No Grid Telecom Base Station Energy Storage System

EDSGN 100 Section 016

Team #4

Submitted to: Professor Jeonghwan Jin

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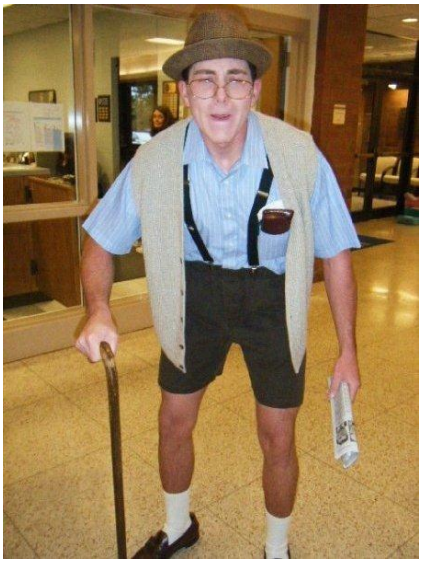
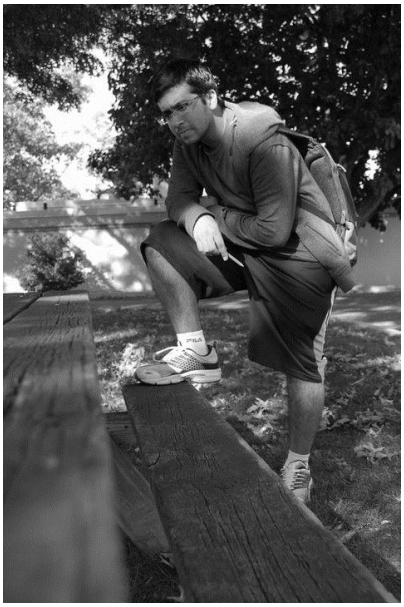
Team #4 Consists of:

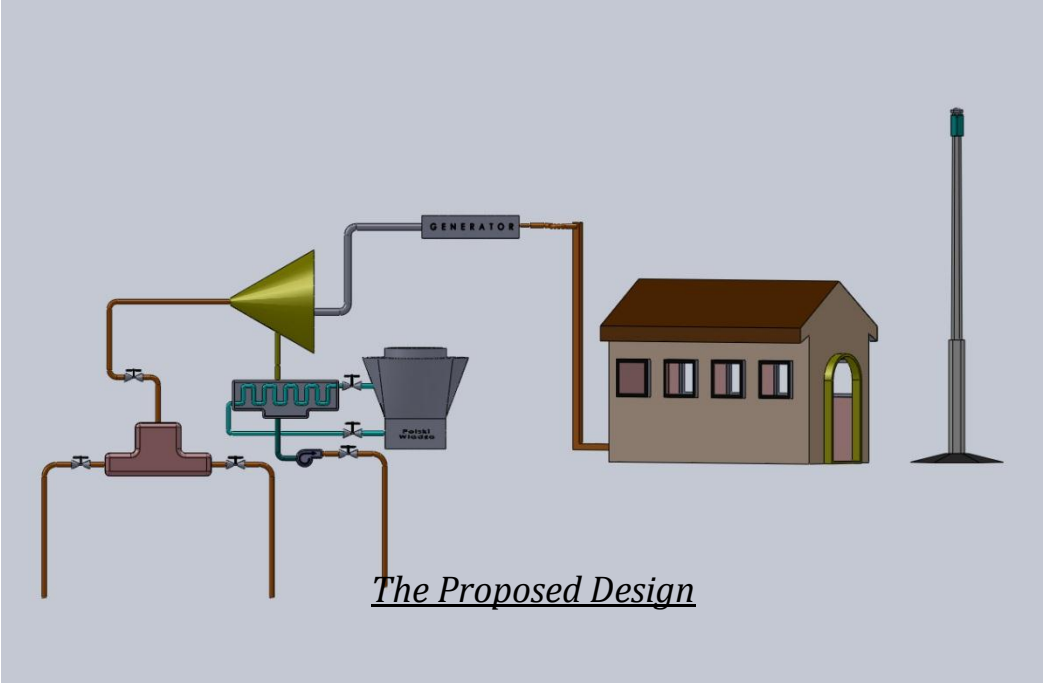
Eric Simmons, ezs5119@psu.edu

Justin Laskowski, jjl300@psu.edu

Hardik Jasani, hkj5010@psu.edu







Abstract:

This report evaluates and proposes the design of a telecom cell phone base station system that uses sustainable renewable energy resources, a diesel generator system, and sodium metal halide batteries to optimize green power used to run the base station. Particularly, this design places emphasis on optimizing available power in an area with either no energy grid or an unreliable energy grid, and also illustrates environmental benefits of replacing the typical current solutions of the region.

Introduction:

The purpose of this design is to acclimate oneself with the engineering design process and to learn to integrate conceptual designs into tangible solutions. The intended design focuses on creating a reliable telecom cell phone grid for a developing or underdeveloped nation with the implementation of a renewable energy resource and the new GE Durathon battery. Our proposal, in providing a reliable cell phone grid for an underdeveloped country, involves the use of a flash geothermal energy system in the Malaysian location of Kelantan. Economically, this proposal will cause a boom in Malaysia's industry – provided that improved communications is key to increased economic growth – and improve Malaysia's current application of sustainable and renewable energy sources.As the Malaysian economy increases, the United States will find more resources for goods and services. Also, there is suggestion that the GE Durathon battery will find great acceptance as a revolutionary means of storing energy and evolve the manner in which energy may be distributed. With the integration of such sustainableenergy and revolutionary batterysystem, one may thus provide an efficient, profitable method of powering areliable telecom cell phone system opening a new market for cell phone service and of GE Durathonbattery sales.

Mission Statement:

"*To provide an efficient, reliable telecom cell phone grid system in an underdeveloped or developing nation through the implementation of a sustainable, green energy source and the revolutionary GE Durathon battery. In doing so, we will subsequently improve communications within the nation - resulting in a state of economic growth - and provide a new market for GE's Durathon battery. Thus, the intended end is to better the target nation and improve the distribution of the new GE Durathon battery.*"

Location Selection

The region of Kelantan, Malaysia is the intended ideal location for the proposed telecom base station. This particular location is ideal in the regard that Kelantan is a growing source of

tourism and wealth. Originally an economy based on agrarian resources, Kelantan has undergone a recent expansionary development. This being said more and more people of the Kelantan region will be acquiring higher incomes and, thus, acquire more technological devices. Thus, there will be a need and demand for a reliable telecom grid to provide for these predicted cell phone users. Also, note that Kelantan, Malaysia is situated near the equator, making a direct PV solar system feasible, and located within the Ring of Fire, making a geothermal system advantageous. Thus, with this location there is a demand for a reliable system and options in the choice of renewable energy.

Benchmarking

Given the opportunity of the proposed location, one may choose a variety of renewable energy resources to compare as ideal system components. For example, one may compare the opportunity of geothermal, solar, wind, and hydroelectric renewable energies on a benchmarking comparison grid and determine the optimal energy resource. Given certain energy resources are more optimal than others one may then compare different methods of the chosen optimal energy resources – for example, a binary geothermal system with a PV solar system. Furthermore, based on selected criterion, one may choose the most efficient and productive energy resource for the actual proposed telecom grid system. The used comparison grids are listed below.

Benchmarking Research Table:

	Geothermal Energy	**Wind Energy**	**Solar Energy (Reference)**	**Hydro Energy**
Price	-	0	0	-
Maintenance	0	0	0	-
Efficiency	+	-	0	+
Eco-Friendly	0	0	0	-
Lifetime	+	+	0	+
Availability	+	-	0	+
Geography	+	-	0	-
Sum +'s	4	1	0	2
Sum 0's	2	3	7	0
Sum -'s	1	3	0	6
Net Score	3	-2	0	-3
Rank	**1**	**3**	**2**	**4**
Continue?	**Yes**	No	**Yes**	No

As observed in the above table, the criterion included price, maintenance, system efficiency, environmental stability, expected system lifetime, generated energy availability, and system to location compatibility. Through research and guided selection, it was determined that the geothermal or solar energy systems would be most efficient and practical in the given situation. As such, these two means of energy generation were then compared in greater detail. (As seen below in the concept selection table below.)

