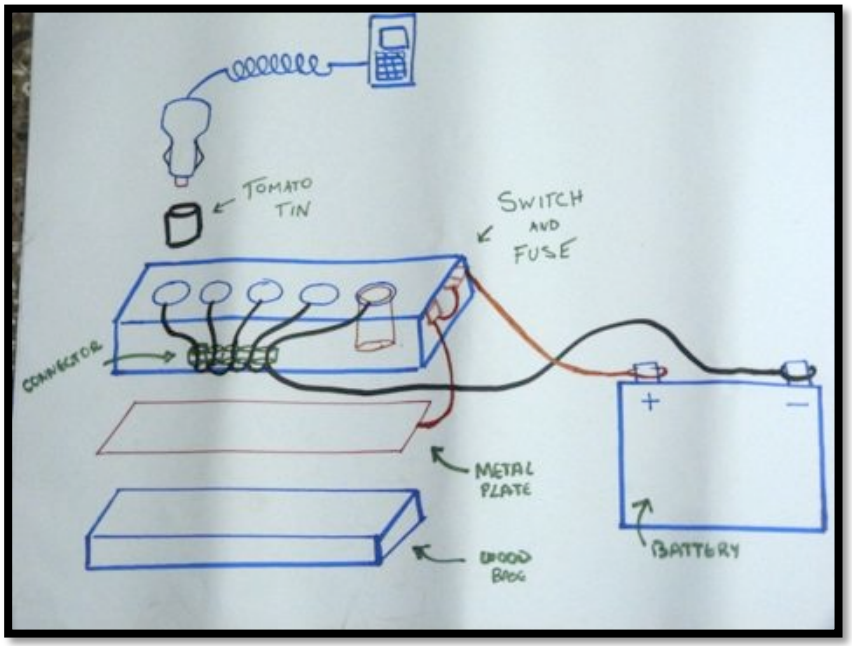
Car Adaptor Type	Efficiency
Big resistor	52% ☹
Micro Chip	85% ☺

4 - Comments

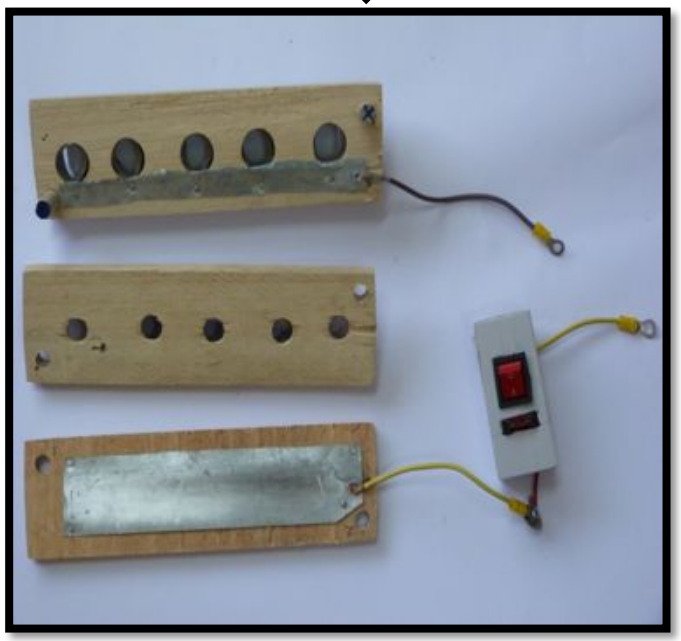
By choosing a good adaptor it is possible to charge almost twice as many phones before recharging the car battery. Also, the car battery will last almost twice as long before it needs to be replaced.

For now, the only way of knowing the type of the adaptor is by opening it and looking at the circuit board.

The Prototype



The original prototype was tested in the Asampu where we encouraged villagers to make design changes. They made the design simpler and more elegant with local materials. For example, using roofing tin instead of tomato tin, which makes better connections. Also, villagers crimped the metal to the wire instead of using solder, which is impossible in a village without electricity.



Design for [x]

Usability: The charger is designed to fit all cell phone car chargers. The car cell phone chargers are Nokia brand, but are interchangeable for many phones. In addition we have adapted a universal charger which can charge any battery that can be removed from the phone.

