Telephone Kiosk Design Project

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1.0 Abstract

The Objective of the project is to design a telecom cell phone base station system powered by a renewable energy source, a diesel generator system, and provided sodium metal halide batteries to optimize green power. Our base station should bring power to an area that has a poor energy grid by using environmentally friendly resources. We did so by using techniques such as customer needs assessment, an external search, concept generation, concept selection, embodiment of the design and feasibility analysis, and developing a prototype. The project report includes our beginning evaluation of this criteria, our development of the solution, the research we gathered and multiple steps taken in order to create the best design, and the evaluation of different climates and background information of countries. In order to do so, we took into account the needs and expectations of General Electric in order to create our final design and criteria in which the final design embodied.

2.0 Introduction

Third world countries are implementing more telephone base stations than anywhere else in the world. Cell phone usage is increasing exponentially even though devolving countries may not have the highest GDP per capita or average income per worker. Therefore, we prioritized to choose a climate in which could support the use of alternative energy resources as well as have the resources to maintain such. The availability of cell phones to civilians could make a world of difference in any country. It is difficult to imagine not having cellular devices in America and how the country would be so severely affected by this loss. This is the same debt that third world countries suffer from on a daily basis. Therefore, it was important to choose a country in which it would truly make a difference in their each and every day lives.

It was also important to use to devise a proper alternative energy source. Some common choices are the use of solar power, hydroelectric power, wind energy and biomass resources. Solar power would require an area that is dominated by sunlight. Hydroelectric power would include an area that contains a major river or water source. Wind energy can be found in most energy and biomass would require an area of conditions such as devastated forests and high crop outputs.

Therefore, our report introduces itself with objectives, as well as a gant chart. The customer needs assessment includes the hierarchal structures, weights of criteria, and the product spec metrics. The external search includes a literature/patent search, benchmarking, and background of the location. The concept generation area includes the amount of our concepts generated, the innovativeness of the concepts, our concept classification tree, and concept classification table. The concept selection includes our incorporation of the criteria of company/social impacts, the revision and combination of concepts, and the concept screening and selection criteria. The feasibility analysis includes the sizes and operating speeds of machinery, the function of the design, the control of the optimized system, upfront and life cost estimates, yearly maintenance costs and social implications. Finally the prototype includes our solidworks model.

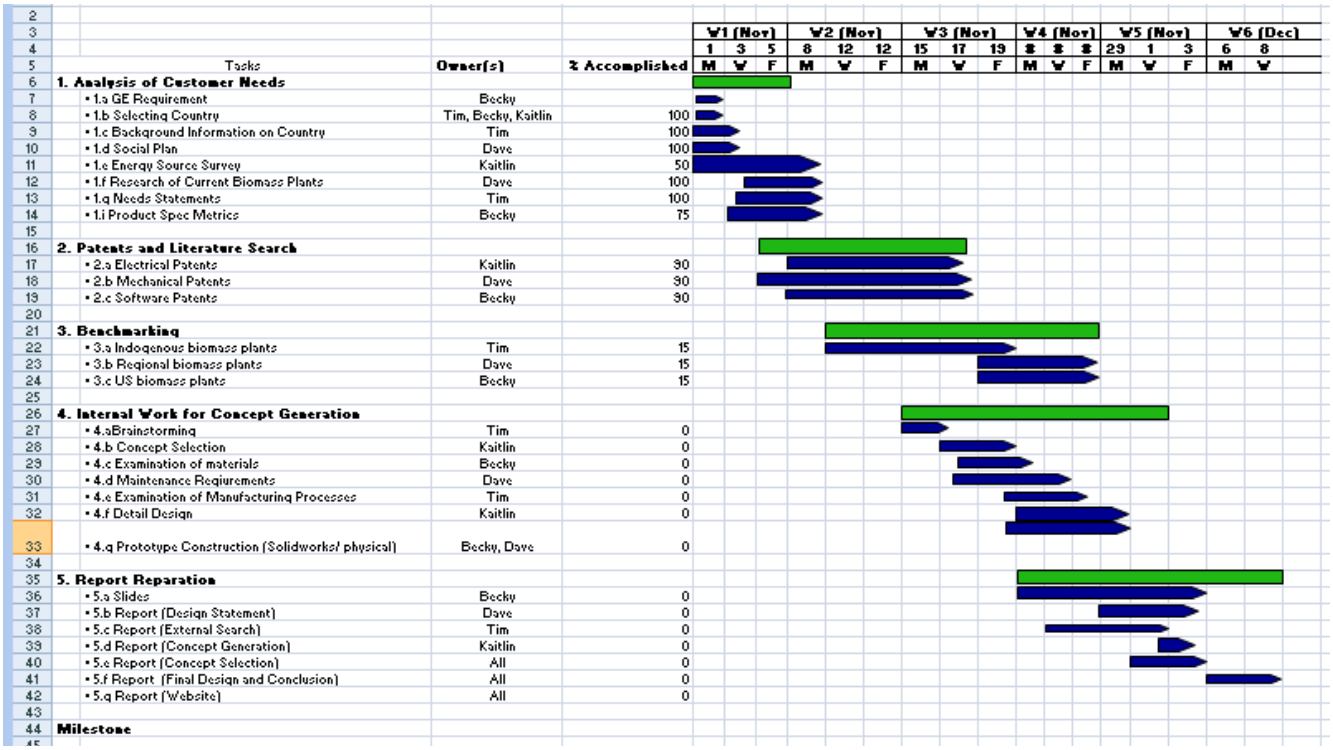
2.1 Initial Problem Statement

Design a telecom cell phone base station system that uses sustainable energy sources (e.g., solar panels, a small wind turbine, geothermal, etc.), a diesel generator system, and sodium metal halide (NaMx) battery to optimize GREEN power used to run the base station. The system should optimize available power in areas with either no energy grid or an unreliable energy grid, and also illustrate environmental benefits of replacing the typical current solutions. The design should be feasible to implement with minimal resources and reusable across developing regions.

