Reducing Electric Energy Operating Expenses at Montana de Luz

Spring Break 2009

Engineering 692

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April 17, 2009

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Introduction

Engineers for Community Service is an OSU student organization that utilizes engineering skills and technologies for local and international service projects. Its primary international work since 2005 has been in a rural region of Honduras at Montaña de Luz (MdL), an orphanage for HIV-infected children. This year our energy team focused attention on reducing MdL's electric energy expenses. Energy consumption, in tandem with environmental issues, has become a major focus for people in all nations of the world. We took a multifaceted approach to the problem.

Lighting options were an important part of our research. We developed an economic model for replacing the facility's older fluorescent and incandescent lights with more efficient fluorescents and compact fluorescent lights. Our model estimated that this simple lighting change would reduce the total facility energy consumption by 3.5% with a 4.8 year payback on the investment.

We investigated a method (variable frequency motor controller) to reduce power consumption of the electric pump that distributes water throughout the facility. We spoke with energy experts from OSU and Battelle Memorial Institute, who provided specific energy-saving suggestions as well as equipment to conduct a true electric energy audit of MdL. At the facility we initiated lighting changes in a prioritized fashion, conducted an extensive electric energy audit of MdL's equipment and appliances, studied the effect of relocating refrigerators and freezers to better-ventilated locations and considered better lighting designs in the most-used rooms.

We analyzed all monthly electric bills and correlated the results with facility usage. We met with Honduran electric energy department personnel in order to understand the national position on energy utilization. We established a set of simple recommendations that would further reduce the electric energy consumption at MdL, including implementing natural lighting solutions and re-educating MdL staff and children on energy-saving practices (practices as simple as turning off the light and fan when leaving a room).

Although we found no "silver bullet" solutions for reducing electric energy consumption at the facility, we identified many small but easily implementable measures that would provide a positive cumulative effect on electric energy efficiency at the orphanage.

Project planning and analysis

Toward the beginning of Winter quarter, the Energy Team had a meeting with Vikki Rush, the director of Montaña de Luz (MdL), to determine what her needs and wants were in comparison to what the group was able and willing to do. She clearly stated that she wanted the team to find ways to lessen the electric bills at the orphanage, install solar perimeter lighting, find a way for the guards to not continually consume as many batteries, hook up a generator that had previously been donated and conduct an electrical audit of MdL.

The Energy Team began planning with an in-class brainstorming session modeled after the one used in November's "World Café" discussion. Based on advice given by trip advisor Roger Dzwonczyk, the group quickly determined that solar perimeter lighting was not something we were willing to install or donate for the orphanage. After that the group conducted research on lighting individually and met with Scott Potter from the Institute for Energy and the Environment. Scott Potter informed us on what equipment we would need for our audit and gave us some tips for saving electric energy. One of his suggestions was to move the refrigerator away from the wall.

From the information gathered throughout the quarter the Energy Team decided they would complete an energy audit to discover potential ways to lower energy costs, convert current fluorescent fixtures (T12s) to more efficient fixtures (T8s) in rooms used the most, convert current incandescent lights to CFLs in beneficial locations, implement a plan for future replacements of the remaining lights, explore ways of making the refrigerator more efficient, explore alternatives to traditional batteries for the guards, and meet with a representative from the electrical company (if possible).

Materials budget

The following is a materials list along with the associated cost of the items. An "x" appearing under costs denotes a donated material or material which did not need to be bought.

Table 1: Materials budget

	Materials	Quantity	Cost/Unit	Total Cost
Pre-departure	CFL Lights	13 pkgs (6per pkg)	$ 8.48	$ 110.24
	T8 Ballasts	3	$ 29.70	$ 89.10
	Laptop	1	x	x
	TED	1	x	x
	Kill-A-Watt	3	x	x
In-country	T8 Bulbs	6	$ 2.43	$ 14.58
			Total Cost:	**$213.92**

Interactions with ENEE and Analysis of Electric Bills

The energy team conducted a meeting with ENEE, the national electric company of Honduras, on March 23, 2009 at their office in Tegucigalpa. ENEE is nationally owned and is the sole provider of electricity for all of Honduras. The primary purpose of the meeting was to understand how MdL was being billed for their electricity, whether there were peak usage periods, and how the meter was being read. The rate for MdL's electricity was found to be 3.7432 lempira/kW-h, which is roughly $0.19/kW-h. There is no peak period for the billing; the electricity is billed at a flat rate no matter which time of the day it is being used. The meter is not read remotely, but rather a company contracted by ENEE goes to MdL to read the meter and then prints out the bill immediately afterwards. The representatives stressed the importance of double-checking that the employee reads the meter as opposed to simply making up a number.

Many other insights were taken away from the meeting, as well. It was discovered there is a possibility to sell back energy, which in MdL's case, was inquired about as a result of investigating solar energy. The sugar cane factory nearby MdL sells back electricity created by steam. In order for this to occur, an energy and environmental study needs to be conducted, and only after these are completed can a contract be drawn between MdL and ENEE. It was also discovered that there is no possibility to purchase the transformer that MdL is currently renting, and that their consumption would have to rise to 250 kW-h in order to qualify for the cheaper rate. Because this consumption is significantly higher than MdL uses, it can be assumed that MdL is locked in at their current billing rate.

Finally, it was discovered that ENEE was sponsoring a nation-wide program in Honduras to switch all the incandescent lighting to CFL's. ENEE offered to donate 50 CFL bulbs to MdL as part of their program, and they also offered to visit the facility towards the end of the week to review practices to further reduce MdL's electrical consumption.

After the billing methodology was obtained, analysis could be performed on the billing data. First, the concern that as the orphanage has gotten larger, the electrical consumption has increased was investigated. Figure 1 shows the historical consumption by kW-h. The data shows a very small upward trend, but no huge increases in consumption over time. A correlation could be run comparing the consumption to the amount of people present at the facility during various times; however, this data has yet to be provided.

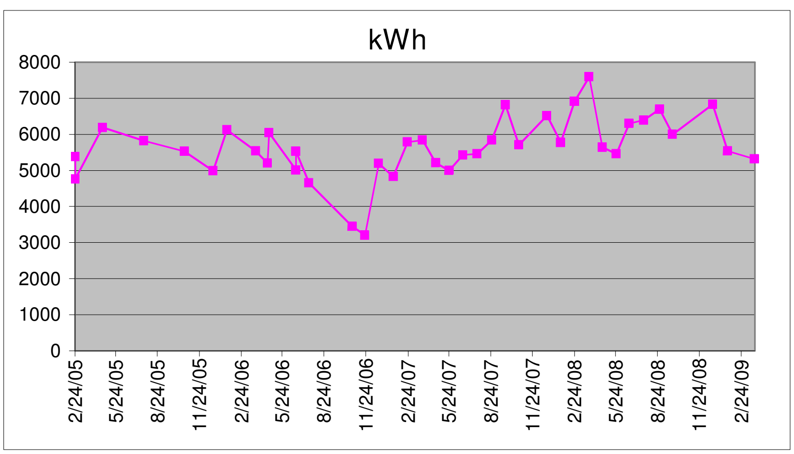

Figure 1: MdL's historical electrical consumption by kWh

Next, the billing was investigated in an attempt to validate the $0.19/kW-h figure obtained from the meeting with ENEE. Figure 2 (on the next page) is a plot of the price per kW-h over time. First, it is important to note that the billing under no steady period was charged at $0.19/kW-h, and the cost only eclipsed this rate in three instances. All three of these instances appear to be a charge of around two times the amount during that period of time.