Manufacturing: The product was designed using local materials, some of which can be found in villages, but all can be found in the larger towns in Ghana. Each unit can be produced in the using village and therefore can be maintained locally. As we learned in Asampu, the holes can be made in a non-electrified village by heating up a metal pipe in a fire and burning it into the wood.

Affordability: The charger was duplicated by a villager in Asampu out of parts found around his home. The main cost of the system is the 12-volt battery (140-160 Ghana cedis, the rest of the parts cost about 20-40 cedis). Affordability could be improved by starting with a 6-volt motorcycle battery (30 cedis), although a different circuit is required using a LM7805 voltage regulator that can be purchased in Kumasi and perhaps other large towns.

Failure: For safety, we recommend including a car fuse in the system. The most likely failure mode is an accidental direct connection between the positive and negative battery terminals. This is called a short circuit and may cause an explosion. If a short circuit happens in the system, the fuse will break first and stop the short circuit.

Sustainability: We believe that using a rechargeable car battery is better for the environment than disposable D-Cell batteries. However, charging a phone directly from grid electricity is probably the best option from an environmental sustainability point of view.

User Feedback

"Give it to me and I'll start a business."

At the high school

The students were really excited about our prototype. It was interesting to see such strong interest in an electrical device at an agricultural school. One of the students took one look at the prototype and said, unprompted, "Give it to me and I'll start a business. However, when asked how he would set this business up, the answer was not so clear.

The Tro-tro driver

We talked to Cleytus, a Tro-tro driver and owner who drives from Techiman to Asampu from Monday to Friday on the harvest season and from Wednesday to Friday on the other months. On Saturday he rests, and on Sunday he always goes to church. Cleytus lives in Agena, a village that also does not have electricity.

We explained that we were thinking of swapping the phone charging battery with the battery in a tro-tro on a weekly basis. He said he would charge the battery in his tro tro for no cost. We insisted that he shouldn't do it for free, because someone else would make money on charging cellphones. His answer was "Why not? I'll do it for free." Surprisingly, we received very similar answers from other vehicle drivers as well.

Cleytus's tro-tro.

Village Feedback

Some of the most impressive feedback came from Donkor, a farmer who lives in Asampu. After talking to us under a tree at his village he came back 2 hours later with a prototype of his own. He used zinc (roofing tin) as conductive metal strips instead of tomato tins. The roofing tin makes a better connection than tomato tins do, and his prototype worked better than ours.

We left a battery with him for an extended trial of the prototype. He was able to charge 37 phones in 6 days (at no cost to the customers.)

He reported that he was able to charge all the phones using the Nokia pins or the universal adaptor. One of his complaints was that he didn't have enough slots to charge all the phones he wanted. The busiest hours were from 3 pm until night time. He said phones took about 1 hour to charge.

He also said he has a friend who could recharge the car battery for free. Because they are friends, Donkor pays him back by charging his phone for free.

Donkor and his own prototype

User Feedback

Charging Phones

At Manguasi, we set up our prototype and with around 20 people watching, we had 8 phones charging.

At the villages, some of the phones we could not charge because of the type of the pin since we only had two universal adaptors.

Charging the Chief's phone in Manguasi

The team at Maker Faire

At the Maker Faire

The community response at Maker Faire was really impressive. Several people asked for the list of materials to build one. We tried to design the charger so that it would be easy for other people to copy and replicate on their own. However, one woman was really insistent that she wanted to buy a prototype from us. She kept calling us on the phone until we agreed to build an extra one and sell it to her.

Frequently Asked Questions

"How can I buy a car battery?" – People who cannot afford a car battery might start with a motorcycle battery or borrow money to buy a car battery; "Why is it better than a generator?" – The voltage from a car battery is very stable and is much less likely to harm a cell phone battery, while the voltage from a generator is unstable; "How much does it cost?" – Roughly 200 cedis for the car battery and charger.

