Cummins Energy Saving

Project Plan and Product Specification

Team Number: Team 2

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1. Dpb11f
2. Wab10
3. Dac10c
4. Krf11b
5. Mjf12g

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Abstract

The focus of this report covers the project plan and product specification for the Cummins Energy Saving project. Cummins needs to reduce the power consumption at their technical center in Indiana by 10%. Team 2 has met with Roger England, the Cummins sponsor, and discussed the initial steps needed to make this a successful project. Weekly team meetings and biweekly advisor meetings have been held, and team members have established positions, project tasks, and resource allocations. Team 2 has completed a solar panel analysis using MATLAB in order to determine the feasibility of solar panels on the technical center. The solar panel analysis is included in the product specification of this report. Currently, the team is working on touring the Off-Grid Zero Emission Building to gather information about grid monitoring systems and brainstorm designs to make the device more efficient for the technical center. Once this has been completed, Team 2 will use the gathered data to make an informed trip to the Cummins Technical Center in Indiana and start work on a final report and design.

1 Introduction

Team 2 has been asked by Cummins to reduce the power consumption at their Technical Center in Indiana by 10%. In 2011, Cummins began to supplement some of its power sources in certain locations with solar panels and rerouting energy developed from their test cell dynamometers back into the grid. Also, they have been attempting to reduce power consumption by conventional means through light bulb replacements and light switch modifications. In order to solve this problem, the idea of solar panels and a grid monitoring system have been presented to assist in the consumption reduction.

Team 2 will create a power consumption reduction plan for Cummins that is both economically and environmentally efficient. Part of the technical challenge is determining the feasibility of solar power for the location, as well as the cost effectiveness of the solar power. Additionally, there is a challenge in designing a prototype grid monitoring system that can be used in an industrial center when the prototype will be based on the local Off Grid Zero Emission Building at FSU. This report consists of additional background research that is imperative to the development of the solar panels and grid monitoring system. Also, the report consists of a project plan and the product specification.

2 Project Definition

2.1 Background research

Since 2011, Cummins has implemented solar cells as an alternative means of power in several of their facilities. Presently the company has five solar arrays capable of generating up to 230kW. While this is an impressive feat, Cummins is looking to further capitalize on cleaner, more efficient sources of energy[1].

Florida State is in a unique position to assist in solving this problem with their Off-Grid Zero Emission Building (OGZEB). The OGZEB is a prototype used to test the feasibility of solar power in residential buildings. Though this is a residential application, the theory and techniques can be applied to an industrial setting. By utilizing the power monitoring systems in the OGZEB, Team 2 will have the ability to do the necessary research to solve the problem for Cummins[2].

2.1.1 Energy Audit

An energy audit is the practice of surveying a facility in order to identify different opportunities to reduce energy consumption and optimize the efficiency of energy usage[3]. To achieve this final goal, the use of energy management is critical; which consists of organizing financial and technical resources and personnel to maximize energy efficiency. Energy management also consists in keeping and maintaining records of energy usage and the performance of all machinery or appliances. An appropriate record keeping can help to determine the areas in which the efficiency is under the standards of the facility. Depending on the building, the approaches to improve the efficiency of the energy usage can vary, and are often subject to the areas that consume the most energy. In most cases, the HVAC (heating, ventilating and air conditioning) is the source of major energy consumption in manufacturing facilities mainly due to heat generation from machinery and processes.

2.1.2 Solar Panels

A solar panel, or module, is a series of interconnected silicon cells joined together to form a circuit. In greater numbers the amount of power produced by these interconnected cells can be increased and used as an electricity production system[4]. For this project, the main focus will be analyzing the feasibility of implementing photovoltaic cells on the roof of the technical center for energy generation. Photovoltaics cells are design to supply energy to commercial or residential buildings. The efficiency of these cells can go up to 19%. These cells need to be in arrays because each cell can only produce a limited amount of energy. Each package of solar panels may include the cell, a DC/AC converter, a solar tracker, and a battery. The theory behind the energy generation of these cells is the photovoltaic effect which consists of converting the energy of the Sun coming to Earth in the form of photons to electrical energy. This is done when the photons interact with the material's surface on the cells and excite the valance electrons, breaking them free and making them jump to the conduction band enabling the use of the electrical energy. The first usage of these modules was in the aerospace industry in 1958.

2.2 Need Statement

The Cummins Technical Center in Columbus, Indiana is looking to reduce their power consumption by 10%. While Cummins has already made great strides in reducing power consumption in their company, they believe there is still more work to be done. Cummins has asked Team 2 to look at the efficiency and feasibility of solar cells as well as rerouting power from dynamometers back to the grid. Additionally, Cummins would like a method to monitor the power grid in order to reroute power and eliminate waste.