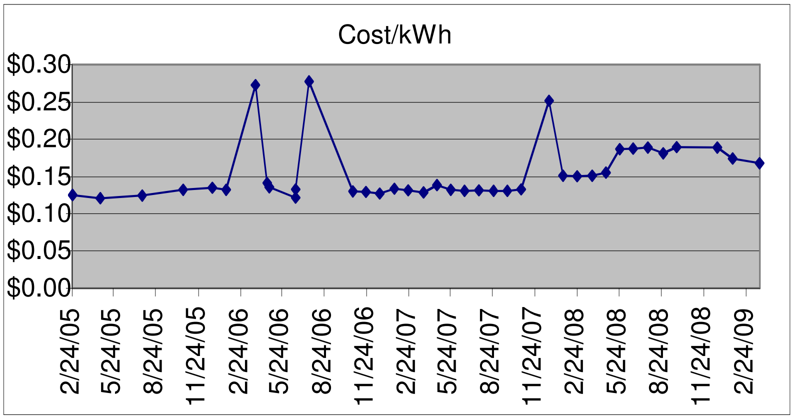

Figure 2: Cost per kWh over time

A second meeting with ENEE took place on March 28, 2009 at MdL. Two representatives came to deliver the CFL lights donated, as well to investigate methods to further reduce energy consumption, as well as provide insight into the remaining billing questions. Appendix F shows the specifications required for all CFL lights issued by ENEE. Lights of 8W, 14W, 18W, and 20W were donated. The following recommendations are being made for installing the CFL lights.

8 Watt Bulbs – Use in rooms that have three lights per room, such as in the guest bedrooms.

14 and 18 Watt Bulbs – Use in areas that have two lights per room, such as the majority of the children's bedrooms. In areas where more light is needed, use the 18 Watt bulbs.

20 Watt Bulbs – Use in areas that have one light per room, or in areas where a significant amount of brightness is necessary.

ENEE also recommended reducing the amount of lights in all rooms possible, to use CFL's instead of fluorescent lights in the rooms where both are installed, and to install CFL fixtures in the bedrooms where fluorescent lights are currently used. They also recommended lowering the lights in the areas with high ceilings, such as in the dining room. In the kitchen, they recommended moving the freezer out of the sunlight if possible, as well as fixing the damage to the freezer's insulation near the opening. In the computer lab, they recommended reducing the heat in the lab through reflective paint and insulation materials. It was also recommended that some roofing panels be replaced by translucent roofing panels in order to allow areas to be illuminated by natural sunlight.

The billing questions were then discussed with the representatives. Specifically, why the bill never reached $0.19 and why the three periods were overcharged. In regards to the rate, they informed that the rate given to us was actually an average over time, and that the actual rate changed daily. In regards to the three anomalies in the data, they did not have answers but promised to inquire about it. However, they did suggest that the corruption of the national government could potentially be leading to overcharge.

Defective TED

Part of the energy audit was supposed to consist of a comprehensive analysis of the energy usage for each circuit breaker box at MdL. The Energy Detective (TED) was purchased by Scott Potter from the Institute for Energy and the Environment, to get information on comprehensive energy usage from each circuit breaker panel. TED was installed in the kitchen's circuit breaker box. The team was unable to get the TED to work. The team then tested the TED in the circuit breaker box to the computer lab. The team e-mailed the company that made the TED. The e-mails resulted in the diagnosis of a defective unit. The cost for international priority shipment of a new unit was too much for the team to justify covering it. Therefore it was not possible to do a comprehensive analysis of the energy usage for anything that did not plug into a standard wall outlet, such as an entire room or the water pump.

Variable Frequency Drive and Transfer Switch Installation

Recently two generators were donated to MdL. MdL wanted to use one of them to pump water from the water cistern to the rest of the complex during power outages. To accommodate this need, a transfer switch, shown in Figures 3 and 4, was installed to allow the pump's power supply to be switched from the electric grid power supply to the generator's power supply.

Theoretically the generators were not capable of supplying the pump's initial power load but could maintain the pump's steady state operations. This was determined from an analysis of the pump's and generator's specifications done by electrician and practicing electrical engineer, Jeff Hutchinson during his visit earlier in the year. A three-phase variable frequency drive (VFD), shown in Figures 3 and 4, was installed to allow the generator to handle the pump's initial load. Unfortunately the pump was a one-phase pump. The VFD could not be altered to be compatible with a one-phase pump. Therefore, the VFD was ineffective and removed.

Figure 3: The final configuration of the main circuit breaker box for the MdL complex (right), and the transfer switch (bottom left) after the VFD (top left) was removed from the system

Figure 4: The VFD (top) after it was disconnected from the circuit and the installed transfer switch.

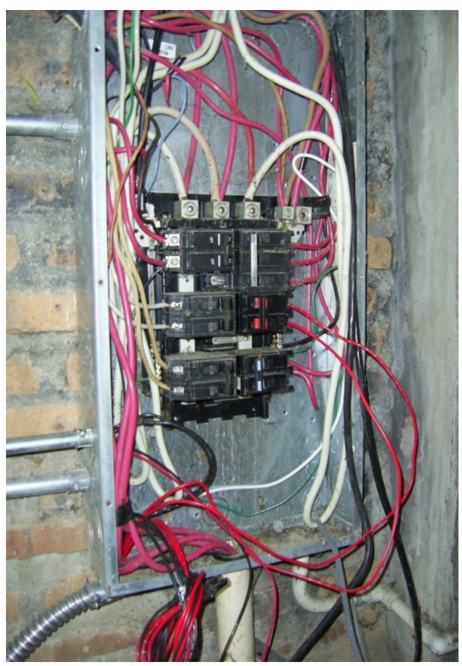

Figure 5: The circuit breaker box for the MdL complex.

Energy Audit

In performing the energy audit of the MdL facilities, the Kill-A-Watt became the main method of measurement. The Kill-A-Watt (pictured in Figure 6) is a small device that can be plugged into any 120V AC outlet that records several useful measurements for most appliances and electronic devices including voltage, power factor, frequency, total complex power, active power, and the length of the data collection time period. To measure the power consumption, the appliance to be measured is plugged directly into the Kill-A-Watt, which is then plugged into a standard wall outlet. Next, the billing rate is set on the Kill-A-Watt, and the devices are left for a time period so that the Kill-A-Watt can record the data from the appliance and the outlet. More accurate cost projections result from longer data collecting periods.