2.2 Gantt Chart

The Gantt Chart was developed to determine a strict project schedule for our group to adhere to. It was a guideline of when certain sections of the report are supposed to be done, as well as who is doing them.

Figure 1: Gantt Chart



3.0 Mission Statement

We as the Flashdrives, strive to present the best possible product to ensure customer happiness. Our biomass fueled cell phone tower takes into account customer needs, concept generation, selection and the manufacturing process to produce the highest quality product at the lowest possible price in order to maintain General Electric's position as one of the top innovators in the world.

4.0 Customer Needs Assessment

Our customer needs were selected by putting our own ideas, along with our peers' ideas, into consideration. We sat down as a group and analyzed what we thought the most important aspects of a cell tower and are. We also asked our friends and fellow classmates their views on renewable energy sources aspects. Through these ideas, we were able to compare each aspect with each other and create criteria weights.

4.1 Weighting Customer Needs

In order to efficiently evaluate customer needs, it is important to weigh the criteria. By developing a series of analytical hierarchical charts will determine what are the most, as well as least important factors to be incorporated into the design.

AHP Comparison charts are needed to weight each category and subcategory. These charts will determine which aspects of a cell tower and energy plant are most important, and what should be considered while designing a tower and plant and ultimately selecting a final design.

Table 1. Customer Needs List Obtained from Focus Group and Individual Interviews

Maintenance
Durability
Plant Supervision
Safety
Cost
Longevity
Low Cost of Biomass Resources
Weather Resistant
Affordable to Build
Productivity
Low Pollution
Energy Efficient

Table 2. Hierarchical Customer Needs List Obtained from Focus Group and Individual Interviews

1. Cost

1.1 Affordable to Build

1.2 Maintenance

1.3 Low Cost of Biomass Resources

2. Productivity

2.1 Energy Efficient

2.2 Durability

2.3 Longevity

3. Safety

3.1 Plant Supervision

3.2 Low Pollution

3.3 Weather Resistant

Figure 2: AHP Chart determining the weighting for the main categories

Weighted AHP Chart	A	B	C	Total	Weight
Cost (A)	1.00	3.00	4.00	8.00	**0.61**
Productivity (B)	0.33	1.00	2.00	3.33	**0.26**
Safety (C)	0.20	0.50	1.00	1.70	**0.13**

Figure 3: AHP Chart to determine Cost sub-category weighting

Cost	A	B	C	Total	Weighted	Group Weighted
Low Cost of Biomass Resources (A)	1.00	0.20	0.33	1.53	0.10	**0.06**
Affordable to Build(B)	5.00	1.00	4.00	10.00	0.63	**0.38**
Maintenance (C)	3.00	0.25	1.00	4.25	0.27	**0.16**

Figure 4: AHP Chart to determine Productivity sub-category weighting

Productivity	A	B	C	Total	Weighted	Group Weighted
Durabilty (A)	1.00	2.00	0.25	3.25	0.22	**0.06**
Longevity (B)	0.50	1.00	0.20	1.70	0.11	**0.03**
Energy Efficient (C)	4.00	5.00	1.00	10.00	0.67	**0.17**

Figure 5. AHP Chart to determine Safety sub-category weighting

Safety	A	B	C	Total	Weighted	Group Weighted
Weather Resistant (A)	1.00	0.33	0.50	1.83	0.18	**0.02**
Plant Supervision (B)	3.00	1.00	2.00	5.00	0.48	**0.06**
Low Pollution (C)	2.00	0.50	1.00	3.50	0.34	**0.04**

Table 3. Weighted Hierarchal Customer Needs List Obtained from Focus Group and Individual Interviews

1. Cost (0.61, 0.61)
    - 1.1 Affordable to Build (0.38, 0.63)
    - 1.2 Maintenance (0.16, 0.27)
    - 1.3 Low Cost of Biomass Resources (0.06, 0.10)
2. Productivity (0.26, 0.26)
    - 2.1 Energy Efficient (0.17, 0.67)
    - 2.2 Durability (0.06, 0.22)
    - 2.3 Longevity (0.03, 0.11)
3. Safety (0.13, 0.13)
    - 3.1 Plant Supervision (0.06, 0.48)
    - 3.2 Low Pollution (0.04, 0.34)
    - 3.3 Weather Resistant (0.02, 0.18)

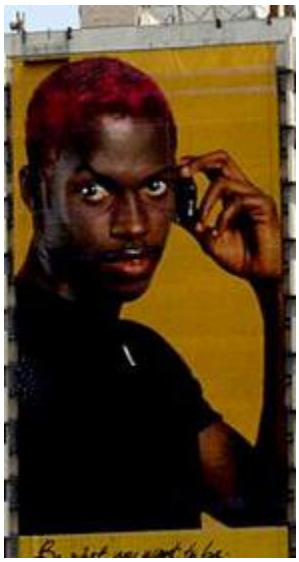
4.2 Product System Specs

Figure 6: Original Product system specs

Needs \ Metrics	Cost to build	Efficiency	Cost to produce	Average time to build
Value	20<x<40	60<x<70	5.2<x<6.7	1
Unit	$ million	%	¢/kW	years
Low cost	X		X	
Efficient		X		
Clean=no harmful bi-products				X
Durability	X		X	
Low maintenance		X		X
Weather Resistant	X	X		X
Affordability	X		X	
Safe		X		