"Cummins needs to reduce their energy usage in order to save money and reduce their environmental impact."

2.3 Goal Statement & Objectives

2.3.1 Goal Statement

The goal of the project is to, “Review current Cummins Technical Center (CTC) electrical usage and devise a plan to decrease it by 10% and design a monitoring system.”[5]

2.3.2 Objectives

- Analyze feasibility of implementing solar panels for energy generation based on weather, altitude, and longitude conditions.
- Measure electricity consumption.
- Evaluate current processes.
- Create a Pareto chart to show opportunities to reduce electrical consumption based on capital invested.
- Decrease the energy consumption by 10%.
- Create a monitoring system for energy consumption.

3 Constraints

The project must be completed under the following constraints:

- Any methods applied for reduction in power consumption must be cost effective for potential capital invested.
- The monitoring system must cost less than $2,000, our allotted budget for a working system.
- Any power saving ideas (e.g., Solar Panels) should apply to weather conditions for Columbus, IN.
- Solar Panels must be able to fit on the roof of Cummins Technical Center.

3.1 Design Specifications

The design specifications for the required solar panels are described in the following section. These design specifications were calculated with the insolation on Indiana equal to $100\frac{W}{m^2}$ on average throughout the year. Cummins wants to reduce their total energy usage by 10%.

Table 1. Annual CTC Energy Usage

Annual Energy Used	759,640 GJ
Annual Energy Cost	$17,935,949.50

As shown in Table 1, Cummins' current yearly usage is approximately $759{,}640\ GJ$, so the annual saving goal would be $75{,}964\ GJ$.

3.1.1 Solar Panels

From the average insolation calculated, solar panel dimensions were derived from the constraint of the roof in order to calculate the total area of the solar panels allowed. As shown in Table 2, the dimensions of both roofs and usable area are presented. Team 2 has not been able to travel to the facility and take direct measurements, so measurements were approximated using satellite imaging of the two technical center roofs. From Table 2, the amount of useable roof area was found to be $2{,}125\ m^2$.

Table 2. Roof Dimensions

	Width (m)	**Length (m)**	**Area (m^2)**	**% Useable**	**Useable solar area (m^2)**
Roof 1	35	35	1,225	100	1,225
Roof 2	90	100	9,000	10	900

3.2 Performance Specifications

Table 3 shows the different specifications Team 2 has developed in order to reduce the energy consumption by 10%. As stated before, Team 2 has not visited the technical center so measurements are based off of background research conducted and are accurate to limited constraints.

Table 3. Performance Specifications

Performance Specifications	**Solar Panels Estimate**
Solar Panel Area	$2{,}125\ m^2$
Energy Per Day Seen	9.18 GJ
Efficiency	19%
Energy Per Day Collected	1.7442 GJ
Annual Energy Generated	636.633 GJ
LCOE	85 USD/MWh
Annual Cost Reduced	$15,031.61

4 Methodology

To complete this project within the deadline, Team 2's first priority will be to gather pertinent information. First and foremost, Team 2 will be researching the Technical Center through the Cummins sponsor Roger England. It will be important to understand the priorities of Cummins and ensuring that the company gets exactly what it needs. The Off Grid Zero Emission Building will be another valuable resource to research grid monitoring systems. By visiting the Off Grid Zero Emission Building, Team 2 will develop an efficient procedure by imitating the Off Grid Zero Emission Building electrical monitoring system. This imitation will assist in monitoring the electrical usage at Cummins' Technical Center. Once the tour of the Off Grid Zero Emission Building is concluded and all relevant information is obtained, the design and fabrication of Team 2's electrical monitoring system can be implemented. While group members work on the grid monitoring system, other members will work on the decision process and analysis of the solar panels. Solar panels will be chosen based on the performance specifications identified earlier in the report. Once the grid monitoring system and solar panels are finalized, Team 2 will begin the cost analysis of the technical center visit at the beginning of the spring semester.

Every two weeks, Team 2 plans to talk with its advisor, Dr. Ordonez, to provide updates and gather insight on how to move forward. Each step forward will be documented weekly on the website by Marvin Fonseca, the webmaster. Once Team 2 obtains the necessary information to proceed, they will create a draft of the overall energy saving plan.

4.1 Schedule

A schedule is important for the completion of the project. In order to finish the project in a timely manner, a Gantt Chart has been developed for scheduling and organizational purposes. The Gantt Chart displayed in Figure 1 and Figure 2 depict varying tasks that were described by Team 2 as important to the overall project. Figure 1 and Figure 2 are a description of tasks that are required to be completed before the conclusion of the fall semester. The Gantt Chart can be found in the Appendix.