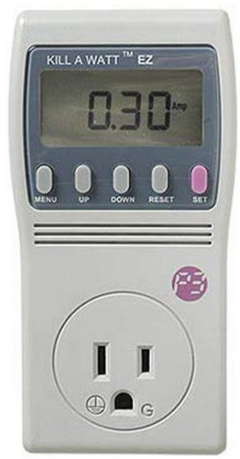

Figure 6: Kill-A-Watt EZ

Various appliances' and electronics' power consumption were monitored at MdL. A main focus of the energy audit was the possible improvement of the energy consumption of the refrigerators in the kitchen. Scott Potter mentioned that simply moving a refrigerator farther from the wall would allow the coils on the back to cool faster and result in lower energy consumption.

To test this method at MdL, the power consumption of the two refrigerators in the kitchen were monitored for a 24-hour period in the locations we initially found them. Then, the refrigerators were moved varying distances from the wall and the resulting drops in energy consumption were recorded over additional 24-hour periods.

An important aspect of this part of the energy audit was deciding on a reasonable distance for the refrigerators to be from the wall. It was crucial that the refrigerators were not moved so far from the wall where it would be unreasonable or inconvenient for them to be located. Doorways and light switches were obstacles in this endeavor. The reasons for moving the refrigerators from the wall were also explained to the kitchen staff at MdL. This was done out of concern that the refrigerators might be moved back to their initial positions out of good intentions of the staff in trying to put the refrigerators back in their normal position.

The energy savings of the Beverage Air refrigerator in its new position was only $7 per year, and the decision was made that the small savings did not justify the inconvenience of the Beverage Air refrigerator partially blocking the doorway and light switches for the kitchen in its new position. The Amana refrigerator was found to be far more efficient than the Beverage Air refrigerator. Although both refrigerators consumed less energy after being moved farther from the wall, the Beverage Air refrigerator's energy consumption is so high that it is highly recommended that it be replaced at earliest convenience.

While the Amana refrigerator experienced the lowest energy consumption with a distance of seven inches from the wall, that distance was determined to be slightly unreasonable for convenience in the kitchen. The decision was made that a distance of four inches from the wall would be the most cost-effective solution with savings of $16 per year.

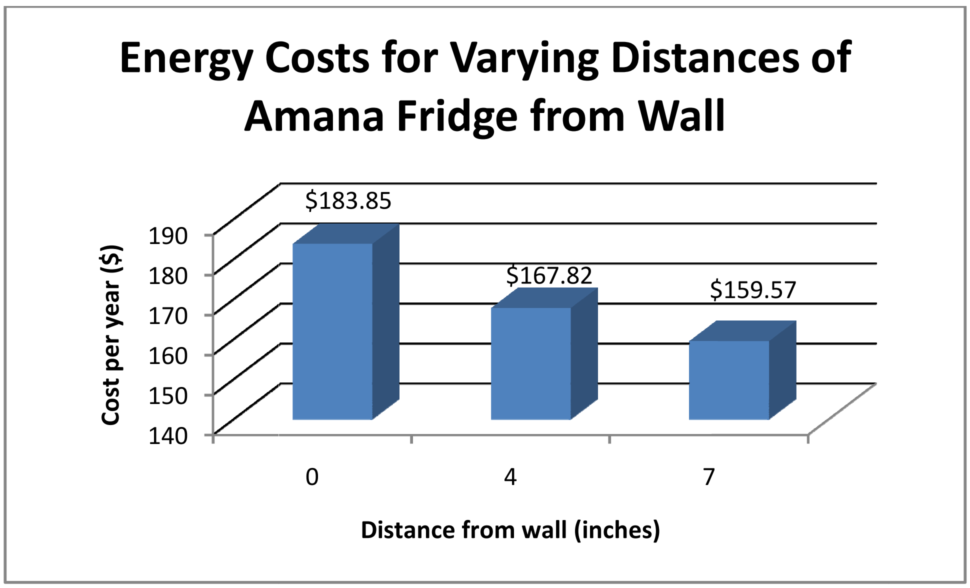

Figure 7: Lowered energy costs because of increased distance between refrigerator and wall

The storage freezer's energy consumption was found to be higher than expected and upon further inspection it was found that the insulation around the freezer's doors were less than ideal. It is recommended that the insulation strips on the door be replaced to reduce energy costs.

The drinking water tank located in the guest dining room was found to cost approximately $120 if left plugged in for the entire year. It is imperative that this water tank be unplugged whenever there is not a group there to use it. The water tank almost costs as much to power as the Amana refrigerator in the kitchen.

While the computer lab is an important investment in the children's education, the energy costs to run it are very high. To run five of the computers for a year, it would cost $334. Therefore, it is very important that the computers be powered down whenever they are not in use. The office computer work stations cost over $250 per year if left plugged in year round. It is also crucial that these be powered down whenever they are not in use.

Several other electronic devices were monitored such as the microwave, television, and VCR. The cost calculations for these devices as well as others can be found in Appendix C: Kill-A-Watt Data. An important takeaway from this portion of the energy audit is that electric devices still draw current when they are plugged into an outlet, even if they are powered off. Therefore, it is always important to unplug something that will not be in use for a long period of time in order to reduce energy costs.

For a future project, it is recommended to explore possible replacements for the Beverage Air refrigerator in the kitchen. Replacing this appliance would significantly lower energy costs per year and be an easily sustainable solution to the rising energy costs at MdL.

T-12 to T-8 fluorescent lighting

A major component of the Energy Team's proposal to lower energy costs at Montaña de Luz was the upgrading of the fluorescent lighting. Currently, the facility uses T-12 fluorescent lighting. While this was much better than incandescent lighting, the T-12s still only had limited efficiency. Since the time of the installation of the T-12 lighting fixtures, newer options such as T-8 bulbs and ballasts had become available. T-8's utilize only 80% of the power that T-12s consume. Over time, this difference in power could add up to a significant reduction in energy bills and cost.

T-8 lighting is not negligibly cheap. In order to upgrade the lighting, there would have to be an initial investment made in the cost of the new T-8 ballasts and lamps. In order to determine how much this initial cost would be, the group researched locally available options for purchasing the new T-8 ballasts and bulbs. They were available at a hardware store in Tegucigalpa.

The next step was to chart energy usage in the orphanage. For the planning phase of the cost analysis, the group had to create its best estimate for power usage in terms of fluorescent lighting. Thanks to a previous report from Elvin Beach, the group had accurate numbers for kilowatt-hour (kWh) consumption at MdL on a monthly basis. Careful observation of the floor plans of the orphanage yielded the exact number of fluorescent fixtures currently in place. This number, along with consultation of those who had been there before and the staff of MdL, allowed the Energy Team to make an average estimate for light usage. This in turn allowed the team to calculate about how much lighting was costing MdL per month.

