Document 523
ALTERNATIVES ANALYSIS REPORT

CHAPTER: North Carolina State University
COUNTRY: Sierra Leone
COMMUNITY: LemonAid Village Schools
Lower Allentown
PROJECT: Renewable Energy

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Submittal Date

ENGINEERS WITHOUT BORDERS-USA

Alternatives Analysis Report Part 1 – Administrative Information

1. Contact Information

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2. Travel History

Dates of Travel	Assessment or Implementation	Description of Trip
Dec. 27, 2010 – Jan. 9, 2011	Assessment	The water systems team traveled to assess the water situation at the school
December 28, 2011-Jan 7, 2012	Assessment	The renewable energy team travelled to assess the energy situation at the school

3. Project Discipline(s): Check the specific project discipline(s) addressed in this report. Check all that apply.

Water Supply
____ Source Development
____ Water Storage
____ Water Distribution
____ Water Treatment
____ Water Pump

Sanitation
____ Latrine
____ Gray Water System
____ Black Water System

Structures
____ Bridge
____ Building

Civil Works
____ Roads
____ Drainage
____ Dams

Energy
_X_ Fuel
_X__ Electricity

Agriculture
____ Irrigation Pump
____ Irrigation Line
____ Water Storage
____ Soil Improvement
____ Fish Farm
____ Crop Processing Equipment

Information Systems
_X__ Computer Service

4. Project Location

Longitude: W13° 9’ 24.6”
Latitude: N8° 25’ 9.7”

Alternatives Analysis Report Part 2 – Technical Information

1. INTRODUCTION

The purpose of this document is to explain our committee's thought process in choosing the method of providing energy to the LemonAid Village School. It lists important factors that will go into our decision of what alternative to choose. It then applies those methodologies to our list of alternatives of a solar energy system, a wind energy system, a battery bank, and energy efficiency . Then the document provides our chosen alternative and give reasons why we chose it. At the end is an affirmation of our professional mentor of his involvement in the process.

2. PROGRAM BACKGROUND

Dr. Nancy Peddle is founder and CEO of the non-profit organization LemonAid Fund which is committed to assisting sustainable development projects in Sierra Leone and throughout West Africa. Dr. Peddle initially contacted EWB-USA during the construction of the LemonAid Village schools. The LemonAid Village schools consist of a preschool, primary and secondary school, serving more than 600 students. At the time, Dr. Peddle foresaw two primary issues of concern for the future of the school, a supply of clean drinking water and a stable energy supply. This project focuses on a renewable energy solution for the LemonAid Village Schools.

From December 27, 2010 through January 9, 2011 an EWB-USA assessment team from the North Carolina State University chapter travelled to the LemonAid Village Schools in Lower Allentown, Sierra Leone. Traveling with water systems engineer, Crag Perry, the primary objective of this trip was to analyze the water situation at the school. The team assessed the water distribution system, meeting with the local water councilor and visiting the construction site of a new reservoir. The team also spent time strengthening ties with the local community and gathering general technical information about the school, including a topographic map of the area.

This assessment trip from December 28, 2011 through January 6, 2012, explored the energy needs of the school. In the words of Francess Browne, head mistress of the LemonAid Village Schools, "We are having energy failure and we are in desperate need of supplemental energy through source such as solar panels and energy storage facility. We are looking forward to working with you and to let this problem be put to an end."

Currently the school relies on the inconsistent power grid of Freetown which only runs a few hours a day, and uses a gasoline generator for most of their energy needs. In order to power their small computer lab they must turn off power to other appliances such as the refrigerator in the office and some of the lights in the classrooms. A renewable energy source is desired which will provide the school with a clean and consistent source of power for their daily activities. A large portion of these energy needs may be improved by using more efficient appliances such as laptops instead of old computers with CRT monitors.

3. DESCRIPTION OF COMPARISON METHODOLOGY

Construction Materials:
Construction materials are an important factor for many reasons; cost, availability, reliability, and safety must all be taken into account when weighing the options. Our system must use materials that are within our budget, not hazardous to work with, and we should be able to find them reasonably close to the community where the project is being implemented. We must also take into account the size of the materials we use, given the fact that we have a limited amount of space to implement the system. All of these factors are of the utmost importance to us and to the community.