4.1.1 Classroom Assignments

Table 4 displays the required assignments and their individual due dates linked with the senior design course. These assignments are relevant to the completion of our project because each deliverable allows for the instructors and teaching assistants to see our progress in an official report.

Table 4. Class Deliverables

Assignments	**Due Date**
Project Plan and Product Specifications	10-Oct
Initial Web Page Design	17-Oct
Midterm Presentation	14-Oct
Midterm Report I	24-Oct
Peer Evaluation I	28-Oct
Midterm Presentation II	11-Nov
Peer Evaluation II	25-Nov
Final Web Page Design	25-Nov
Final Design Presentation	2-Dec
Final Report	5-Dec

4.2 Resource Allocation

- **Daniel Baker:** Create a budget for the grid monitoring system once the plans are complete. Additionally, he will also create and forward a travel budget to Cummins. This travel budget will be used to fly to Indiana and walk through the Cummins Technical Center to gather the information for the final draft of the energy saving plan for 20 days.
- **Beau Bell:** Research and technical analysis of grid monitoring system, make grid monitoring info graph, look into utilities enhancement programs for 21 days.
- **Daniel Carnrike:** Research and technical analysis of Solar Panel technology, possible avenues for geothermal energy, latitude and longitude location coordinates for 14 days.
- **Kyle Fields:** Research into power required to run compressed air at facility for 6 days, compressed air leak study for 9 days, and oversight for entirety of the project.
- **Marvin Fonseca:** Will look into energy audits for 1 day, handle website updating daily, will research fabrication techniques for 10 days and be the Duke Energy contact liaison for the entirety of the project.

5 Conclusion

Following the completion of the Needs Assessment report, Team 2 has made significant strides in determining certain product specifications for the solar power energy options that Cummins requested. The cost effectiveness of the solar panels has been estimated based on calculations made using prior knowledge in MATLAB code as well as Excel in order to find the feasibility and cost savings, respectively. Just as well, Team 2 has come up with a Gantt Chart and resource allocation for each team member that will help the project stay on schedule. The team has had difficulty meeting at the OGZEB house due to scheduling conflicts with the staff on site, and it is recommended that work begins there as soon as possible to avoid any further delays. Once the team visits the OGZEB house, work can begin on the design of the prototype grid monitoring system. The results of this trip and the subsequent designs made will be presented in the Midterm Report I that was shown in Table 4. The team also plans to continue meeting with the advisor Dr. Ordonez for support in the design of the solar panels and grid monitoring system, as well as gaining access to the OGZEB. Additionally, Team 2 will have staff meetings to ensure that the work being done is productive and will help ensure that deliverables are completed in a timely and satisfactory manner. After the presentations and reports have been finished, Team 2 will finalize the traveling budget for the trip up to the Cummins Technical Center in Indiana. From there on, the data collected from the facility will allow the team to have accurate data for the final design of the grid monitoring prototype, and an accurate calculation of the cost effectiveness of solar panels for the technical center, along with any other ideas that are suggested by the sponsor while the team is visiting.

6 References

1. "Cummins Explores Solar to Help Power Facilities." Cummins, n.d. Web. 22 Sept. 2014. <http://www.cummins.com/cmi/navigationAction.do?nodeId=201&siteId=1&nodeName=Cummins+Looks+at+Solar+Power&menuId=1050>