The team then calculated what the cost per month of energy usage with T-8 lighting fixtures would be. The cost savings were appreciable, but not as much as had been hoped. Of particular concern to the group was the fact that recouping the cost of buying all the T-8 lighting ballasts and lamps could take an excess of three years.

The conclusion from this analysis was that MdL should not partake in one complete turnover from T-12 lighting to T-8 lighting, but rather implement a phased upgrading of the lighting.

Phased T-8 Implementation

In order to fund the changeover from T-12 to T-8, MdL's best option was to phase in the T-8 lighting fixtures over time. The Energy Team set out to target the most-used rooms that utilized fluorescent lighting. By first implementing the changeover first in high-usage areas, the payback-to-investment ratio could be maximized. The next step would be to proliferate the use of T-8s to the mid-usage areas. Finally, the last step would be to completely replace all T-12 fixtures and ballasts. The Phased T-8 Implementation should be as follows:

- Phase I - Assessment and Preliminary Installation
    - One year/visit
    - Assess the areas of highest usage
    - Consult with staff as to which lights get used the most often
    - Assess accessibility of light fixtures in order to determine which ones will require specialized equipment to reach and perform maintenance on
    - Install limited number of T-8 ballasts/lamps with locally available materials
    - Create easy-to-understand manual so that other groups can continue installation
- Phase II – Continued Implementation
    - Multiple years (2-3)
    - Continue replacing T-12 lights with T-8 alternatives, prioritizing the rooms of highest usage first.
    - Utilize TED from Scott Potter (The Energy Detective) to measure energy savings
    - Educate the staff at MdL in simple energy-saving practices (using the minimum number of lights necessary for a room, turning off lights when leaving a room, etc.) This will optimize the light electricity savings
    - Track local pricing of energy-efficient lighting to stay on-cost
- Phase III – Final Implementation
    - One year/visit
    - Do complete survey of fluorescent lights remaining at MdL
        - Determine if there are any T-12 fixtures that are used so infrequently that they do not need to be replaced
        - Determine if additional lighting is necessary anywhere in the MdL facility
    - Replace any remaining candidates for upgrade to T-8
    - Ensure that disposal of T-12 lighting has occurred (selling in the MdL store?)
    - Ensure that good energy practices will be continued
    - Ensure that T-8 supplies will continue to be available

In order to get data to compare the projected cost savings to actual cost savings, the TED unit (The Energy Detective) needs to be taken and installed in the breaker boxes prior to installation of T-8 bulbs and then again after installation to measure the power usage difference. These numbers can be compared to the calculated values in order to ensure the project is staying on-target and on-budget.

Flashlights

One of the biggest energy-related budget concerns of MdL was the battery consumption of the guards' flashlights. The guards patrolled the ground of MdL at night, carrying flashlights. These flashlights were vital in order to see obstacles, hazards, and possible safety risks. In short, they were too essential to discontinue using. At the same, they were chewing through D batteries at an alarming rate. Vicki expressed a desire to find a more cost-effective lighting option.

Earlier in the year, MdL had attempted to address the flashlight problem on their own. They had purchased locally available solar-powered flashlights and given them to the guards. The guard, however, rejected these solar-powered alternatives. They cited problems in brightness and reliability and fell back to using the battery-eating model of flashlights.

The flashlights had not originally been part of the Energy Team's plan to save electrical energy costs at MdL. Only after planning had begun for the trip did the idea of flashlights come to the attention of the OSU group. Consequently, the decision was made to only take preliminary problem-solving steps. It was too far into the project to re-adjust the budget, the timetable, etc. To this end, the group focused solely on researching the problem rather than actual implementation.

Two group members visited Batteries Plus, a business with a Columbus location that specializes in batteries and energy storage. They had several options, including a limited solar-powered flashlight supply, mass quantities of conventional D batteries available for mass sale, and several plug-in rechargeable flashlights. Batteries Plus was extremely helpful and offered discounts on all of the available options.

The most promising solution looked to be rechargeable LED flashlights that the Columbus Police use. They were long-lasting, low-energy, and reusable for years. The initial flashlight units cost upwards of $100, however, so it would be a significant investment from MdL.

While at MdL, we were able to examine the current flashlights used by the guards. The flashlights actually surprised us in terms of simplicity and low levels of brightness. They looked extremely out of date. This made us question our earlier high-tech solutions and re-assess.

Though we hope future groups will do further research into this energy problem, our final suggestion was to simply replace the flashlights at MdL with conventional, newer LED flashlights. While they would most likely still operate on batteries, the LED flashlights are cheaper than the rechargeable variety and the batteries would last much longer. Additionally, these flashlights would be brighter than the current flashlights in use by MdL personnel.

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Appendix A: Summary of communication needs

Some Spanish words that the Energy Team used to communicate with the locals about the project are listed below.

Table 2: Useful vocabulary

English	Spanish
Light	Luz
Fluorescent light	Tubo fluorescente
Incandescent light	Luz incandescente
Electricity	Electricidad
Energy	Energía
Power	Potencia
Current	Corriente
Voltage	Voltaje
Equipment	Equipo
Fan	Ventilador
Tools	Herramientas
Generator	Generador
Flashlight	Linterna
Refrigerator	Refrigerador
Ballast	Lastre
Wire	Cable

Appendix B: Team's working agreement

Team Members

Jessica Burk

Rob Kapaku

Stephen Marks

Lisa Reisenauer

Roger Dzwonczyk

Team Project Expectations

- Complete an energy audit
- Supply new information to future groups
- Install generator(s)
- Explore possibility of exterior solar-powered lighting
- Do a cost/benefit analysis of converting the current fluorescent fixtures (T12s) to more efficient fixtures (T8s)
- Explore possibility of weather system that could send data back to OSU

Team Member Roles and Responsibilities

- Come to class on time and prepared
- Do equal share of work
- Keep good documentation

