IPRO 337 Final Project
Fall 2008

Zero Energy Lab

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1.0 Abstract

The IPRO 337 team's objectives for this semester were to make further progress in updating the top floor of Machinery Hall into a lab for future energy and lighting technology research. The research conducted this semester helped us transform the space into a more sustainable working environment. The team accomplished these goals by setting up and incorporating several systems into the existing solar electrical network, as well as furthering the research on the lab space design and use. The research conducted and the projects implemented this semester will help to assure the success of IPRO-337 in the future.

2.0 Background

IPRO 337: Zero Energy Lab is a project dedicated to devising a comprehensive zero energy solution for the Zero Energy Lab atop Machinery Hall. In the past, the IPRO team investigated potential technologies and methodologies including the use of photovoltaic arrays and wind turbines for power generation, battery systems for energy storage, passive cooling and heating systems, desiccant systems, and various devices native to the laboratory environment. These technologies presented unique challenges and issues to the team, as many of the systems that were to be put into use were (and still are) either experimental or have not been used in this fashion. Several things came out of the previous IPROs, including a proposed solar cell / hydrogen fuel cell hybrid system to supply energy to the Zero Energy Lab, a passive climate control system, and the idea that the Zero Energy Lab could be a place where individuals from all aspects of science and engineering could come together, collaborate, and educate one another.

Last semester, the goal for the Zero Energy Lab was to create testing mechanisms for various renewable and green technologies and methodologies. Different groups investigated different aspects of these technologies and methodologies and divided these into various categories such as lighting, technology, and furnishings. By the end of the semester, the team began the ZEL-rating evaluating system method for testing new technologies. The team also worked out some of the costs for improving the lab areas and found possible subcontractors to work on the spaces.

3.0 Objectives

As previously stated this IPRO is dedicated to the continuation and development of the Zero Energy Lab Concept. Realizing that the Lab is a work in progress we used the work of previous 327 semesters as a starting point, assessed several of the remaining problems and decided that development of the lab space proper would necessarily be priority one. Priority two was investigating sustainable alternatives to the electric grid as a way of providing lighting, equipment power and climate control. The third priority was to exploring ways of expanding the existing battery array in ways that might be non-conventional and would better suit the needs of the Lab.

4.0 Methodology

Zero Energy Lab Fall 08: 290 hrs

-Research: 32 hrs

-AC Research: 17 hrs

-Loading of AC unit on current system: 4 hrs
-Air conditioning systems and methods: 4 hrs
-Air conditioning brands research: 4 hrs
-Cost: 5 hrs

-Solar Thermal Research: 15 hrs

-Shading effects: 5 hrs
-Loading of solar thermal on system: 5 hrs
-Cost: 5 hrs

-Development: 258 hrs

-ZEL Cart Team: 88 hrs

-Design/ cost study: 17 hrs
-Cart Modification: 66 hrs
    -Disassembly/Assembly: 18 hrs
-Acquisition of materials: 19 hrs
-Paint/preparation: 23 hrs
    Sanding: 6 hrs
    Paint/Repaint: 17
-Finishes: 6 hrs
-Presentation: 5 hrs

-Wind Turbine Team: 85 hrs

-Sound/resonance study: 9hrs
-Voltage correction: 9 hrs
-Location selection: 9 hrs
-Speed Research: 7 hrs
-Shade Study: 5 hrs
-Research quantity of turbines for future: 8 hrs
-Mounting hardware selection: 9 hrs
-Assembly/installation: 16 hrs
-Cost: 7 hrs
-Presentation: 6 hrs

-Lab Space Team: 85 hrs

-Desk Prototype: 52 hrs
    -Design: 4 hrs
    -Acquisition of parts: 3 hrs
-Manufacturing of parts: 9 hrs
    -Modification of Parts: 18 hrs
    -Assembly of unit/fine tune: 6 hrs
    -Hardware selection: 4 hrs
-Hardware Installation: 8 hrs
-Lab Space: 24 hrs
-Space Design: 9 hrs
    -Floor Plan: 3 hrs
    -Images: 6 hrs

-Banner Prototype: 15 hrs
-Design: 3 hrs
-Acquisition of Parts: 4 hrs
-Manufacturing of Parts: 4 hrs
-Assembly: 4 hrs
-Presentation: 9 hrs

5.0 Team Structure and Assignments

Team Structure:

Name	Major / Year	Skills / Strengths	Experience	Team
Abdelmalek Aouissa	Electrical Engineering 4th	AutoCAD, Revit, Photoshop, InDesign, Adobe Illustrator, Pspice , Mathematica,	Tutoring, Research,	Wind Team
Chris Chiu	Architecture 4th	CAD, Photoshop, 3D modeling	CAD Drafting, Model Shop work, hand drafting	Lab Space Team
James Dodgen	Architectural Engineering 4th	Patient, energetic, hard working		Wind Team
Jennifer Gambrell	Architecture 5th	3D modeling, Photoshop/Illustrator	CAD Drafting, Model Shop work, tutoring	Lab Space Team
Adam Kadzban	Computer Science, Psychology 3rd	Java, C, Python, motivated	Robotics, tutoring	Golf Cart Team
Evan Larkin	Computer Science 4th	Computer tech support, construction, troubleshooting	Tutoring	Blog and Construction Documents Team
Scott Lowe	Architecture 5th	AutoCAD, 3DSMax, Photoshop/Illustrator	Solving architecture problems	Blog and Construction Documents Team
James (Jim) Meyer	Electrical Engineering 4th	Teamwork skills		Golf Cart Team
Brian Rojas	Aerospace Engineering 3rd	Logical, calculating and analyzing data	Illinois Tech Robotics	Golf Cart Team
Oba Vincent	Electrical Engineering 3rd	Photoshop, Java, C#, Python		Golf Cart Team
Clark Wolfe	Electrical Engineering 4th	Teamwork skills, works well under stress	Tutoring	Wind Team

Farouk Yaker	Chemical Engineering 4th	AspenTech Hysys, Ni LabVIEW, MS Office, diverse background	Researching Lithium-Ion batteries	Lab Space Team

Subteams:

Team	Contributions	Members
Blog and Construction Documents Team	Maintained blog of the zero energy lab Created renderings of the systems to be added to Machinery Hall	Evan, Scott
Wind Team	Took initial wind data Found location for windmill Put up windmill between Galvin Library and Crown Hall Took data with windmill in place	James, Clark, Malek
Golf Cart Team	Disassembled and cleaned golf cart Painted body and reassembled golf cart Designed an electrical system to integrate with current system and to supply energy from the golf cart	Oba, Jim, Adam, Brian
Lab Space Team	Designed a system for partitioning the Zero Energy Lab Designed and created a mobile, portable table to be used in the lab	Jennifer, Farouk, Chris

Changes:

The group reorganized into four subteams: blog and construction documents, wind, golf cart, and lab space. The reason why this was done was because the team was too spread out, and there was not enough focus on each area. This new organization allowed for defined roles, clear tasks, and well spread out manpower.

6.0 Budget

Income

- IPRO
  - $330.00 – Services
  - $100.00 – Travel
- TGIF Grant
  - $2000.00

Expenditures

Project	Cost	Description
Wind Experiment		
	$500.00	12 Volt Windmill
	$500.00	Wind Tower
	$160.00	2 Deep Cell Batteries
	$20.00	Battery Cables
	$20.00	Inverter

	$10.00	3 Way Automotive Switch
	$10.00	Photocell
	$14.20	Battery and Inverter Boxes
	$9.68	Battery Posts
	$156.00	LED Lights
	$30.00	LED Lights
	$50.00	Site Sign
Total:	$979.88	
Mobile Energy Vehicle		
	$1,000.00	Used Golf Cart
	$565.00	New Batteries for Cart
	$950.00	48 Volt DC to 120 Volt AC Inverter
	$65.00	48 Volt DC to 12 Volt DC Converter
	$35.00	Baby Moon Hubcaps
	$70.00	Paint, Wax, Buffer
	$750.00	Wiring & Boxes to Connect to Photovoltaic Arrays
	$100.00	Batter Switch
	$40.00	LED Lights
	$20.00	Work Shelf
	$50.00	2/0 Batter Cable to Replace Cart Wiring
	$50.00	Logo Painting
Total:	$3,695.00	
Workstation		
		Oak Faced Plywood
		Casters
		Hinges and Latch
		Sandpaper & Masks
		Glue
		Recycled Counter Top
Total:	$0.00	

7.0 Results

Because our group did not have one main focus but several, there are many results from our work. The groups were broken down into three section and therefore it is more simple to explain the results individually from each of those sections and then collectively. The first group will be the Lab Space group. They succeeded in creating a more usable lab space and set the tone for the completion of a very useful lab space for future projects. They developed the idea of sectional desks and work areas that allow each lab space, of which there can be many spaced throughout the lab, to be customized to each groups needs. The work areas are collapsible and can easily be stored. They successfully created a prototype for this new and innovative system. The next group will be the Mobile Energy Station team, aka the Golf Cart team and MES team. This group had the daunting task of being the center for integrating all three systems successfully, both through ease of use and electrically. Therefore the MES team was then split into two more groups; the electrical team and the aesthetics team. The electrical team succeeded in creating a solution to the electrical integration problem and began purchasing the proper systems necessary for the next team to carry on installation.