Natural resource availability (How much power is produced in a given day):
Since we are helping the LemonAid School to have a more consistent and reliable source of green power, the availability of natural resources for each possible system must be considered. If there was not enough wind or solar energy to make a difference, then we could potentially waste resources attempting a solution. Measurements of the resource quantities have to be compared based upon the current and future needs of the school. This involves weighing each system against each different type of system to find the most beneficial option, incorporating Sierra Leone's specific climate in our comparison.

Safety during installation and long term:
After considering the planning stage of the systems, the installation and what follows for years to come requires consideration as well. Safety and protection of the system itself and those that will be in it's vicinity are top priority for our project. Since the system will be in close proximity to children, it has to be secured well enough that nothing is left undone that a curious child could injure themselves on. An unsafe system may include one with loose bolts/screws, not secured in place, lots of wires out in the open, or dangerous to touch. With energy and electricity, any of these problems could arise and we will need to be careful in choosing a method and when implementing the system.

Reliability:
As the system is going to be the school's primary source of power, it needs to be very reliable; it should not be vulnerable to failure and should be expected to provide power for a good fraction of each day. A proposed system that has fewer complex or fragile parts will score higher in this

category, as will a system that can be repaired quickly if part of it does fail. Any system that is designed to continue functioning should one part fail will be ideal.

Efficiency:
A proposed system should be as efficient as possible. Efficiency improvements at the point of energy use greatly reduce the amount of energy that needs to be captured and stored, reducing size requirements. This also ties into cost, as a more efficient system will most likely be more cost-effective long term.

Complexity:
A more complex system is not only difficult for us to implement, but it will be confusing for the community to maintain on their own. Ideally, we want to choose a method that is as simple as possible given the resources we have to ensure that the system can be both cost-effective and feasible.

Security:
Whichever system we choose, it must be simple for the people of the community to monitor. Since the system will most likely be inside the school or on the school grounds, security is a high priority with this project. The system must also not place the community in any kind of danger; if they have to be constantly worried about crime, then we did not carry out the project to the best of our ability.

Cost of the system:
The cost is an important factor in which system we implement. For one, EWB-USA NCSU has to raise the money for the cost of constructing the system. Also the cost of upkeep in Sierra Leone must be relatively low to be sustainable and solve their energy problem. It would be ineffective to implement a system that the community would not be able to afford down the road.

Feasibility:
Feasibility is a valuable consideration. If the project cannot be executed because of lack of land space, materials, or technology, then it is useless as a solution to solving the school's energy needs. Feasibility involves ensuring that the project stays within budget and that it is within our means and ability to construct it.

Social Acceptance:
Having the support of the community is a key issue. If the system implemented is not wanted or if the community feels as if we are intruding, they are not going to put in the effort to maintain it. Our group also does not want to install a project that goes against the society's beliefs. This last part is very important because the culture in Sierra Leone is different from ours and we need to be sure we understand their opinions and respect them.

Climate Effects:

Sierra Leone has a very distinct wet and dry season, so any system will have to take into account the effect of the seasonal climate changes. The rainy season during the months of July, August, and September includes heavy precipitation and relatively colder temperatures. The dry season during the months of November through April is characterized by high temperatures, low humidity, and little cloud cover. Our project needs to take into account these seasons and ensure that energy is not available only when the season is convenient.

Land Use:
Choosing where to actually place the system at the school is vital. The school only owns the plot of land the buildings are on and not much more, so any system that would need extra space would require getting the use of that land through another authority. Choosing a system that would fit inside of the school's current land ownership would be optimal so that we can avoid the issue of dealing with outside authorities if at all possible.

Long-term operation and maintenance:
Taking care of the system and making sure it stays operational for a long time is integral to the success of our project. We would need our system to not require an excessive amount of care; we also need people in the area who know how to take care of the system while we are gone.

Project Sustainability:
For a project with such a long term planning period, long term results are critical to make it worthwhile. The gains made by the project need to last as long as possible. This not only entails seldom breakdowns, but also a system which can be easily repaired even once our partnership has passed. Since our project is being implemented in a school, it should last for many years. Schools do not come and go quickly and we would like to design a system that will be useful to them for a long time. Sustainability is a huge priority of EWB-USA and we need to uphold that standard.

4. DESCRIPTION OF ALTERNATIVES

Solar energy system:
This alternative would include solar PV panels, a battery bank, a charge controller, safety components, wiring, and an inverter in order to store the energy created by the panels. The panels would need to be placed in an area of direct sunlight for the most amount possible during a day, and the battery bank and inverter would need a separate room to be housed in.