Team Meeting Ground Rules

- Be respectful
- Avoid distractions and keep meetings on topic

Team Member Signatures

1. ______________________________________

2. ______________________________________

3. ______________________________________

4. ______________________________________

Appendix C: Kill-A-Watt Data

Appliance	Volts	PF	Hz	VA	Watts	Amps	Hours	Total Cost	per Hr	per Day	per Week	per Month	per Year	Rate
Refrigerator-Amana	108.9	0.98	60	154	151	1.39	24.2333	$ 0.51	$ 0.02	$ 0.51	$ 3.54	$ 106.07	$ 183.85	$0.19
Refrigerator-Amana @ 4in.	110.1	1.00	60	0	0	0.00	22.3833	$ 0.43	$ 0.02	$ 0.46	$ 3.23	$ 96.82	$ 167.82	$0.19
Refrigerator-Amana @ 7in.	109.1	1.00	60	0	0	0.00	25.1833	$ 0.46	$ 0.02	$ 0.44	$ 3.07	$ 92.06	$ 159.57	$0.19
Refrigerator-Beverage Air	108.9	0.65	60	440	288	4.05	24.1500	$ 1.37	$ 0.06	$ 1.36	$ 9.53	$ 285.91	$ 495.58	$0.19
Refrigerator-Beverage Air	111	0.65	60	440	288	4.05	23.0833	$ 1.29	$ 0.06	$ 1.34	$ 9.39	$ 281.66	$ 488.21	$0.19
Storage Freezer	113.7	0.56	60	451	255	3.97	4.7833	$ 0.21	$ 0.04	$ 1.05	$ 7.38	$ 221.27	$ 383.53	$0.19
Microwave	111.7	1.00	60	0	0	0.00	23.7000	$ 0.14	$ 0.01	$ 0.14	$ 0.99	$ 29.77	$ 51.61	$0.19
Drinking Water Tank	112.5	0.71	60	18	0	0.16	3.6667	$ 0.05	$ 0.01	$ 0.33	$ 2.29	$ 68.73	$ 119.13	$0.19
Office Power Strip- Ellen's	112.2	0.80	59.9	150	114	1.30	23.9833	$ 0.44	$ 0.02	$ 0.44	$ 3.08	$ 92.46	$ 160.27	$0.19
ydia's Computer	112.7	0.94	59.9	109	112	1.00	24.9000	$ 0.26	$ 0.01	$ 0.25	$ 1.75	$ 52.63	$ 91.22	$0.19
Efficient Washer	112.5	0.23	60	11	2	0.10	26.9667	$ 0.17	$ 0.01	$ 0.15	$ 1.06	$ 31.77	$ 55.07	$0.19
Television	113	0.57	59.9	58	33	0.51	0.1333	$ -	$ -	$ 0.15	$ 1.05	$ 31.50	$ 54.60	$0.19
VCR	112	0.56	59.9	23	13	0.20	0.2167	$ -	$ -	$ 0.05	$ 0.35	$ 10.50	$ 18.20	$0.19
Coffee Maker	107	0.12	59.9	7	0	0.07	23.5000	$ 0.16	$ 0.01	$ 0.16	$ 1.14	$ 34.31	$ 59.48	$0.19
5 Computers	116.7	0.41	60	56	23	0.49	25.1167	$ 0.96	$ 0.04	$ 0.92	$ 6.42	$ 192.64	$ 333.90	$0.19

Table 3: Kill-A-Watt Data

Appendix D: Instruction Manual for T12 to T8 Transition

Converting

T-12 Fluorescents

to

T-8 Fluorescents

Background

In 2008, Montaña de Luz asked engineering students from The Ohio State University to look into energy-saving solutions. The cost of energy in the rural regions of Honduras had been steadily climbing for years. Developing nations such as Honduras have been struggling to provide enough electricity for its populace. By reducing the energy usage of Montaña de Luz, the OSU Engineers could help ensure that MdL had enough financial means to continue its humanitarian mission to HIV-positive children in Honduras.

Among other energy solutions, the team decided to gradually upgrade the fluorescent lighting at MdL. T-12 fluorescent lights use 25% more power than T-8 fluorescent lights. The cost savings would be immediate and long-lasting. However, when the cost of purchasing the new lighting was calculated, it was determined that one massive switch to T-8s would not be cost effective. Thus, the decision was made to make the changeover a gradual process that could be a justified expense over a long period of time.

Because the OSU Engineers only visit MdL once a year, other groups would need to help the lighting upgrade process. To that end, this document was created in order to instruct groups how to install new T-8 lighting in place of the current T-12 lighting.

For questions or concerns, contact Rob Kapaku at kapaku.1@osu.edu or robert.kapaku@gmail.com.

Materials Needed

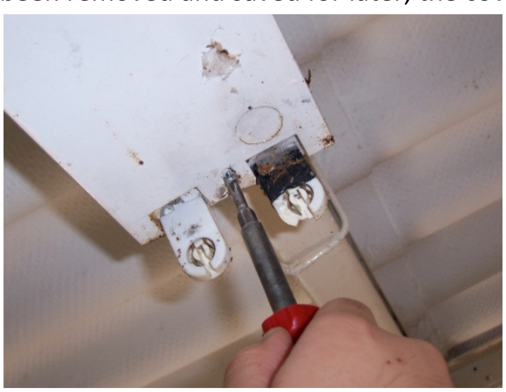
- (1) T-8 Ballast (found in Tegucigalpa hardware store)
- (2) T-8 Lamps (aka bulbs, found in Tegucigalpa hardware store)
- (1) Ladder
- (1) Screwdriver
- (1) Electrical Tape / Wire Caps
- (1) Wire cutters / trimmers
- (1) Pliers

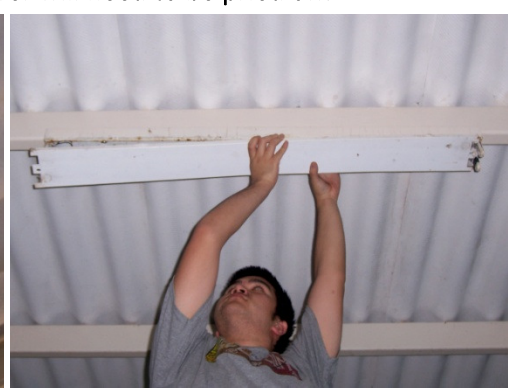
DIRECTIONS

1. Locate fuse box; turn off.

2. Put ladder comfortably under T-12 light fixture.
3. Carefully remove the current T-12 bulbs by twisting and pulling down.

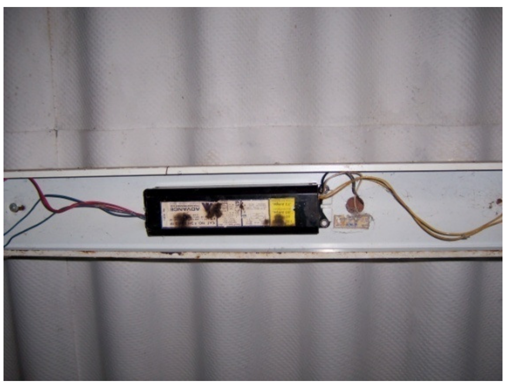
4. Remove light fixture cover; should be two screws, one on either end. After the screws have been removed and saved for later, the cover will need to be pried off.





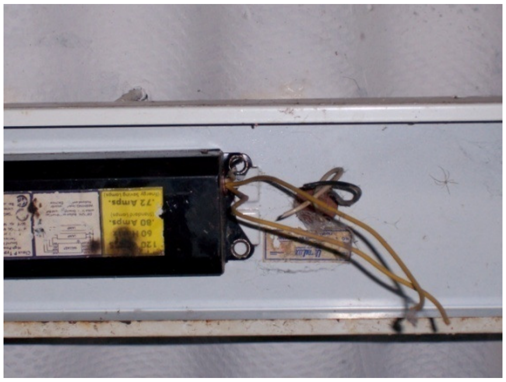
5. Using broom, hands, whatever, clean out any critters and nests that may be inside the light fixture.