Concept Selection:

	Geothermal Dry Steam System	**Geothermal Flash Steam System**	**Geothermal Binary Steam System**	**Photo-Voltaic Cell (Reference)**
Price	+	+	-	0
Maintenance	-	+	-	0
Efficiency	0	+	+	0
Eco-Friendly	0	0	0	0
Lifetime	0	0	0	0
Availability	0	0	0	0
Geography	0	0	0	0
Sum +'s	1	3	1	0
Sum 0's	5	4	4	7
Sum -'s	1	0	2	0
Net Score	0	3	-1	0
Rank	**2**	**1**	**3**	**2**
Continue?	**Yes**	**Yes**	No	No

Thus, given that geothermal or solar energy is most practical within this application and speculation, different forms of geothermal and solar systems were compared to one another. Specifically these systems included dry geothermal, flash geothermal, binary geothermal, and photovoltaic solar.

In a dry geothermal system, a turbine is spun by the piped steam generated deep within the Earth's crust due to geothermal heating. Dry geothermal is the oldest means of geothermal energy.

In a flash geothermal system, water – not steam – is pumped at very high pressures from underground reservoirs. The high pressure forces the water into a liquid state though the water is well above the boiling point. As the high pressure water reaches the surface, the pressure is relieved – instantly 'flashing' the extremely hot water into steam. This steam then spins the turbine to generate electricity.

In a binary geothermal system, gaseous water is not used to turn the turbine. Instead, a binary fluid with a much lower boiling point than water is heated by the piped underground water. The heat transfers to the fluid causing vaporization and the vaporized fluid spins the turbine. Note, that a binary system can make use of relatively low temperature geothermal water due to its nature.

In photovoltaic solar cells, direct sunlight is absorbed by the semiconductor material within the cell. As the light is absorbed, electrons become excited. Essentially, this means energy transfers from the absorbed light to the semiconductor material. This energy knocks electrons loose, allowing the electrons freely flow about the system in which they can be directed and collectively converted to an electrical current.

Thus, given this information and the circumstances, the conclusion was that the flash geothermal and dry geothermal systems were best suited for the situation. This is based on the fact that each of these two systems is environmentally friendly, efficient, lasts for a relatively long time period, and produces an almost continual source of energy. With such benefits, one may easily outweigh the initial price of the slightly expensive system. However, only one system can be implemented and thus a decision between the two was made using a system or product matrix.

Design Matrix:

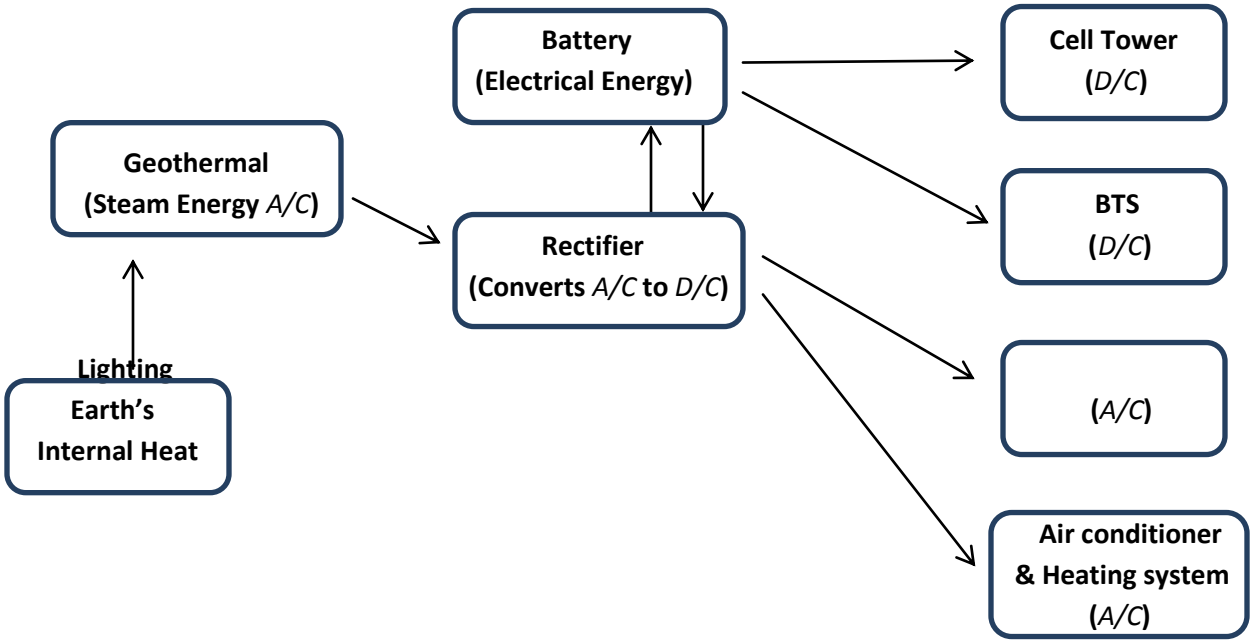
		Geothermal Dry Steam System (Reference)		**Geothermal Flash Steam System**	
	Weight (%)	**Rating**	**Weighed Score**	**Rating**	**Weighed Score**
Price	30	*3*	*0.90*	*4*	*.90*
Maintenance	15	*3*	*0.46*	*3*	*0.46*
Efficiency	10	*3*	*0.30*	*4*	*0.4*
Eco-Friendly	10	*3*	*0.30*	*4*	*0.4*
Lifetime	20	*3*	*0.60*	*3*	*0.6*
Availability	10	*3*	*0.30*	*3*	*0.3*
Geography	05	*3*	*0.15*	*3*	*0.15*
Total Score		3.01		**3.21**	
Rank		2		**1**	
Continue?		No		**Yes**	

Being that price, maintenance, and system lifetime are most important within this application, each of these criteria received relatively high weights. The other criteria of efficiency, environmental stability, energy availability, and location compatibility were relatively

equal in weight as each of the two systems had approximately the same rank in each of these categories. In the end, the flash geothermal system was chosen based on the fact that it produces more energy and is more efficient than a dry geothermal system but does not cost as much as a binary geothermal system. Also, note that the geothermal system was chosen over solar as the geothermal system can continually produce electricity while the solar system can only produce electricity in the presence of light. Furthermore, the location of Malaysia provides an adequate means of Earthly-internal heat as it is located on the Ring of Fire. This fact would suggest geothermal energy is abundant. The fact the equator is located near the Ring of Fire is a deterrent to a solar energy system as the great possibility of overcast days will decrease the amount of sunlight able to reach the photovoltaic cell. Thus, the proposed renewable energy resource is that of a flash geothermal energy system.

Note that the entire grid system would have an energy flow as depicted below. This is due to the fact that the geothermal system produces an A/C current. To store this energy in the D/C battery, a rectifier must be used to convert the energy to D/C. From the battery, the cell tower, the grid utilities, lighting, and air conditioning may all be powered – assuming respective D/C currents are rectified to power the lighting and air conditioning of the base station.

Energy Flow Diagram



Design Description:

The proposed design of the green telecom grid base station was based upon three monumental concepts: energy efficiency, environmental stability, and economic adequacy. For example, the proposed design was intended to include the use of an environmentally safe and renewable energy resource while that could provide for a reliable telecom base station. Note that the proposed design was also meant to be economically adequate in the sense that a profit could be made from the system – making the system an asset rather than a liability.