Bill of Materials

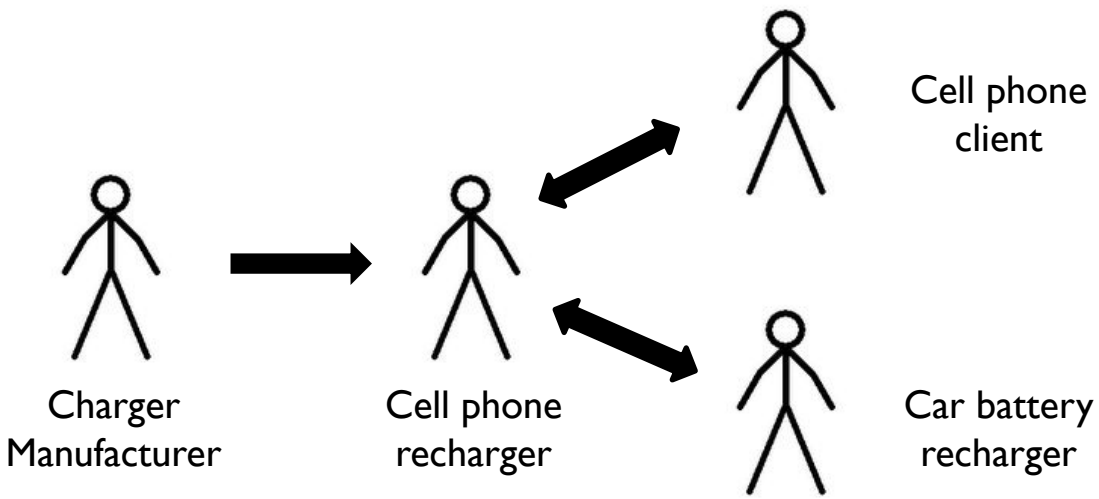
Materials	***Suppliers***	***Cost per charger (Ghana cedis)***
Zinc roofing metal	Scrap	Less than 0.20
Switch	Local hardware stores	0.50
Auto fuse holder	Suame Magazine	1.00
Fuse 15 amps	Suame Magazine	0.50
26 AWG wire Diameter .405 mm Length 30 cm	Local hardware stores or scrap	1.00
Wood 2”x4”	Scrap	
Car battery 12 volts	Automotive store	160.00
Car phone chargers	Phone stores	2.00 each 10*2.00 = 20.00
Universal chargers	Phone stores	2.00 each 5*2.00 = 10.00

The Market

In the initial phase we are deploying the prototype in Asampu. The village has 400 inhabitants and around 100 cell phones. It also seems like about half the adults we talked to in other villages like Manguasi that about half the adults had a cell phone.

About 30% of Ghanaians (7.5 million) that have cell phone coverage, but do not have access to the national electrical grid. However, Ghana is expanding access to the electrical grid. The market for cellphone charging dies almost completely in a village that becomes electrified because most people have friends that will do it for them for free.

Our team is not quite clear yet on which business model we will pursue, or which part of the value chain where we belong. However we have identified several key players, shown below



Others?

- Cellphone companies
- Microfinance institutions
- Community development organizations

Business Model and Pricing

It is clear that many people are very willing to pay 0.50 Ghana cedis to charge their phones about twice a week. However there are still many questions about how to build a network of charging systems and collect payment from them. We are looking at three possible models for moving forward.

1. **Teaching/information sharing** - We will use the prototype to teach villagers to build the charger, and leave them to purchase the battery and car cell phone chargers at the local markets. We do not expect to make a profit with this approach, but rather enable people to start their own independent charging businesses.
2. **Provide battery financing –** Teach villagers to build the charger and we finance the purchase of the battery and car cell phone chargers. The loan should be paid back in 3 – 6 months. Once the loan is paid off the villagers should use a portion of the funds for social/community projects in their villages. This model returns our capital and allows us to move to other villages with in 3-6 months and help another village. However, the market for cellphone chargers is only about one per village. This is very dispersed and expensive to manage only one charger per village.
3. **Partner with a "distributor" -** Find a local organization (either for profit business or an NGO) that is currently networked in the type of villages that can benefit from cellphone charging. We would leverage the distribution system of the third company to distribute the batteries and the charging system. We would piggyback on their distribution system and the partner would receive income or other benefits from the venture.
   a. **Microbank** – It's rare to find a market in remote villages that people are so willing to consistently pay for, regardless of the season. A phone charging system could be used as a savings tool. Once the village battery is paid off and enough is saved for the next battery, when people pay to charge, they're actually depositing money into their own account
   b. **Village fundraising** – Use a phone charger as tool for the village to raise funds for its own projects, like repairing a borehole or buying school books.

Thecapital cost of the system is $147.00 US and can be recouped in 2 – 3 months. I the village of Asampu the capital cost will be recouped in just over three months. The variable cost can be kept low buy using Trotro to charge the the care batteries at a reduced cost. Once the the car battery has been paid off the system will generate $50.00 US every month based on charging 37 phones every week. This will increase as the number of people in the village become aware of the presence of the charger and become convinced of the safety of the system.