4.3 Social Plan

The Democratic Republic of Congo is a large country located in the south center of Africa. It is a relatively large country, with 70,916,439 people living there. 34% of the population (24,111,589) lives in urban areas. Congo produces 8.217 billion kWh of electricity per year and consumes 5.997 billion kWh of electricity per year. There are only 40,000 main telephone lines (168th in the world) but there are 10.163 million mobile cellular phones in Congo. Only 7% of the country has access to electricity however, which presents a large issue. Congo has barely adequate connection/wire service for phones and an inadequate fixed-line infrastructure. This is the main issue that we as a group aim to solve. By implementing a biomass plant in the Democratic Republic of Congo, we hope to provide more electricity to all parts of the country. By granting the Congo population with this, cell phone usage will hopefully become more widespread. The electricity created from the biomass will allow mobile telephone users to have power to charge the phones, which only 7% of the population currently has.



4.4 Revised Problem Statement

After the full customer analysis of our project, we have rearranged our customer needs assessment. Cost, Productivity, and Safety were the three main subplots of our project. Among these concepts the affordability to build, energy efficiency and maintenance of the product were the three most important factors.

Taking this assessment into account we decided that if it was not cost effective it would be impossible for General Electric to buy into our product. Therefore it would need to repay itself out and must supply enough energy to the telephone base. We also decided that maintenance would be highly crucial because humans are some of the most important resources.

5.0 External Search

It is important to research all the current alternative energy power plants in order to develop the best product.

5.1 Literature Review

Our external literature search consisted of researching different telephone towers, as well as biomass plants. Through Internet research of the different already existing products, we were able to find strengths and weaknesses of each design. After benchmarking these products in a table, we found the ideas that we thought were best for our product. For example, the guyed tower was the least expensive product and produced about as much energy as needed to power our station. Also after benchmarking, we were able to compare biomass plants and telephone towers in a cost and electric output basis.

5.2 Patent Research

A patent search is important in order to recognize the kind of technology that is already out in the world and to give credit to the ones who have already designed biomass plants and telephone towers, as well as the specifications of both.
The base station will consist of an antenna that can receive beams and transform them in order to allow two-way communication between cell phone users. The biomass plant will provide the energy needed in order for the station to complete this process. The antenna will be capable of being steered in order to receive beams more easily. The receive antenna will hold the signals it is sent until it receives information to transform these signals; it will then send these to the requested destination. When the signals are received by the antenna, it transforms them into the desired signals before resending them to the new destination.

Patent US6463301 is for a base station that will use the energy from the biomass plant in order to transform the beams it is sent. Patent US5303240 is for the transmission of signals between cell phones. The base station will consist of a steerable antenna to provide more reliable service, as seen in Patent US7006040. Patent US7065373 allows for the antenna to face one direction when receiving a signal and another direction when sending a new signal. Patents US5488737 and US5701583 allow the base station and antenna to both receive and transmit signals between two cell phones. The two-way communication is allowed by Patent US5625885. Patent US4065771 helps prevent the interference of this two-way communication. Patents US5008680 and US6091788 transform the signals received by the antenna and sends them to the desired location.

Table 4: Art-Function Matrix and Patents for Biomass Plant/Telephone Tower

	Conversion of Biomass to Fuel	Use of Energy	Movement of Antenna	2-Way Data Communication	Beam Transformation
Biomass Plant	US 20060225424				
Base Station		US6463301 US5303240			
Steerable Antenna			US7006040 US7065373		
Land-Based System				US5488737 US5701583	
Antenna System				US5625885 US4065771	US5008680 US6091788

5.3 Benchmarking

Table 5: Telephone Tower Benchmarks

Type	Lattice Tower	Monopole Tower	Guyed Tower
Cost	Most expensive due to its greater support structures	For 120', $60K	Cheapest to produce, but requires the most land
Benefits	Offers greatest flexibility, good for rough conditions	Uses a minimal space requirement	Very easy upgrading existing structures
Aesthetics	Typically 3 sided with a triangular base	Single tube tower with one foundation	Tall, straight tower supported by guy wires anchored to ground

Table 6: Biomass Plants Benchmarking

Plant	1. Mesquite Lake Biomass	2.Scotia Biomass Plant	3. Bertrix Biomass Plant in Belgium
Cost	$46 million	$60 million	$30 million
Size	17.9 MW	28 MW	8.45 MW
Productivity	Can burn up to 990 tons per day of manure	Powers the entire town of Scotia and sells remaining electricity	Heat output can form up to 100,000 tons of pellets per year, sells remaining electricty
Safety	No large recorded accidents	No large recorded accidents	No large recorded accidents
Environmentally friendly		recognized by the American Society of Civil Engineers for its design and environmental attributes	
Longevity	Running since 1987	Running since 1988-89	Running since 2006
Inputs	Biomass, manure	Mill residuals and other available biomass	Wood, biomass
Durability	Refurbished in 2007, still selling electricity	Just purchased by new biomass power company this week	No refurbishing