6. The current T-12 ballast should have a total of 8 wires coming out of it. One side will have two reddish wires and two blue-green wires. The opposite side should have two yellow wires and then a set of black and white wires.

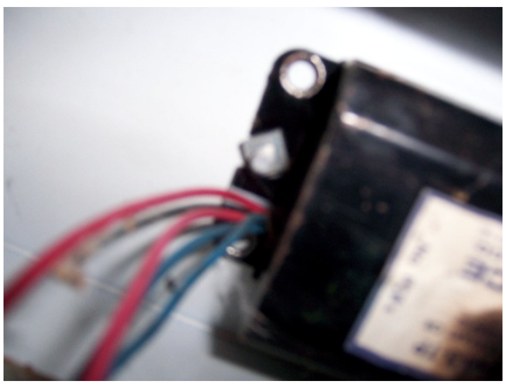


7. Cut the red, blue-green, and yellow wires. Cut them so that most of the wires' lengths remain with the fixture rather than attached to the T-12 ballast.

8. Cut the black and white wires as close to the current T-12 ballast as possible.

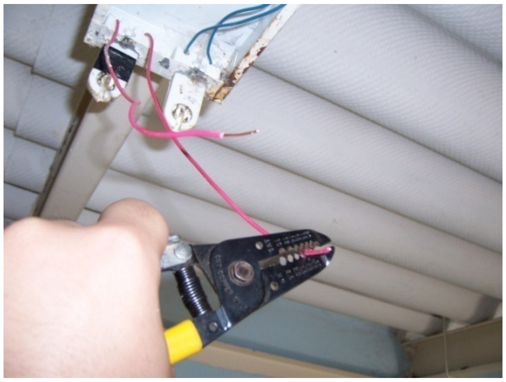


9. There will be at least one washer securing the T-12 ballast to the fixture. There may be one on either end of the ballast. Remove it (them) and completely remove the T-12 ballast. Save the washer(s). The ballast should be kept for storage and safe disposal, or for use as a replacement T-12 ballast for malfunctioning light fixtures elsewhere in the complex.

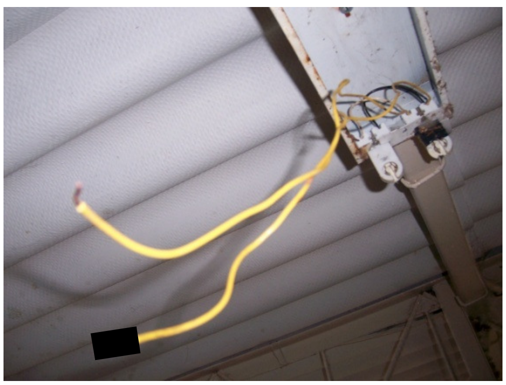
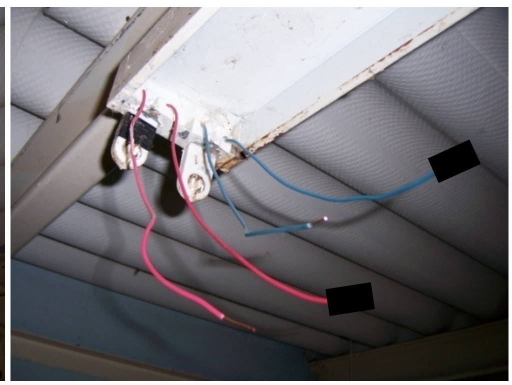



10. Strip the wires on the replacement T-8 ballast. There are two blue wires on one end and on the other end are a red wire, a black wire, and a white wire. Strip the ends of all of these wires about 1 centimeter from the ends. Use wire strippers.

11. Strip the wires left in the fixture. Only one of each color wire needs to be stripped (1 red, 1 blue-green, 1 yellow, the black, and the white).

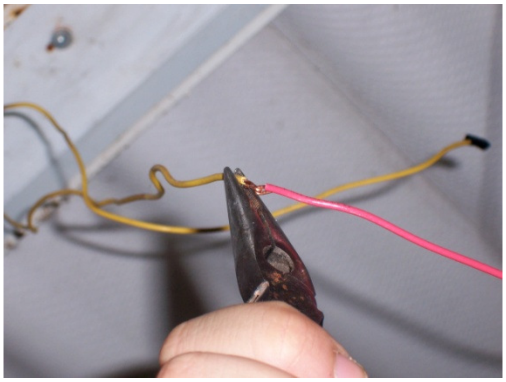
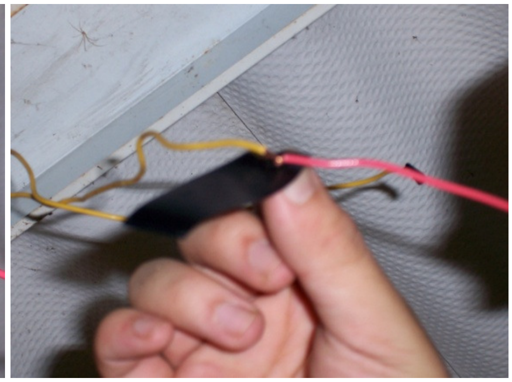
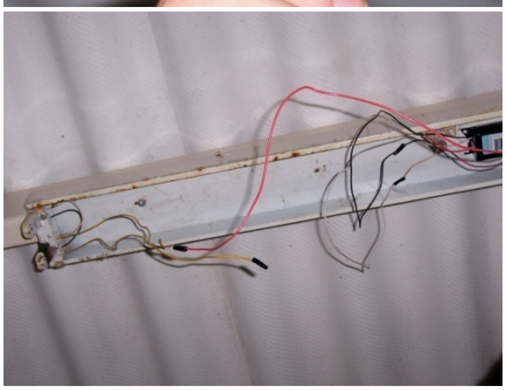
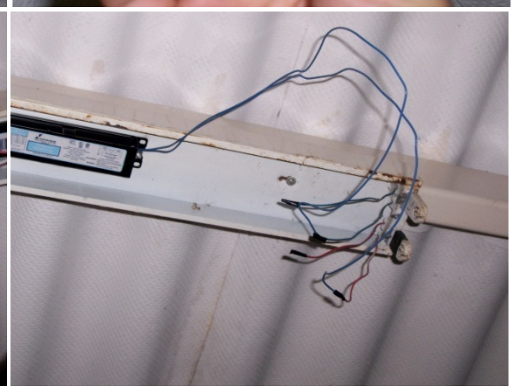


12. Use electrical tape or wire caps to cover the unstripped wires in the fixture. For safety reasons, these wires (1 yellow, 1 red, 1 blue-green) should be completely insulated by the electrical tape or wire cap.

13. Making sure to orient the T-8 ballast's black and white wires on the side where the fixture black and white wires are, place the T-8 ballast where the T-12 used to be. It should fit exactly where the T-12 used to be. Use the washer that held the T-12 in place to secure the T-8 in place.