Wind energy system:
This alternative would include wind turbines, a battery bank, a charge controller, safety components, wiring, and an inverter in order to store the energy created by the turbines. The wind turbines would need an area of land, both horizontally and vertically, to be housed on. The battery bank and inverter would need a separate room to be housed in.

Battery bank storage:
This alternative would include a battery bank, a charge controller, safety components, wiring, and an inverter in order to store some of the power the school gets from the grid in order for it to be used later. The battery bank and inverter would need a separate room to be housed in.

Energy efficiency:
This alternative would include helping the school be more energy efficient so their power needs are lesser. Some options would include more efficient light bulbs, more efficient computers, and nontraditional methods such as education to help cut down the amount of energy they are using.

5. ANALYSIS OF ALTERNATIVES

Construction Materials:
Solar: We visited a store in Freetown named RCD Solar that could provide all of the parts we would need for our proposed solar system. If the supplies there do not meet our specifications, we might have to import some goods. We also visited the Barefoot Women College's Solar Village, and talked to the woman in charge there. The woman's contact in India could also be a source of many of the components we need for the solar system, including panels.
Wind: We have not heard of any place to get parts for a wind system from any of our contacts in Sierra Leone. The materials to build the wind turbines would have to be imported (which creates a whole other host of issues), but the battery bank could be purchased in country.
Energy Efficiency: We could find some energy efficiency supplies in Freetown, but would have to import our replacement for the computers, the largest single load on the system.
Battery: RCD Solar downtown Freetown had all of the supplies we would need for a battery system.

Natural Resource Availability:
For the renewable sources, natural resource availability of wind and solar can be found from various sources on the internet. The global energy network institute (www.geni.org) presents resource maps for wind and solar in the continent of Africa.
Solar: Sierra Leone has a moderate amount of available solar energy (5200 W/m^2). It is possible for the necessary amount of energy to be harvested with a large enough capacity of solar panels.
Wind: Sierra Leone is in the lowest wind class in the rating system (average wind speed < 5.9m/s). This is less than optimal for a wind turbine system.
Energy Efficiency: Some energy efficient appliances like light bulbs are in country. In order to replace the computers at the school (one of the major loads on the system), we would have to import the laptops from America, which will be a logistical challenge.
Battery: The availability of power from the grid is not very consistent. Therefore, battery systems should be very large if they are designed to power the school reliably while the only source for recharging is the grid. Alternatively, battery systems used to supplement a more reliable source of power such as solar or wind could be much smaller.

Safety:
Solar: The location of implementation of the solar panels can greatly impact whether it is safe or not. Placing the panels on top of the three story roof would be dangerous, because there is a potential for falling. A much safer option would be a one story building dedicated to the panels alone, because then it would be lower to the ground.
Wind: A threat a wind turbine could pose on safety is the chance of it falling. To reduce this small risk, the turbine would have to be a proper distance away from the school in case it does fall it does not injure anyone or damage the building. Another safety issue is the installation of the turbine, as it would require the movement and installation of heavy parts.
Energy Efficiency: The safety risks are negligible for plugging in a laptop, changing a light bulb, or any other energy efficiency measures.
Battery: With proper ventilation and a secure location, there is relatively small safety concern with batteries, assuming they are being properly maintained at the proper charge settings.
Overall the wiring of each system can be detrimental to the safety of the school if not done properly.

Reliability:
Solar: The batteries will be the weakest link in the system, having an average lifespan of 5-10 years. Solar PV panels usually have a 20-25 year warranty, and will likely last 40-50 years if they are not vandalized. The inverters typically have a 10-15 year warranty and should last 20 years or more, depending on the environment where they are located (they like to be cool and dry, which might not be always possible with the high humidity levels).
Wind: A wind turbine has a moderate amount of moving parts, but also has some relatively simple mechanical components that can be fixed at least temporarily on site. Most small wind turbines will last 20-30 years, and as previously stated a battery system's batteries would have to be replaced in 5-10 years. In the US, the estimated annual maintenance cost of a small wind turbine is 2-5% of the capital cost, or $.01/kWh. It is recommended that the wind turbine is serviced 1-2 times per year.
Energy Efficiency: Depending on the particular replacement devices purchased, improvements to the devices using power can be very reliable.
Battery: Battery systems are reliable for 5-10 years before they need to be replaced, and we have contacts with a local group that has the expertise needed to repair them or train people at the site in repairs. The batteries will need to be serviced or checked on every month, depending on how deep the batteries are discharged.