5.4 Background Information on the Democratic Republic of Congo

At the time of its independence in 1960, The Democratic Republic of Congo was the second most industrialized country in all of Africa, behind only South Africa itself. However the genocide, which lasted until 2004, cost the lives of nearly fifty million people. The Democratic Republic of Congo's geography contains the twelfth largest area in the world, yet due to the genocide is sparsely populated in relation to its total area. This leaves the vast potential to collect biomass resources without interfering with the lives of civilians. Forests cover almost 60 percent of the total land area, as well as account for 50 percent of all African forests. Among these forests, there is over 150 million acres of exploited forest area with an endless supply of timber resources. Agriculture also accounts for 57 percent of the national GDP so there is no lack of energy crops either. The main biomass crops include yams, plantains, rice, corn and rubber. These crops account for 3.5 percent of Congo's total land area.

6.0 Target Specification

Table 7: Final Product Specs

Feature	Current Specs	Target Specs	
		Ideal	Marginal
Cost	$10 million	<$10 million	<$20 million
Capacity	5MW	<1MW	<5 MW
Height	30 feet	<30 ft.	<40 feet
Width	43 feet	<40 feet	<50 feet
Depth	10 feet	<5 feet	<10 feet
Ease of use	easy	<easy	<hard

7.0 Concept Generation

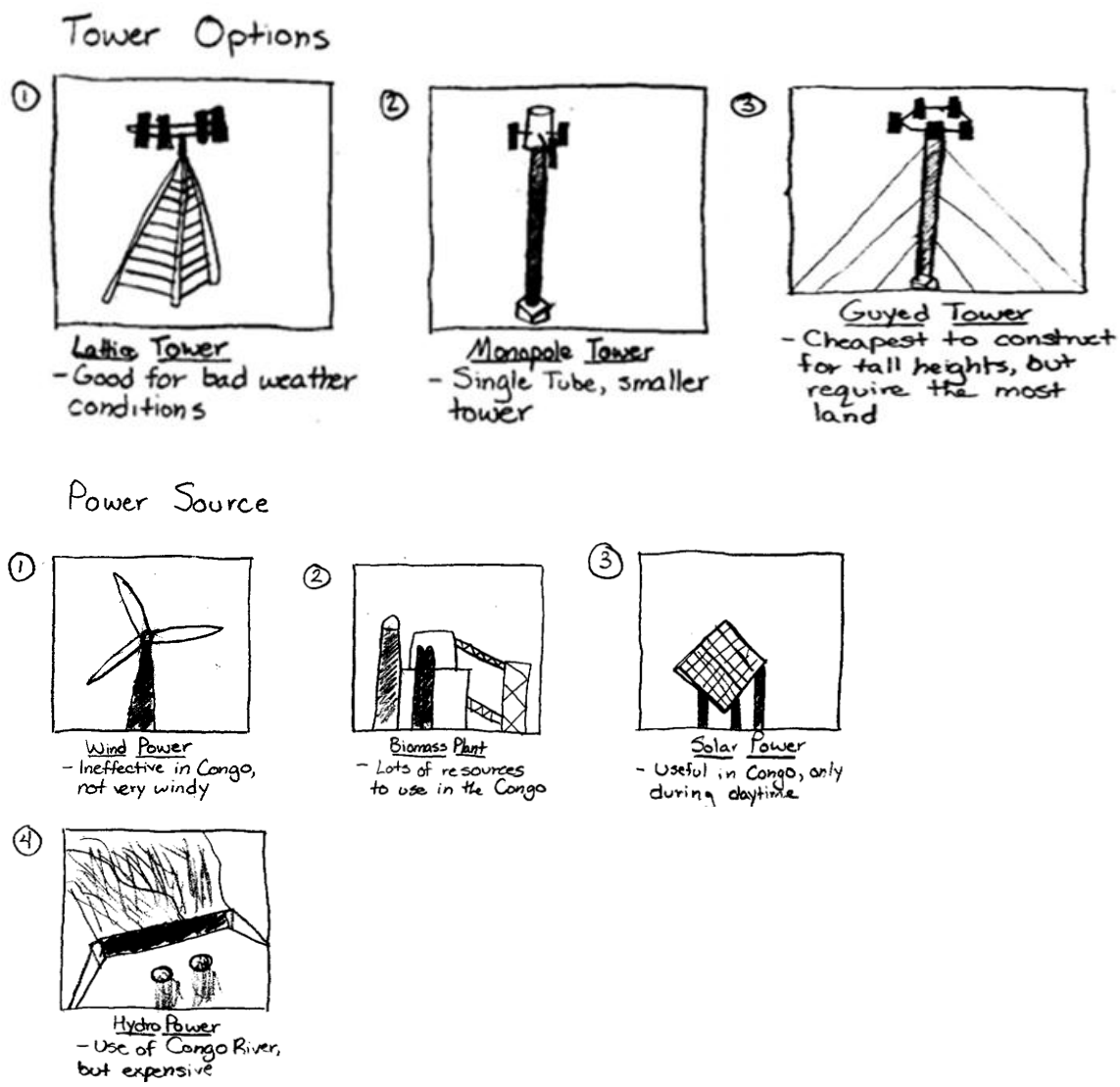
Through out concept generation, we dissected multiple power plants and telephone towers. The three towers dissected were the Lattice tower, Monopole tower, and Guyed tower. The Lattice tower was the most expensive of the three but also puts out the most amount of energy. The monopole tower was also very costly, but takes up limited space. Finally, the guyed tower is the least expensive and cheapest to upgrade. However, it takes up the most space. Our group came to the decision that since the Guyed tower is cheaper than the rest; its need for landmass will not be a factor due to the geography of the Congo.