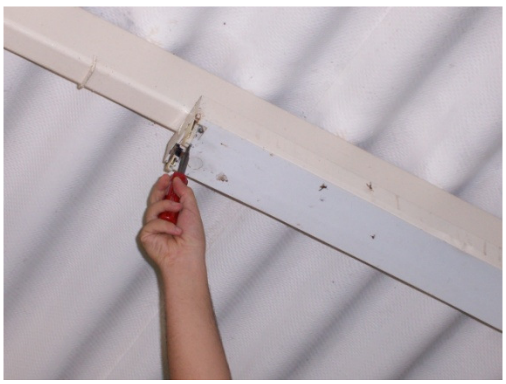

14. Connect the white wire from the T-8 ballast to the white wire from the light fixture. The exposed wires should be completely entwined, forming a secure connection. Use electrical tape or wire caps to insulate the connection.
15. Connect the black wire from the T-8 ballast to the black wire from the light fixture.
16. Connect the red wire from the T-8 ballast to the exposed yellow wire from the light fixture.
17. Connect one of the blue wires from the T-8 ballast to the exposed red wire from the fixture.
18. Connect the other blue wire from the T-8 ballast to the exposed blue-green wire from the fixture.

19. Before covering everything up, place new T-8 bulbs in the light fixture. Insert them the same way the T-12 bulbs were inserted, by installing them and then rotating to secure them in place.

20. Making sure all wires are completely insulated and no one is touching any wires, turn the circuit breaker back on. Flip the light switch to verify a successful installation. If the lights do not illuminate, go through previous steps and re-check all connections.
21. If bulbs successfully illuminate, turn off lights and turn circuit breaker back off.
22. Carefully remove T-8 bulbs by twisting and pulling down.
23. Making sure all wires are insulated once more and all connections are good, push the wires into the fixture and out of the way.

24. Re-attach the cover to the light fixture with the screws from Step 2.



25. Insert the T-8 bulbs by installing them then rotating to secure them in place.

26. Pack up all tools and supplies.

Appendix E: MdL Lighting Analyses

Facility Assumpions			
Usage %			
Total Daily Usage (hrs)	6		
Cost per kWh	$ 0.19		
Total Electric Bill	$ 9,700.00		
Proposed Change			
% to T8	100%		
% to CFL	100%		
Light Type	**Watts**	**Current # lights**	**New # Lights**
T8	32	x	6
T12	40	150	144
Incandescent	60	0	0
CFL's	13	x	0
Current Usage Cost:	**Daily Cost**	**Yearly Cost**	
T12	$ 6.84	$ 2,496.60	
Incandescent	$ -	$ -	
Total	**$ 6.84**	**$ 2,496.60**	
Future Usage Costs	**Daily Cost**	**Yearly Cost**	
T8	$ 0.22	$ 79.89	
T12	$ 6.57	$ 2,396.74	
Incandescent	$ -	$ -	
CFL's	$ -	$ -	
Total	**$ 6.79**	**$ 2,476.63**	
Analysis			
% Reduction	**-0.80%**		
Yearly Savings	**$ 19.97**		

Figure 8: Analysis of lighting transition at this point in time

Facility Assumpions				
Usage %				
Total Daily Usage (hrs)	4			
Cost per kWh	$ 0.19			
Total Electric Bill	$ 9,700.00			
Proposed Change				
% to T8	100%			
% to CFL	100%			
Light Type	**Watts**	**Current # lights**	**New # Lights**	
T8	32	x	150	
T12	40	150	0	
Incandescent	60	76	0	
CFL's	13	x	76	
Current Usage Cost:	**Daily Cost**	**Yearly Cost**		
T12	$ 4.56	$ 1,664.40		
Incandescent	$ 3.47	$ 1,264.94		
Total	**$ 8.03**	**$ 2,929.34**		
Future Usage Costs	**Daily Cost**	**Yearly Cost**		
T8	$ 3.65	$ 1,331.52		
T12	$ -	$ -		
Incandescent	$ -	$ -		
CFL's	$ 0.75	$ 274.07		
Total	**$ 4.40**	**$ 1,605.59**		
Analysis				
% Reduction	**-45.19%**			
Yearly Savings	**$ 1,323.75**			

Figure 9: Analysis of complete lighting transition

Appendix F: Fact Finding Summary and Recommendations

Engineers for Community Service (ECOS) 2009 Spring Trip to Montaña del Luz (MdL) Honduras CA

Fact Finding Summary and Recommendations

Empresa Nacional de Energia Electrica (ENEE) 23 March 2009

- Meeting with Jose Jorge (channelsfan@yahoo.com) and Carlos
- Current MdL cost of electricity – 3.7432L/kWh or approximately $0.19/kWh flat rate
- ENEE will buy back electric energy generated by MdL
- Monthly Charges – ENEE contracts with third-party company to read MdL meter. The employee generates an invoice at the time of reading and gives the invoice to MdL staff.
- ENEE has an active program to reduce electric energy consumption in Honduras. The Country has mandated a 100% switch from incandescent lights to CFLs by 2010. Actively involved in educating the population on energy saving practices (see brochures).
- ENEE Recommended CFLs. Samples left at MdL.
    - Landlite 100W/20W Mini Lelitron, 1300L, 10,000hour, 6,500°K, 120VAC, 60Hz, m/n ELH20W/6,500°K, www.landlite.com
    - Global 90-140VAC, 60Hz, 90W/18W, 6,000hour, m/n ELG/B18W6,400°K, not for use w/dimmers, electrical timers, photocell devices, occupancy sensors or in enclosed downlights
    - HiLight, 90W/18W, 90-140VAC, 6,400°K, m/n HLSC T318W6,400°K
    - Dien guang, Luz del dia, 70W/14W-E27, 115VAC, 60Hz
    - HiLight, 40W/8W, 90-140VAC, m/n HLBA/T3-3u8W6,400°K
- Recommended CFL Venders
    - Sylvania
    - GE
    - Phillips
    - Osram

Specification and Pricing for Lights and Devices Brought from Columbus

- CFL – Bright Effects, 60W/13W, 825L, 8,000hour, soft white 2,700°K, Item 252003, China, $8.48/6-pack
- T8 Ballast – Advance Transformer, m/n ICN2P32SC, for 2 F32T* RS/IS lamps, 120-277VAC, 50-60Hz, $26.44/each, www.advancetransformer.com, 10275 West Higgins Road, Rosemont, IL 60018, 800.322.2086, 800.372.3331.