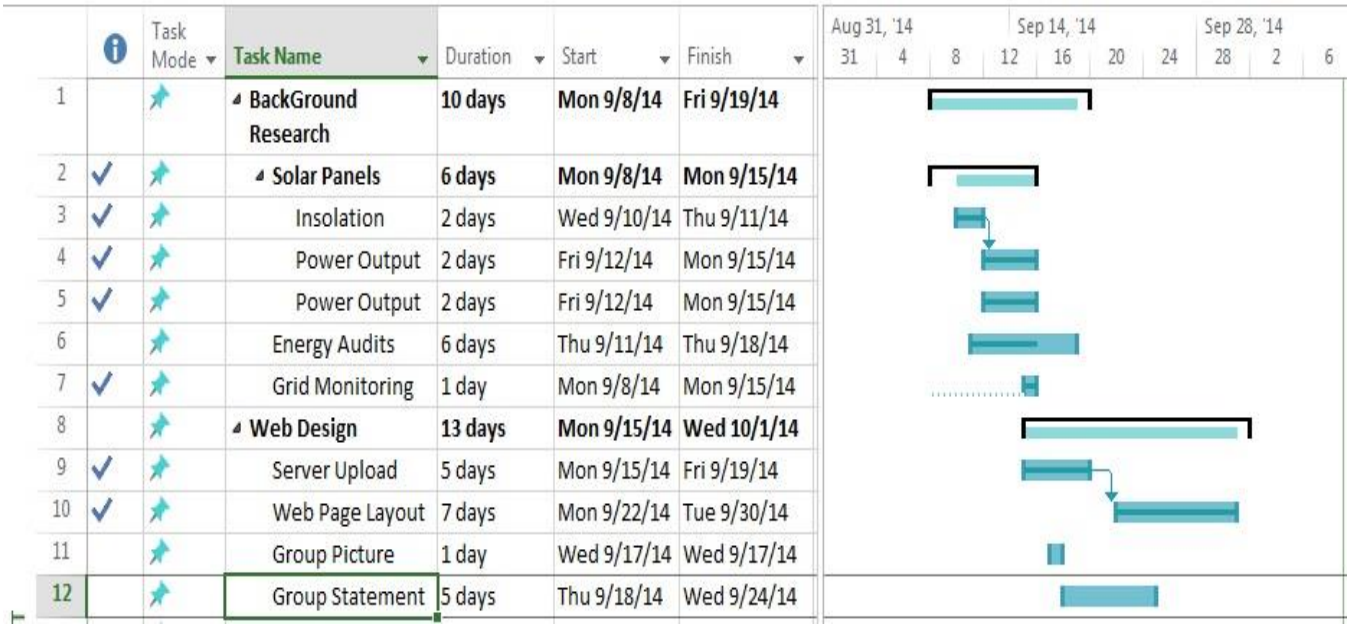
2. "Off-Grid Zero Emission Buildings." *FSU*. N.p., n.d. Web. 25 Sept. 2014. <http://esc.fsu.edu/currentProjects.html>

3. Kutz, Myerq. "Energy Audits." *Mechanical Engineers' Handbook*. 3rd ed. Vol. 4. Delmar: Mcgraw Hill, 2005. 272-301. Print.

4. "What Are Solar Panels Made Of?" *Solar Power World*. Web. 10 Oct. 2014. <http://www.solarpowerworldonline.com/2013/05/what-are-solar-panels-made-of/>

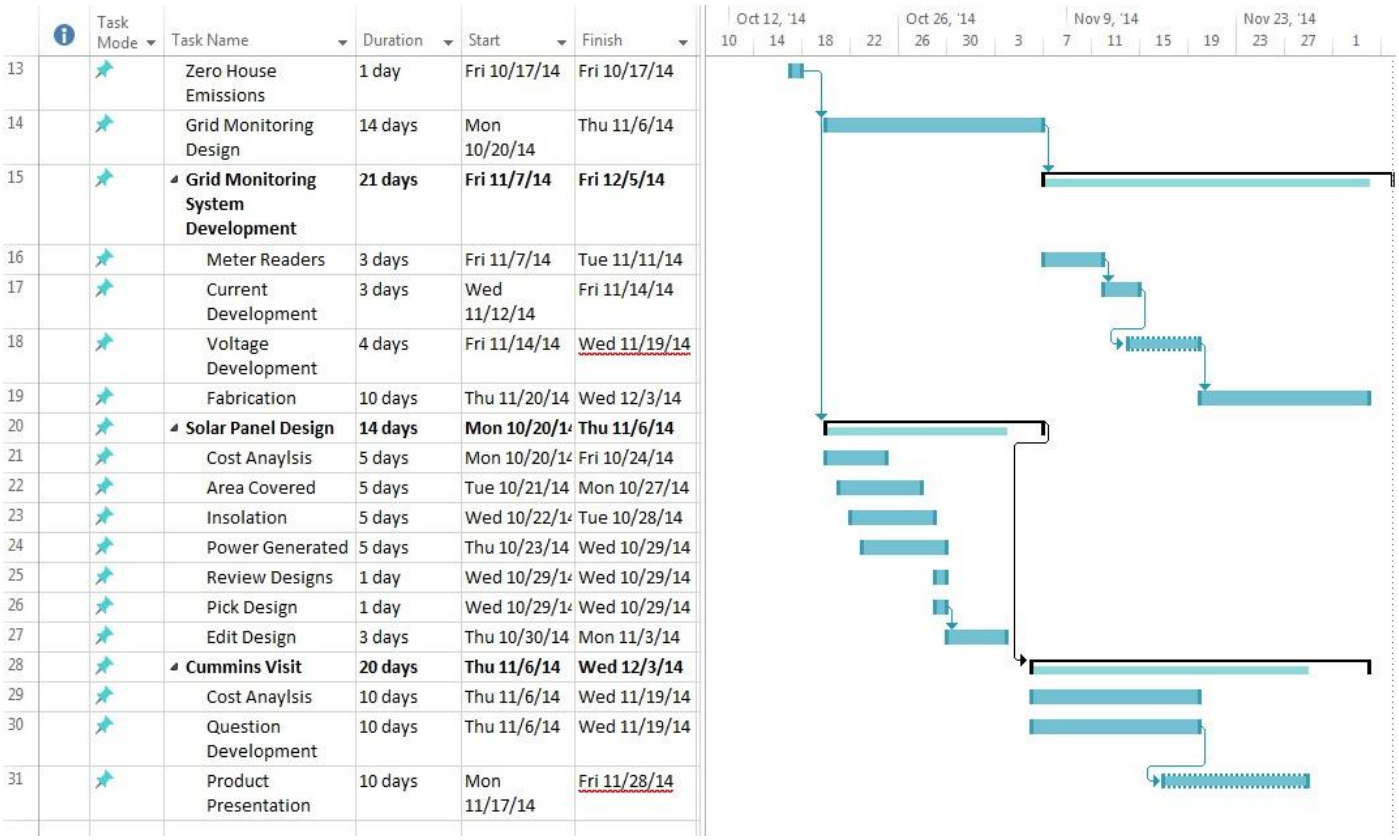
5. "Senior Design Project Definition – Decreasing Electricity Usage at Cummins Technical Center." *FSU*. Web. 10 Oct 2014. <Senior Design Project Definition>