Our four types of alternative energy sources included wind energy, solar energy, hydropower and biomass fuel. Wind energy would not be very effective in the Congo as it only blows at an average of 5 mph. Solar power could also be very useful in Congo, but

concerns were made over the sunshine at nightfall. The Hydropower option was also very plausible due to the Congo river, however, it would be highly expensive and take a mass amount of resources to build. Finally, the biomass plant would have a very expensive base cost, but would be able to repay itself over a maximum of ten years. There is also an excess amount of biomass resources in the Congo being is possess' over sixty percent of Africa's forests.

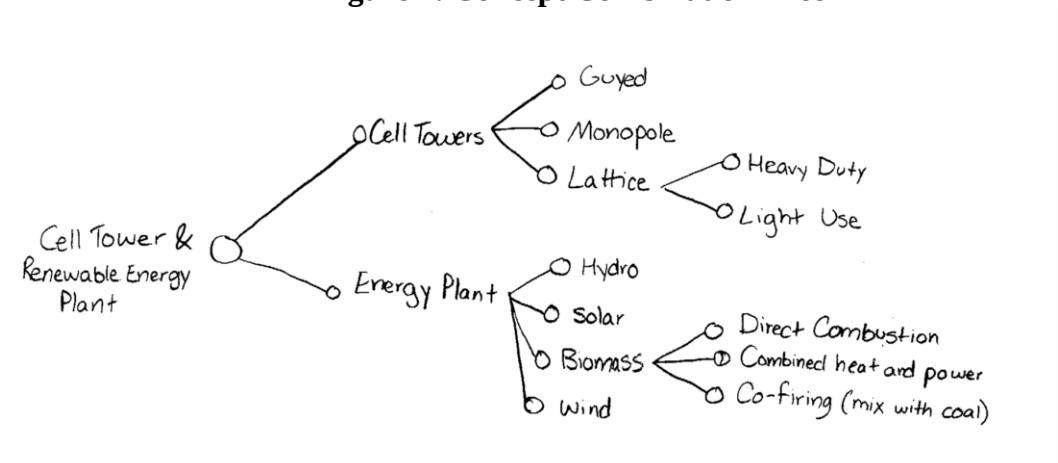
7.1 Concept Combination

Table 8: Concept Combination Table



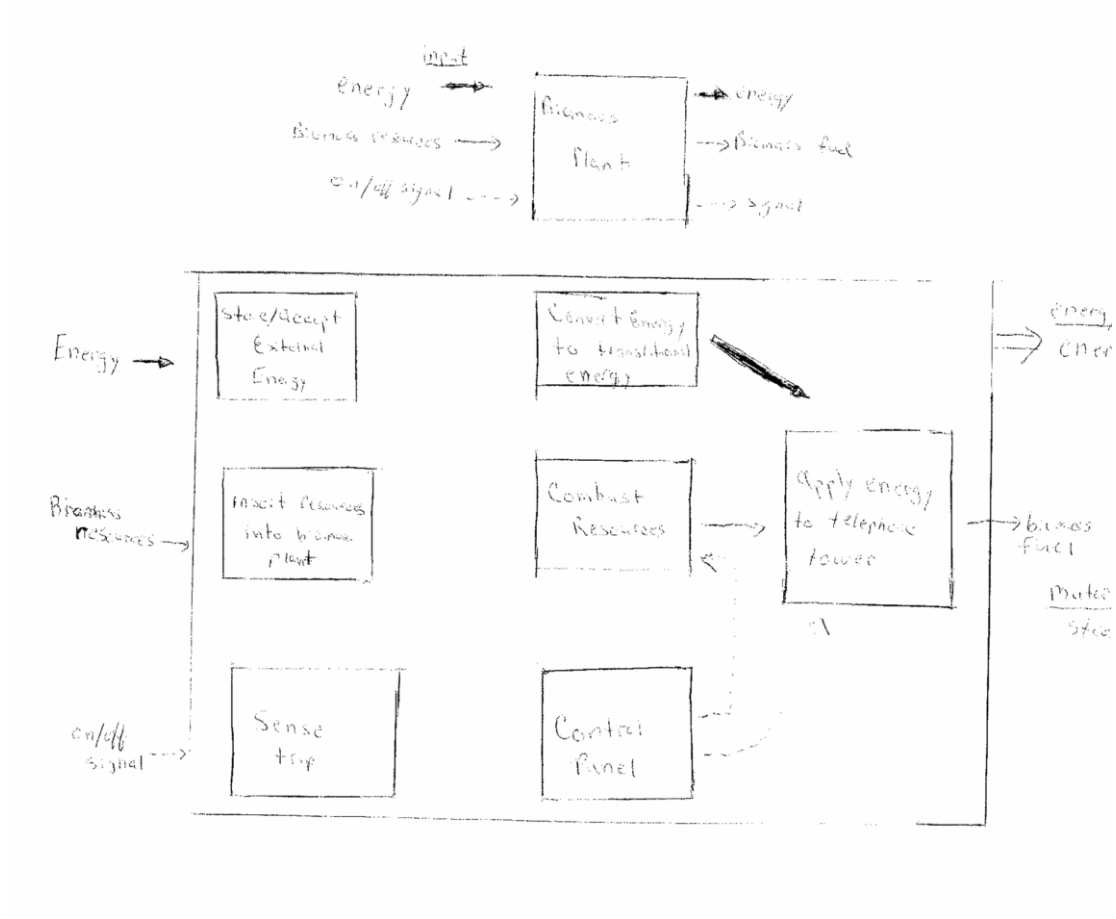
7.2 Concept Combination Tree

Figure 7: Concept Combination Tree



7.2 Black Box Model

Figure 8: Black Box Model



8.0 Concept Selection

Operation and Components will be at a smaller scale than conventional biomass plants. Large scale plants can be up to 40 MW, which would generate way too much power than we need. An optimal plant size would be from 5 MW-10 MW, allowing plenty of energy to power the tower, as well as being able to sell electricity to cover costs.

Table 9: Example Biomass Plant Power Output

Plant Size	Steam Produced	Estimated Power
10 MW	100,000 lb/hr	2,450 kW
20 MW	200,000 lb/hr	5,700 kW
40 MW	392,500 lb/hr	11,200 kW

8.1 Social Impact

As previously stated, human is the most essential resource in this project. Their GDP per capita or average income per person is 348 dollars. This is an extremely low amount for any family to survive on no matter what the location. The basic jobs that will be established from the biomass plant will be the maintenance of the plant, farmers needed to grow crops, and those who are going to retrieve biomass materials. It will also boost the unemployment rate in an effort to bring the Congo back to the second biggest industry in Africa as it was in the sixties.

Secondly, the effect that cell phone usage has on a country is astronomical. It will bring them to that next step of communication which will advance transportation, education and the working community. The population will be able to now advance to "make poverty history." It will create new opportunities for entrepreneurs to sell phones to users. These entrepreneurs include poor youths and unemployed adults. Finally, the users of phones gain new business opportunities especially if the internet is implemented on these phones. Cell phones are saving Africa.

8.2 Concept Selection Data

Table 10: Energy Selection Table