Efficiency:
Solar: A solar photovoltaic system would be ~15% efficient at converting solar energy into electricity. Efficiency of available panels will all be similar in terms of this efficiency. The system would be designed with an overall focus on efficiency in order to get the most energy we can out of the panels.

Wind: The conversion efficiency of a microturbine wind system is estimated to be 20%, and we would design the system with an overall focus on efficiency.
Energy Efficiency: When choosing which efficiency improvements to implement, it is important to find what will give the greatest improvement in efficiency for the least cost. The improvements should affect the overall load of the system greatly, so as to make a significant impact on how much energy the school needs.
Battery: Storage efficiency for battery systems is fairly high, and no other options for energy storage exist. The storage system should be sized so that it can hold most of the excess energy produced during a day, reducing waste. Batteries could give 5-10 years of service before needing to be replaced.

Complexity:
Solar: The most difficult piece of implementing solar energy is the wiring of the off-the-grid energy system at the school. This will require a detailed knowledge of how to connect different components and testing of the system.
Wind: Wind is going to be the most complex out of our choices. The wind turbines would stand tall above most of the buildings in Lower Allentown. With the turbines being a relatively large distance away from the school, complex wiring connecting the turbines with a battery storage system would also be an issue.
Energy Efficiency: Installing energy efficient appliances will most likely be the easier idea to put into this school. The hardest will be getting these appliances to the school, but the set up will not be greatly altered from what it is now.
Battery: The complexity of the battery system is similar to solar energy, but would not involve connecting the battery system to panels. It would still have to involve knowledge of wiring and connecting different components.

Security:
Solar: The solar system is going to be outdoors and visible, the main crime concern being someone stealing the panels. The battery bank will have to be in a secure place, so securing the panels and making sure they are not stolen is of the utmost importance.
Wind: Security is also a large concern with wind energy. The wind turbines will be the most vulnerable to theft, as they would have to be well outside the confines of the secure school. In order to secure the wind turbines and prevent public access, we would have to build a separate security compound for the turbines themselves.
Energy Efficiency: The biggest issue with security in regards to energy efficiency is protecting any computer replacements we would provide the school. These computers would be the most valuable appliances in the school, and proper care would need to be taken to make sure they are not stolen.
Battery: A battery bank would have a fair amount of security, as it will be inside, away from public access, and secured with a lock. Like the other options, it is always a chance that someone could tap into the system if they have expertise in electrical systems.

Cost of the system:
Solar: Our current estimates for an appropriately sized system would be 30,000 dollars. This would be a 4200 watt system including 24 PV panels, 4 batteries, 1 charge controller, 1 inverter, 6 mounting systems for the panels, and wiring. All of these materials would be bought in Sierra Leone.
Wind: Small wind turbines themselves cost between $10,000 and $15,000 per kW of rated capacity. Assuming the school's needs of 10 kW and 5 peak sun hours, we would need 2 wind turbines costing a total of $25,000. This would be in addition to a $8,000 dollar battery system, extra wiring to go to the location of the turbines, and an unknown cost of installing the wind turbines. The maintenance cost of the system is usually 2 to 5 percent of the upfront cost per year, so about 750 dollars per year.
Energy Efficiency: This is extremely variable. Our main cost for energy efficiency would be replacing the school's laptops. The most expensive way to do this would be buying 20 new laptops for the school. The least expensive would be getting donated laptops, whose only cost would be getting the laptops to Lower Allentown.
Battery: Only a battery system would cost about $8,000. This includes the cost of 4 batteries, a charge controller, inverter, and wiring all purchased in Sierra Leone.

Feasibility:
Solar: Installation of solar cells only requires setting in the panels on the roofs and then connecting the wires to a battery. This doesn't require any heavy machinery and tools and can be done more easily. Furthermore, since there aren't any moving parts in the solar cells, this has a lesser chance of requiring maintenance. Even though the cost of implementation of solar cells is more than a wind turbine, the long term maintenance cost associated with solar panels as compared to wind turbines makes solar panels the more feasible choice.
Wind: Wind energy has several disadvantages compared to solar energy. Wind turbines have to be set up on towers which will require the use of heavy machinery. They have moving parts, so they will require fairly constant maintenance. Big and heavy machinery will be required for this too. This heavy machinery will cost more to use and will have to be used more frequently. Wind turbines require land in addition to what the school already has.
Energy Efficiency: The only feasibility issue with energy efficiency would be the transportation of energy efficiency appliances (laptops, light bulbs) to the school. Our committee would have to figure out how to ship these appliances to Lower Allentown safely and securely.
Battery: The construction of a battery system is very feasible. The hardest part about installing this type of system would be taking off-the-shelf components and configuring them to create a functional system. This type of battery system is already implemented in other parts of Sierra Leone, so it is known to work.