7 Appendix



	Task Mode	Task Name	Duration	Start	Finish
1		**BackGround Research**	**10 days**	**Mon 9/8/14**	**Fri 9/19/14**
2	✓	**Solar Panels**	**6 days**	**Mon 9/8/14**	**Mon 9/15/14**
3	✓	Insolation	2 days	Wed 9/10/14	Thu 9/11/14
4	✓	Power Output	2 days	Fri 9/12/14	Mon 9/15/14
5	✓	Power Output	2 days	Fri 9/12/14	Mon 9/15/14
6		Energy Audits	6 days	Thu 9/11/14	Thu 9/18/14
7	✓	Grid Monitoring	1 day	Mon 9/8/14	Mon 9/15/14
8		**Web Design**	**13 days**	**Mon 9/15/14**	**Wed 10/1/14**
9	✓	Server Upload	5 days	Mon 9/15/14	Fri 9/19/14
10	✓	Web Page Layout	7 days	Mon 9/22/14	Tue 9/30/14
11		Group Picture	1 day	Wed 9/17/14	Wed 9/17/14
12		Group Statement	5 days	Thu 9/18/14	Wed 9/24/14

Figure 1. Gantt Chart



	Task Mode	Task Name	Duration	Start	Finish
13		Zero House Emissions	1 day	Fri 10/17/14	Fri 10/17/14
14		Grid Monitoring Design	14 days	Mon 10/20/14	Thu 11/6/14
15		**Grid Monitoring System Development**	**21 days**	**Fri 11/7/14**	**Fri 12/5/14**
16		Meter Readers	3 days	Fri 11/7/14	Tue 11/11/14
17		Current Development	3 days	Wed 11/12/14	Fri 11/14/14
18		Voltage Development	4 days	Fri 11/14/14	Wed 11/19/14
19		Fabrication	10 days	Thu 11/20/14	Wed 12/3/14
20		**Solar Panel Design**	**14 days**	**Mon 10/20/1**	**Thu 11/6/14**
21		Cost Anaylsis	5 days	Mon 10/20/1	Fri 10/24/14
22		Area Covered	5 days	Tue 10/21/14	Mon 10/27/14
23		Insolation	5 days	Wed 10/22/1	Tue 10/28/14
24		Power Generated	5 days	Thu 10/23/14	Wed 10/29/14
25		Review Designs	1 day	Wed 10/29/1	Wed 10/29/14
26		Pick Design	1 day	Wed 10/29/1	Wed 10/29/14
27		Edit Design	3 days	Thu 10/30/14	Mon 11/3/14
28		**Cummins Visit**	**20 days**	**Thu 11/6/14**	**Wed 12/3/14**
29		Cost Anaylsis	10 days	Thu 11/6/14	Wed 11/19/14
30		Question Development	10 days	Thu 11/6/14	Wed 11/19/14
31		Product Presentation	10 days	Mon 11/17/14	Fri 11/28/14

Figure 2. Gantt Chart Continued