Given such concepts, the flash geothermal system proposed was developed on fulfilling these goals. The proposed geothermal system [as depicted in the below diagram] functions on the principle of pumping pressurized underground water to a 'flash tank.' This pressurized water is at temperatures higher than the boiling point of water but cannot vaporize due to the high pressure exerted upon it. Within the 'flash' tank, the pressurized water is depressurized and the extremely high temperature water is able to vaporize instantly. This instant vaporization produces a great amount of steam that is piped into a steam turbine. The blades of the turbine, connected to a generator, spin and generate electrical current. As the steam passes through the turbine, more piping leads the steam into a cooling tank, which is connected to the cooling tower. The cooling tank and tower are a closed system in which water of a lower temperature is exposed to the hot steam. The heat transfers from the steam to the cooling water and the once gaseous steam particles condense into the liquid state again. This cooled water is then pumped back into the reservoir and the cycle repeats.

Note that the cooling water becomes hot enough to become steam itself too. However, the cooling tower provides a means of heat release as the gaseous cooling water reaches the opening of the cooling tower. For example, the steam is released from the open cooling tower but instantly condenses as the heat is dissipated into the air. The cooling water then can repeat its own cycle. Thus, one may see that the proposed system is self-sufficient and requires little maintenance costs. Also, the proposed system is relatively unique in the fact that it can generate electricity almost constantly and is not dependent upon weather conditions or the amount of sunlight within a daytime. It is also important to note that the proposed system would be more thermally efficient if a brine solution was used in the actual steam cycle. This is a result of brine having a lower boiling point than water and thus making the heat necessary to generate steam less. In other words, the brine solution would reduce the depth at which one must drill and provide a better means of heat transfer.

The system itself is very environmentally friendly as there is no waste produced besides excess heat and possibly some solid material. However, this excess heat is dissipated through the air and becomes negligible as time passes and the solid materials such as zinc, sulfur, and silica are extracted for sale. Thus, the geothermal system can actually produce usable

resources through its negligible amount of solid wastes. However, at the time of construction there is the need to drill holes within the ground and penetrate the water table. This may not provide an environmental hazard in itself, but the construction and act of building the system may prove a disturbance in the flow of the natural region. For example, animals and humans may find the construction of the base station as a disturbance or annoyance. However, this cannot be avoided and would be a result of building any proposed telecom grid base station. Also, it is important that geothermal power if homegrown and reduces the dependency on foreign oil – thereby reducing excess pollution.

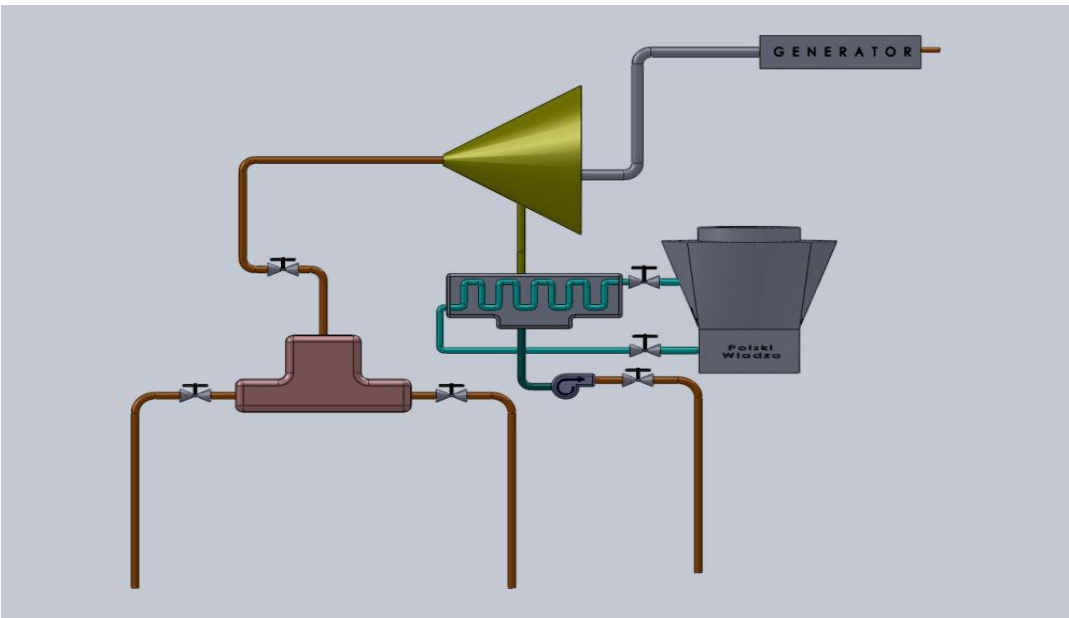
Thirdly, the proposed plan is economically efficient. The geothermal system is essentially weighted by initial expenses as compared to maintenance costs. For example, once the system is built, there is little to no expense on keeping the system running. It is suggested that the initial cost of the geothermal system is approximately based on $2500 per installed kW and that the maintenance and operating costs range from $0.01 to $0.03 per kWh. Note the system may run at nearly 97% availability – nearly 24 hours every day of the year. Also, it is suggested that the system can sell power at $0.05 per kWh.