Social Acceptance:

Solar: The people of Lower Allentown were excited at the prospect of solar energy, as they had seen its successful implementation at the clinic in order to keep vaccines cold.
Wind: The travel team got the general impression that the people of Lower Allentown did not know much about wind energy, and were less accepting of the idea.
Energy efficiency: The people of Lower Allentown realized the importance of using as little energy as possible, so energy efficiency was important to them.
Battery: The people of Lower Allentown recognized the need to store energy and the travel team found that the people were very open to a battery bank system.

Climate effects:
Solar: The climate effects will have the most effect on the solar system. During the rainy season, there will be cloud cover so the panels will not see as much sunlight. This could be a problem because if there is a particularly rainy day, the school will not get enough power to last the day. Also in the dry season there is a lot of dust, which will cover the PV panels and require cleaning on a regular basis.
Wind: The rainy season will probably generate more wind power, and the dry season will not have any effect.
Energy efficiency: The climate will not have any effects on energy efficiency.
Battery: The only concern would be batteries overheating in a confined, non-air-conditioned space.

Land use:
Solar: A solar system will not require any additional land use outside of the school's current holdings. A structure in the courtyard of the school could both be the location of the panels and the site of the battery bank system.
Wind: This is the least viable option, as the school would have to purchase or get permission to use land outside of their current means in order to put up wind turbines.
Energy Efficiency: Energy efficiency will not be affected by land use, the school currently has a room dedicated to computers.
Battery: There is no current room suitable for a battery bank, so a room would have to be constructed or cleared out. This room would have to be secure for both security and safety reasons.

Long-Term Operation and Maintenance:
Solar: The only long-term maintenance would come from cleaning the panels and making sure the batteries functioned properly. In order to maintain the batteries, someone would have to monitor them and make sure they are replaced when they fail to function.
Wind: This option is the least viable, as there are not technicians in the area with the knowledge to repair wind turbines if they were to break.
Energy Efficiency: This option would be the best in regards to operation and maintenance, as there would be almost none. The only possibility is making sure the computers function for a long time.

Battery: In a battery system, someone would have to monitor the batteries and inverter to make sure they functioned properly. Eventually, the batteries would have to be replaced.

Project Sustainability:
Solar: Based on most company guarantees, solar panels are expected to maintain 90% of their advertised efficiency for 10 years, 80% for the next ten years, and they are expected to function a total of 30 to 35 years. This gives them a better life-expectancy than wind, and they are much easier to expand or repair. Installation or replacement of a solar panel entails only mounting and basic wiring.
Wind: Modern wind turbines ten to last around 20 years, but with a sizable variance depending on how they are constructed. While this is an admirable lifespan, repairs or expansion of a wind system would be very difficult for the school on its own. Erecting turbines is physically and technically demanding, involving many moving parts, great heights, and greater distances of wiring.
Energy Efficiency: Overtime, the amount of efficiency these appliances have compared to newer products will decrease, and as the school grows the energy requirements of the school will increase. Therefore, the efficiency of the appliances will have to offset the growing energy needs of the school.
Battery: The lifetime of a battery bank varies greatly, depending not only on the quality of the batteries, but upon how often and at what intensity they are charged and discharged. In a system this size, the batteries could last 5-10 years before needing to be replaced. Replacement is a simple matter of finding new batteries and hooking them up where the old ones had been.