Along with that helped increase the size of the existing battery banks for the entire lab. The aesthetics team succeeded in cleaning and painting the MES and creating and applying the Zero Energy Lab logo. The next team was the Windmill team. They also had a daunting task and such the basis of the Zero Energy project by testing and supplying this new energy. The first task that was completed was the mapping of wind speeds in the area of interest, in this case on top of Machinery Hall. Next, based off of the wind studies, a compilation and rendering of several probable locations for the windmill were found and created. There was still a long way to go before the windmill would actually be implemented and used with the lab, so the team decided to do further testing in a temporary, more accessible location. In this temporary location (the south side of the Galvin Library) the team set up the 27 foot tall windmill and began testing. In the holiday spirit the team used low power led lights to both warn onlookers of the guy wires and also act as our draw for our studies and rapped the lights in the shape of a tree. The testing thus far has been very successful, showing very pleasing results. The windmill was able to keep the lights with an average draw of 35 Watts at a constant battery level throughout the nights, and continue to charge throughout the day while the lights were off. This testing shows that windmills are a great 'next step' for this Zero Energy Lab for producing great power in the Windy City.

8.0 Obstacles

In working with the Zero Energy Lab, each sub-team encountered many obstacles during their work:

The mobile energy cart team's main challenge was to get the cart up to the forth floor of Machinery Hall, where it would be used. In addition to this, they had to design and build a custom electronics system for the cart that would allow the cart to charge off of the green energy solution in place atop Machinery Hall, as well as have plugs for 120V AC electricity. As a finishing touch, they also had the challenge of painting and decorating the cart. The cart was brought up to the forth floor of Machinery Hall by dismantling it and taking it up part by part. The electronics systems were designed principally by James Meyer (correct me if I'm wrong), along with Oba Vincent (again, correct me if I'm wrong). The paint job was spearheaded by Adam Kadzban and Brian Rojas, and the logo was designed by Abdelmalek Aouissa (correct me if I'm wrong).

The Wind station team faced the challenges of finding a mounting point for wind turbines on Machinery Hall, as well as actually mounting a test wind turbine. Scott Lowe was the primary researcher into the placement of the mounting points, and the entire team mounted the turbine next to Galvin Library.

The lab space team focused on designing and implementing a rapidly re-purposing lab space. They accomplished this task by building a prototype desk that could be assembled and disassembled quickly, as well as moved around quickly to form large or small desks as needed.

9.0 Recommendations

For future IPRO 337 classes, it would be helpful to set mile markers to help accomplish the overall goal. These smaller achievements will also help for tracking progress and judging time to complete the tasks at hand. The IPRO team also would benefit from researching the cost benefits of each solution considered as well as past systems for comparison. The semester's team has found that it was very effective to divide into teams and change roles from time to time so each member has a feel

for all the major goals of the IPRO. However, it would be better if the roles were defined clearly so when the changes were made, each person knew which roles were left unfulfilled. The next team would benefit from looking into one new technology to add to Machinery Hall as well as adding to the lab space and the battery bank.

10.0 References

- Wind Turbine
  - Specifications, http://www.windenergy.com/products/air_x.htm
- Mobile Energy Station
  - Wire Gauge Calculator http://www.mogami.com/e/cad/wire-gauge.html
  - Club Car Manual
  - Geno Gargas and other electrical engineers
- Lab Space Design
  - Architecture Shop Professor

11.0 Resources

Team member	Project	Hours
Evan Larkin	Blog	15
	Computerized Power Meter	60
Brian Rojas	Lab Space	10
	Golf Cart	70
Scott Lowe	Drawings/Renderings	40
	Research	20
Chris Chiu	Lab Space	50
	Research	30
Clark Wolfe	Golf Cart/Electrical	35
	Windmill	35
James Meyer	Golf Cart/Electrical	35
	Windmill	35
Jennifer Gambrell	Lab Space	65
	Research	40
Adam Kadzban	Golf Cart	70
	Research	20
James Dodgen	Golf Cart	30
	Windmill	50
Farouk Yaker	Research	25
	Lab Space	50
Oba Vincent	Golf Cart/Electrical	35
	Windmill	35
Malek Aouissa	Golf Cart/Research	35
	Design	35

12.0 Acknowledgements

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