	Wind Power	Biomass Plant	Solar Power	Hydropower
Weather Resistant	+	+	+	0
Plant Supervision	0	0	0	0
Low Pollution	+	+	+	0
Durability	-	+	+	0
Longevity	0	+	-	0
Energy Efficient	+	+	+	0
Low Cost of Resources	+	+	+	0
Affordable to Build	-	-	-	0
Maintenance	-	0	0	0
Sum +'s	4	6	5	0
Sum 0's	2	2	2	9
Sum -'s	3	1	2	0
Net Score	1	5	3	0
Rank	3	1	2	4

Table 11: Cell Phone Tower Selection Table

	Lattice Tower	Monopole Tower	Guyed Tower
Weather Resistant	+	0	0
Plant Supervision	0	0	0
Low Pollution	0	0	0
Durability	+	+	+
Longevity	+	+	+
Energy Efficient	0	0	0
Low Cost of Resources	0	0	0
Affordable to Build	-	-	+
Maintenance	-	-	-
Sum +'s	3	2	3
Sum 0's	4	5	5
Sum -'s	2	2	1
Net Score	1	0	2
Rank	2	3	1

9.0 Final Specification

At today's rate biomass plants tend to be renovated close to every 20-30 years, but until then can sustainably function without much yearly maintenance cost. Generally, the biomass plant can pay itself off in around 10 years or less, through selling electricity back to power companies.

Table 12: Bill of Materials and Upfront Costs for Tower and Biomass System

Part #	Part Name	Qty	Function	Mass (kg)	Material	Manuf. Process	Dimensions (ft)	Cost
1	Short Base	1	Provides support for the structure	15.91	Steel	Electric welding	1.1 x 5	$128
2	Joint Bolt Kit	1	Holds sections together	0.3	Steel	Assembly	.04 x .1	$4.70
3	Tower Section	1	Gives support and height	31.82	Steel	Electric welding	1.1 x 10	$293
4	Top Section	1	Used with communication	31.82	Steel	Electric welding	2.25 x 1	$347
5	Base Plate	1	Attach to foundation	16	Steel	Electric welding	1 x 1	$139
6	Top Plate	1	Seal exposed tower legs	10.66	Steel	Electric welding	1 x 1	$253
7	Guy Bracket	1	Secures guy wire to tower section	9.91	Steel	Assembly	.5 x .5	$172
8	Beacon Plate	1	Protects antenna	7.73	Steel	Electric welding	.5 x .5	$257
9	Accessory Shelf	1		3.59	Steel	Electric welding	.4 x .4	$126
10	Anti-Climb Sheets	1	Prevent trespassing	54.55	Steel	Stamped	1.75 x 9.5	$481
11	Biomass Plant	1	Creates energy used in the tower					$10,000,000

10.0 Embodiment of Design and Final Design Description

The final design for our tower and renewable energy source is a guyed tower and a direct combustion biomass plant. The guyed tower will be generate the cell phone signals through its main antennae and will stay supported to the ground by three levels of guyed wires. The tower will be connected to the biomass energy plant through the generator hut. The direct combustion plant will be able to send the energy generated to the tower relatively easily. The direct combustion biomass plant will have many parts to

it. It will have a reactor, coolers, filters, combustion turbine, and a generator to covert the steam into usable electricity.