Business Model Canvas

Key Partners

Suame Magazine
Local hardware stores
Village Chief
TroTro Drivers
TroTro Owners

Key Activities

Provide access to cell phone owners during two primary times of the day. Morning and afternoon.

Key Resources

1. Trotro driver
2. Retailer with building experience
3. Access to a local town to get supplies.

Value Proposition

We charge phones for small villages in a way that is cheaper, safer and closer to the client.

Customer Relationships

Cell phone owners pay each time they recharge their phone.

Channels

One retailer / battery charger per village.
One Trotro driver per village.

Customer Segments

Village Cell Phone users
Small Entrepreneur
Cell phone companies

Cost Structure

Variable Cost
Charging car battery ($3.30 US per charge)
Fixecd/Capital cost
Car battery and replacement ($100.00 US per 100 cycles)
Car chargers and replacement ($30.00 US for ten)
Building materials ($ 20.00 US)

Revenue Streams

Charging cell phones ($0.33 US/charge)
Asampu: 148 charges per month

Getting To The Market

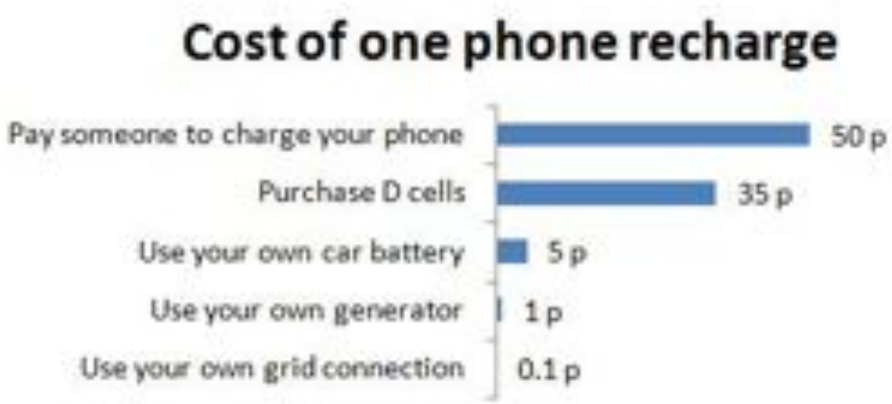
Initially the system will be distributed to the select villages that assisted in development of the prototype. Once the system has been field tested for 3 months we will review the prototype make changes and move to the next village that fits our criteria.

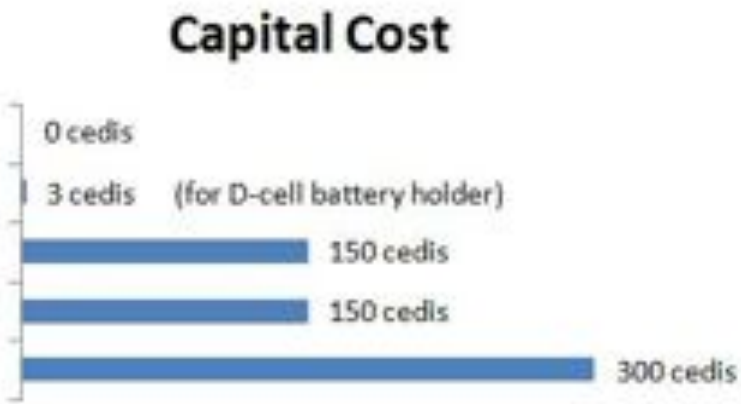
Market Alternatives

Grid charging

D cells

Generator





Although it may appear cheaper to charge phones with a generator, generators have a reputation for spoiling cell phone batteries. Furthermore, too much energy is wasted if a generator is charging a small number of phones at the same time. This is not a problem for a car battery.

Continuation Plan

The chargers will continue to work with the villagers in Asampu to refine the project. We will deliver the battery and the charging system to Asampu in August,2011. Asampu will use the income from charging phones to pay for the battery and save enough to replace the battery again when the time comes. We will continue to work with Asampu to improve the system with a focus on reducing cost and increasing the usability.

After the initial field test we intend to design a venture that can be reproduced in other villages in need of this device.

Contact Information

The Chargers can be reached at:

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