Pricing for Lights and Devices in Honduras

- CFL – 100W/24W L 91.00, $4.90
- CFL – 60W/15W L68, $3.67
- T8 2-bulb Ballast – L380, $20.54
- T8 48" 32W bulb – L45, $2.43
- 2-Bulb Reflector – L110, $5.95
- T8 Fixture w/reflector w/o bulbs – L230, $12.43

Water Heater Data

- Dormitory Water Heater – Cal-O-Rex, electric, m/n E75/240/4500/2, s/n010000012003, 220-240VAC, 50-60Hz, 276L, approximately 73g, top element 3,800-4,500W, bottom element 3,800-4,500W, total 3,800-4,500W.
- Kitchen/Residents Water Heater – Bradford Electric, m/n WL2443165, 302.8L, approximately 80g,240VAC, upper coil 4,500W, bottom coil 4,500W, pressure test 300psi, working pressure 150psi, Energy Guide 5,355kWh/year.

Area Lighting Specifications

- The Designer's Edge, 120VAC, m/n L-1700, 175W, mercury vapor, 6,000L.

Solar Energy Alternatives Tegucigalpa Honduras

- Soluz Energea Soar – www.soluzhonduras.com, 130W panel, $1,000.
- Soaris – 100W panel, $650.

Variable Frequency Motor Controllers

- Schneider Electric/Telemecanique – m/n ATV31HU40M3X, 4kW/5hp 200-240VAC 3-phase controller

Auxillary Water Pump for Pumping Water from City Tank to MdL

- Typhoon, m/n T55CXBSE-1066 CAT SF, 115/230VAC, 60Hz, 15.6/8.2A, single phase

Accomplishments

- Replaced two 2-bulb T12 fluorescent fixtures with T8 bulbs and T8 ballasts in dining area.
- Replaced one 2-bulb T12 fluorescent fixture with T8 bulbs and T8 ballast in old kitchen.
- Collected 24-hour energy usage data on most appliances in kitchen, computer lab, laundry facility.

- Met with ENEE officials to discuss billing issues and electric energy conservation measures.
- Analyzed all monthly billing data for MdL from 2005-current.
- Permanently wired the generator transfer switch at a location adjacent to main power panel.
- Did preliminary wiring for installation of a variable frequency pump motor controller.
- Diagramed the MdL water distribution system. (Figure 10 on the next page).

<u>Recommendations For Reducing Electric Energy Consumption</u>

- Replace incandescent bulbs with CFLs as the incandescent bulbs fail. Do not replace working incandescent bulbs. Wait for the incandescent to fail.
- Replace T12 fluorescent lights with T8s. Do not replace working fluorescent lights. Wait for the fluorescents to fail. This replacement will require changing the bulbs and the ballasts. Change defective end connectors on the fixtures.
- Change the 2-bulb T12 fixtures with 1-bulb T8 fixtures with reflectors.
- Consider new lighting designs in the most used areas of the facility. For instance, in the dining room use only two 2-bulb T8 fixtures with reflectors rather four 2-bulb T12 fixtures. Change the placement of the fixtures to provide even illumination.
- Replace transparent roofing panels with translucent roofing panels in various rooms of the facility so that the areas can be illuminated with natural sunlight. Refer to the shop area where two translucent panels allow enough sunlight into the area to be able to work without using the fluorescent lights.
- Install variable frequency controllers on the lift pump and distribution water pump.
- Replace the flashlights at MdL with conventional, newer LED flashlights

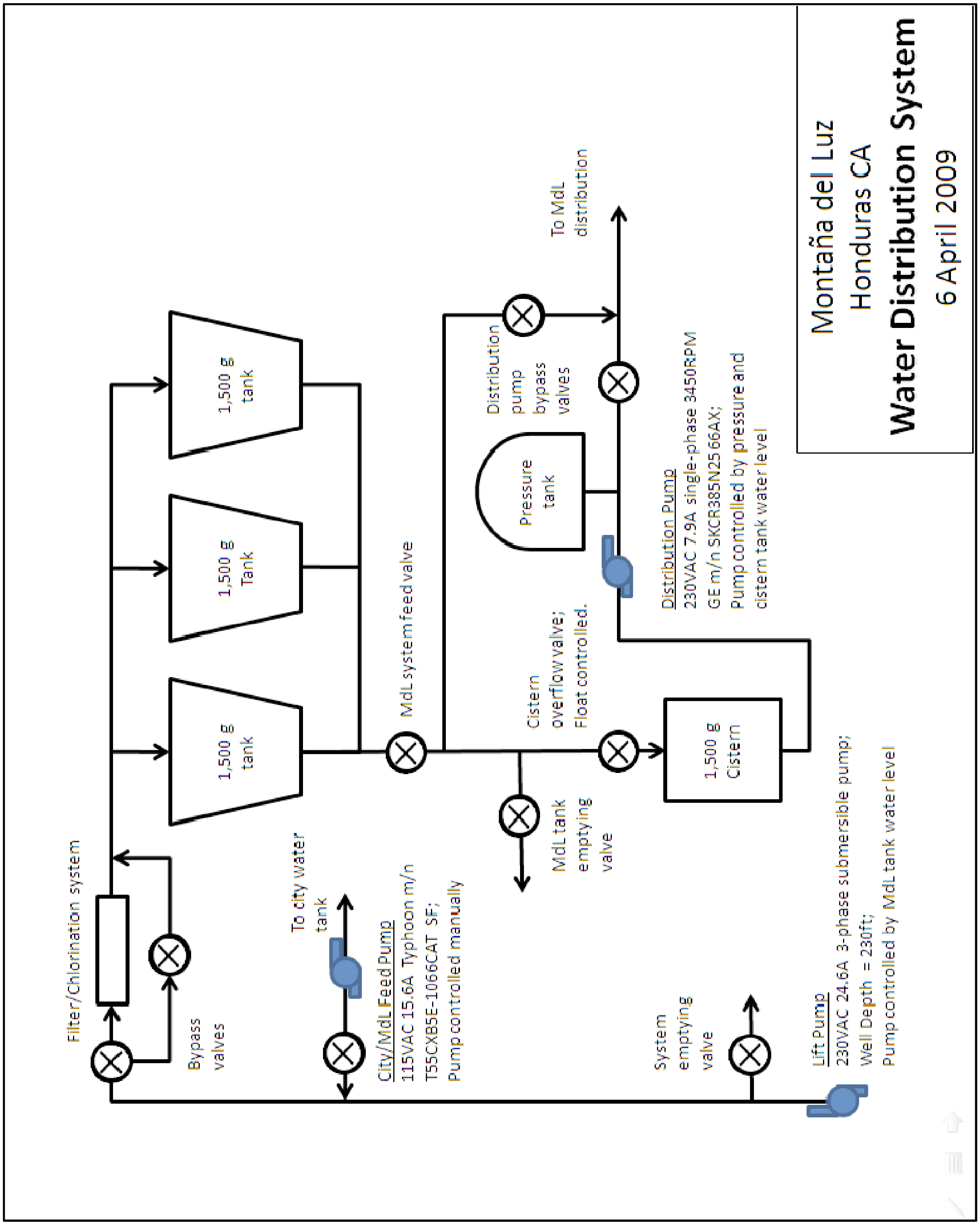


Figure 10: Water Distribution System at MdL