Quantifying our Analysis of Alternatives (Scores are on a scale of 1-4, 4 being the highest):

	Solar	Wind	Battery Bank	Energy Efficiency
Construction Materials	4	1	4	4
Natural Resource Availability	4	1	2	2
Safety	4	3	3	4
Reliability	4	3	3	4
Efficiency	3	3	2	4
Complexity	4	2	3	4
Security	4	2	4	4
Cost	3	1	3	4
Feasibility	4	1	3	4
Social Acceptance	4	1	3	3
Climate Effects	3	3	4	4

Land Use	4	1	2	4
Long Term Operation and Maintenance	4	1	2	4
Sustainability	4	2	3	4
Total	53	25	41	53

6. DESCRIPTION OF PREFERRED ALTERNATIVE

Solar energy system:

Our chosen alternative is the solar energy system, in combination with energy efficiency. This makes the most sense for a number of reasons. Being near the equator and the long days that accompany it, the natural resource availability of solar energy is great. Another advantage to solar is that it will not require any additional land, which would cause a whole other host of issues related to acquiring more land for wind power. A system on the school's current land also helps security, as the school is having a tall barricade built around the school. Solar energy is also accepted and promoted by the community, and is supported in country by a store that could potentially provide replacement parts. A solar energy system's cost is great (our estimate is around 30,000 dollars), but the upfront cost is worth it for a system that has little recurring cost. The solar system will be safe, as there will be no moving parts to hurt someone during operation and the battery system will be secure. A solar system for the school will also be the easiest to construct, as installing panels and building a battery bank is within the technical knowledge of our group.

Energy efficiency is also important because if we decrease the school's current energy use, any system we build for them can be smaller and cheaper. The cost afforded by replacing the school's computers, for example, is nothing compared to the cost of buying additional solar panels. Energy efficiency will augment any solution we come up with for the school, and will make that solution more efficient.

Overall, a solar energy is best for the school because it is the most cost effective, most supported by the community, and most feasible.

7. PROFESSIONAL MENTOR/TECHNICAL LEAD ASSESSMENT

1. Professional Mentor/Technical Lead Name (who wrote the assessment)

Edward Witkin

2. Professional Mentor/Technical Lead Assessment

This alternatives analysis document was prepared by members of the NC State University Chapter of Engineers Without Borders, who are involved with the Sierra Leone Energy project. These individuals include Emma Besaw, Elizabeth Mooney, Nathan Hansen, Jeremy Clark, Sharvil Patankas, and Raz Comby, as well as Dylan Cawthorne and Bryan Peele who I traveled with to Sierra Leone on the assessment trip. The Sierra Leone energy project team has been meeting weekly to process the information gathered, develop a strategy to move ahead with the project, and to prepare this document. Individual members of this team took responsibility for certain sections of this assessment, and Bryan and Dylan have coordinated the process of compiling this information.

Prior to our assessment trip, the Sierra Leone Energy project team considered several scenarios for providing reliable electricity to the Lemon Aid School. Based on this preliminary work and the discoveries of the assessment trip, the group has determined that a solar electric system installed at the school, in conjunction with implementing energy efficiency measures will provide the most viable long-term solution for the school.

Wind energy was one option that was considered. Wind resources in the area were studied by assessing the local terrain, and consulting wind charts for Sierra Leone. These studies showed Sierra Leone to be the lowest wind class in the rating system. Based on this information, and after considering difficult installation issues, on-going maintenance required by wind turbines, and limited (if any) local availability of parts, the team opted to look for other options.

Upgrading to a larger generator to accommodate the electrical loads was a consideration. However through conversations with the on-site facilities coordinator at the Lemon Aid school prior to our assessment trip, and also considering our own observations once in the country, it became clear that an internal combustion generator is not a reliable, economical, or sustainable source of energy for this project. During our trip fuel prices and availability changed dramatically. Additionally, there is a strong desire within the Lemon Aid school community to utilize renewable energy resources.
The project team analyzed solar resources in Sierra Leone based on local weather data, and a thorough site analysis was conducted at the Lemon Aid school during our assessment trip. Measurements of energy use of all the electrical loads in the school were taken, as well as an estimation of future energy usage as the school continues to grow. We took measurements and photos of possible solar array locations at the school, and looked at structural considerations for supporting the solar array and the balance of system components that would be necessary for a complete solar generating system. We also visited two technical training centers in Sierra Leone, including a solar electric training facility. Based on our findings, and several conversations with Lemon Aid school officials, we determined that a new building to support the solar array and system components would be the most practical solution for the school. This new solar electric system along with on-going energy efficiency improvements at the school will provide a long-lasting solution to their electricity issues.

The Sierra Leone Energy Project Team is continuing to meet on a weekly basis, and is enthusiastic about the overall project.

3. Professional Mentor/Technical Lead Affirmation

I have been involved with the Alternatives Analysis throughout the process and agree with the course of action that the project is taking.