Figure 9: Proposed Biomass System

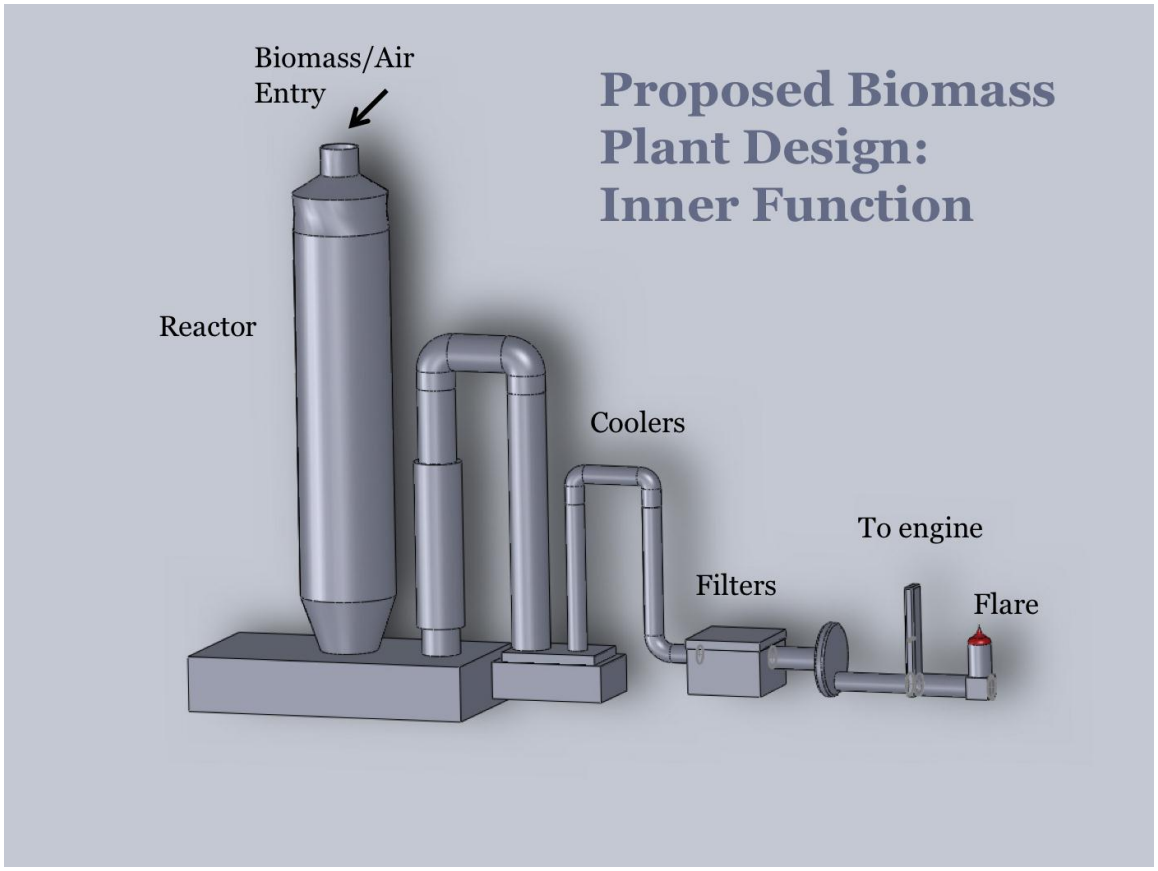


Figure 10: Proposed Guyed Tower

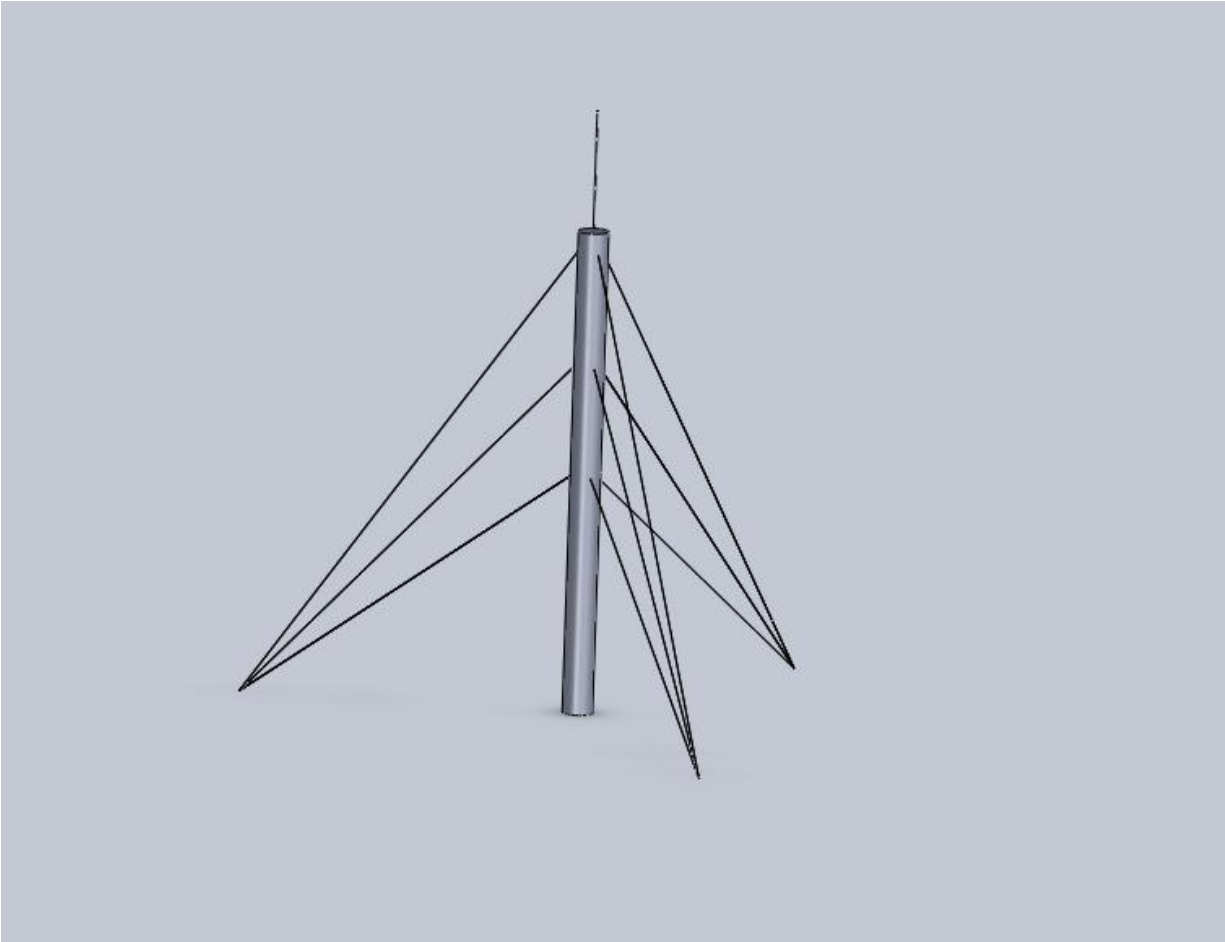
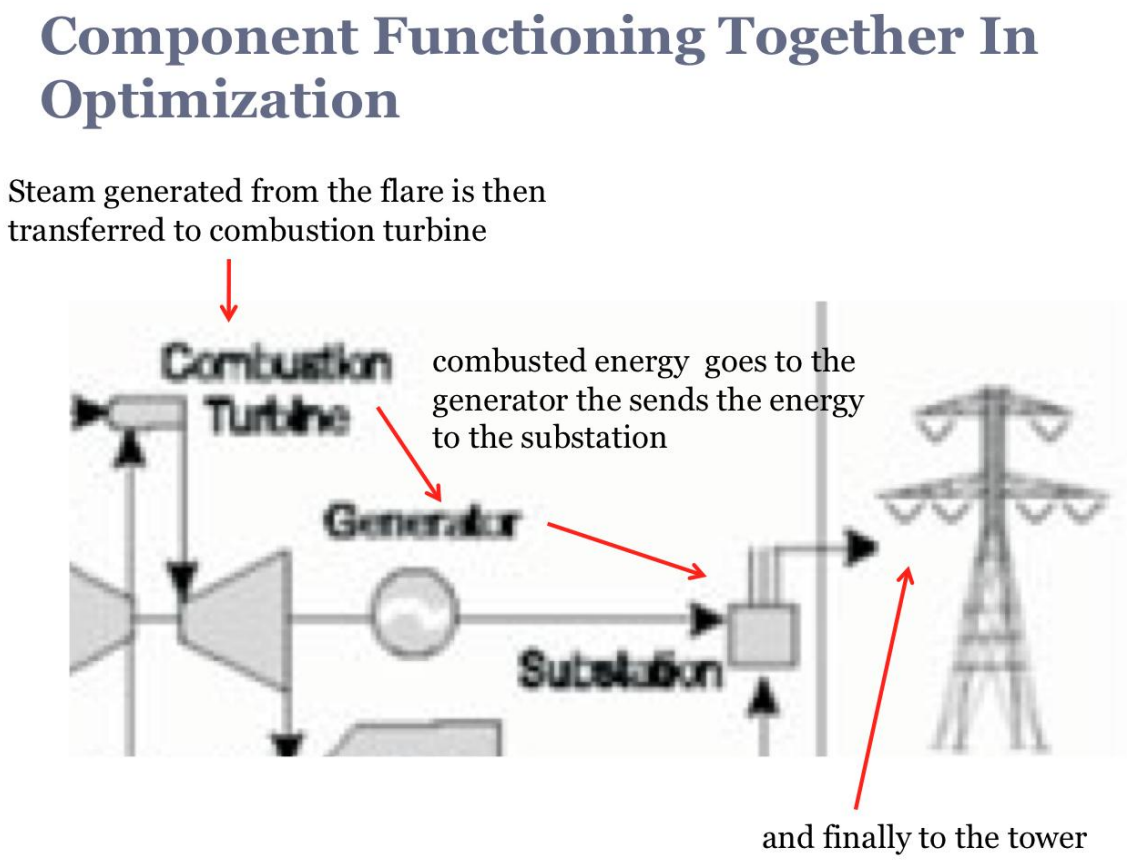


Figure 11: Components Functioning Together in Optimization



11.0 Conclusions

Through our strict and tedious research the "Flashdrives" have come to the conclusion that implementing a low scale biomass plant with a Guyed tower will be the most costly and energy efficient design. Although biomass plants can be of high costs, it will repay itself in ten years at a maximum. Not only will this project benefit General Electric, but will also highly affect the Democratic Republic of Congo. It will leapfrog them to a new business perspective, as well as provide the foundation for internet access across the Congo. By implementing this cell phone system, General Electric is making the preliminary steps in order to save Africa one country at a time.

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