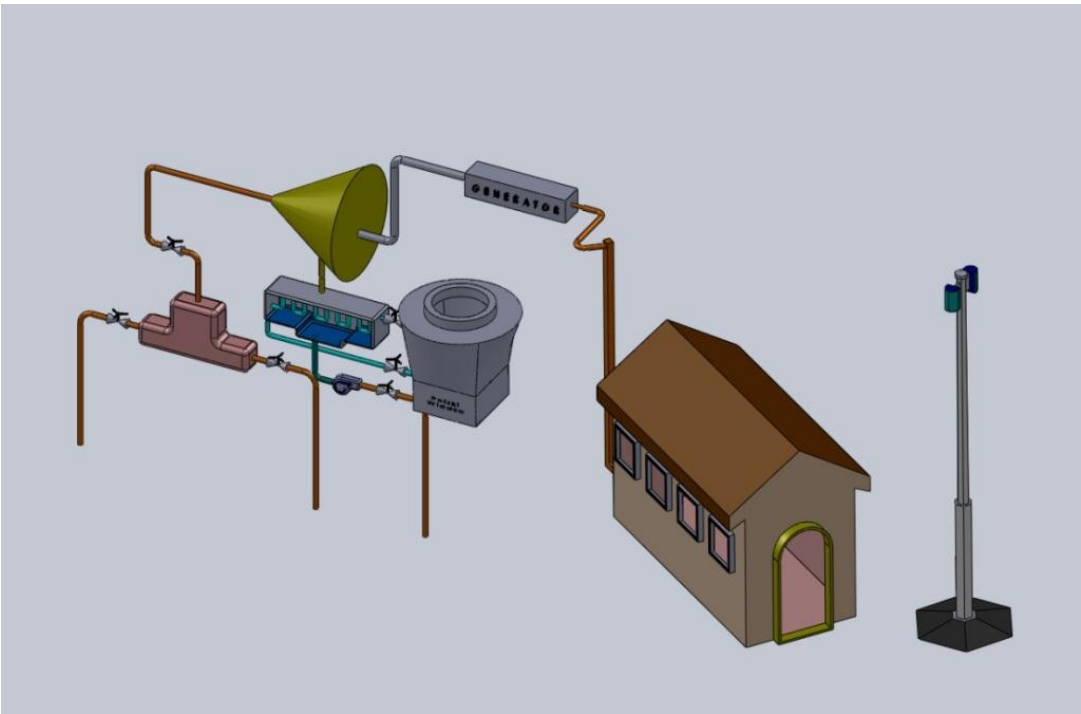
However, there are restrictions on the implementation of the geothermal system. It is suggested that the hot geothermal fluids contain low mineral and gas content and remain relatively close to the surface. These guidelines are meant to make the system more efficient and cost adequate considering drilling is the greatest cost to the system. If the fluids are closer to the surface, less drilling is required resulting in less initial costs. Also, it is suggested that the approximately 450 to 600 gallons of water per minute be pumped into the system at 300 degrees Fahrenheit at an air temperature of 60 degrees Fahrenheit. Also, 45 to 75 gallons of water per minute would be needed for the cooling supply. Thus, the proposed system would require enough geothermal heat and water to function properly. Though, once an adequate location is found, the geothermal system becomes extremely cost efficient.

Component-wise, there are many necessary parts to the system. Besides the actual piping, water solution, geothermal heat source, turbine, and generator, there is a need for a diesel generator to 'jolt-start' the system, utilities for the actual grid hut, and a monopole communications tower. Furthermore, each component is imperative to function of the system and can be observed within the cost analysis.

Furthermore, the actual proposed system functions at 32 kW. This effectively covers the 1.2 kW/hr requirement of the telecom grid system and provides enough excess energy to power the GE Durathon battery within a day. Once the battery is charged, it can power the telecom grid by itself for a little less than a day – meaning the geothermal energy system may be utilized to provide electricity for the local region. Thus, essentially, the system may function as both a telecom grid base station and a power plant. As a result, the entire system becomes

extremely valued in the community. Communications increase and the local region is provided with a reliable source of cell phone service and electrical energy. It is important to note that an original plan focused on charging a vast amount of smaller GE Durathon batteries and shipping them locally for use at a rental cost. This proposal would greatly increase the sales of the Durathon battery but would not be efficient enough to be implemented. For example, the energy lost in transferring the batteries and the natural discharge of the batteries would make the batteries only temporarily useful. Thus, the proposed flash geothermal powered telecom grid base station focuses on providing the cellular signal at a constant rate while alternatively providing great amounts of energy to the local region.





Cost Analysis

The cost analysis of the system is described below. It is important to note that these numbers are estimates and may vary from the actual costs and profits when applied to the construction of the actual system. Note, at the given estimates, it is believed that the system may have a lifetime up to 25 years in which each year there is a profit of approximately $100,000 after maintenance costs. This would result in approximately an NPV of $.5 million dollars and a $2.3 million dollar profit after 25 years having subtracted initial costs of the system. This profit may not seem like much in modern view; however, the goal of this design is to provide a reliable telecom grid for the target people - thereby increasing communications within that area and increasing the economy of that area. The goal is more set on providing a necessary telecom system and proving the capabilities of the GE Durathon battery.

Cost Analysis:

Geothermal System Components:

1. Steam Turbine
2. Generator
3. Piping
4. Steam Flash Tank
5. Condenser
6. Cooling Tower
7. Water Pumps

Cell Tower/Hut Components

1. Monopole Tower
2. Base Transmitter Station
3. Antennas
4. Utilities
5. Durathon Batteries
6. Bio-Diesel Generator

Costs:

Initial:

-Drilling - $1,500/100 ft.
2 holes @ 1279 ft
= $38,370

-Geothermal System - $2,500/kW installed
@ a 32 kW system
= $80,000

-Cell Tower/Hut/Utilities
= $150,000

-Durathon Batteries - $3,000/each
@ 1 battery
= $3,000

-Bio-Diesel Generator - $2,000
@ $1.85/gal Fuel with 30 gal tank
= $55.50 + $2,000 = $2,055.50

Total Initial Costs - $269,241.50

Maintenance Costs:

-Geothermal System - $0.05/kW/h
@ 1 year
= $13824.00/yr

Total Maintenance Costs - $13,824.00/yr

Revenue:

-Lease Cell Tower - $2,000/month
@ 12 months
= $96,000/yr

-Selling Power - $0.07/kw/h
@ 1 month = $1552.32
@ 1 year = $18627.84

Total Revenue - $114,627.84/yr

Salvage Value:

- Geothermal System - $1,000/kW
@ a 32 kW system
= $32,000

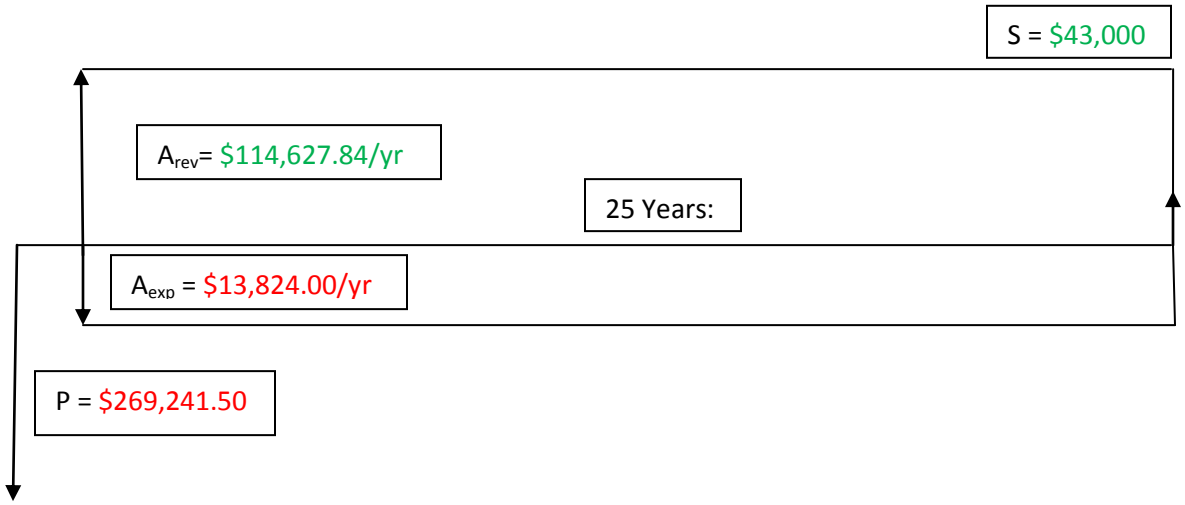
-Cell Tower/Hut/Utilities - $10,000
@ 1 system
= $10,000

-Durathon Battery - $1,000
@ 1 battery
= $1,000

Total Salvage Value - $43,000

Total Expected Life - 25 years
Proposed Total Revenue after 25 Years: $2,293,854.50

Cash Flow Diagram:



NPV = - $**269,241.50**+$A_{rev}$(P/A, i= 13%, N=25**) - A_{exp}(**P/A, i= 13%, N=25**) + $**43,000

$$(P/A, i= 13\%, N=25) = \frac{(1+i)^N - 1}{i(1+i)^N}$$

$$= \frac{(1+0.13)^{25} - 1}{0.13(1+0.13)^{25}}$$

$$= \frac{20.23}{2.75} = 7.35$$

NPV = - $269,241.50 + ($114,627.84 * 7.35) - ($13,824.00 * 7.35) + $43,000.00

NPV = - $269,241.50+ $842,514.00 - $101,606.40 + $ 43,000.00

NPV = $514,666.10

Conclusion:

Thistelecom grid system design will benefit the growing region of Kelantan, Malaysia by providing an environmentally safe and efficient telecom grid base station necessary for the growing demand of cell phone service. Simply by utilizing the power of the Earth's own geothermal heat, one can provide a nearly constant resource of electrical energy needed to power the telecom grid daily, while providing residential electricity to the local region. With the use of the GE Durathon battery, one can evidently power the telecom grid system for a short period of time and redirect the nearly constant flow of electrical energy to local residential homes and businesses – thereby improving the life of the region. Also, the inclusion of the GE Durathon battery will prove to the public the power of its revolutionary design and increase the demand and circulation of said battery. As a result, more and more nations will become environmentally friendly due to the implementation of the GE Durathon battery in combination with green renewable energy systems, ultimately improving the state of the Earth. Note that GE will observe increased sales of the Durathon battery, the Earth will benefit from increased use of green energy resources, the telecom leasers will receive an annual $100,000 profit per years, and – most importantly – the target region will be provided with a reliable telecom grid system. Conclusively, the suggested design is economically sound, environmentally safe, energy efficient, and completes the task at hand - hereby the project is a success.

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