IPRO 337: THE ZERO ENERGY LAB

ILLINOIS INSTITUTE OF TECHNOLOGY

INTRODUCTION

IPRO 337, The Zero Energy Lab, is an ongoing project located on the fourth floor of Machinery Hall. The larger goal of the IPRO is to create a lab space that will be improved to become an energy neutral space. The lab would be used to help IIT, other universities, and companies develop and test their energy concious designs and find better energy saving products.

BACKGROUND

The fourth floor of Machinery Hall was previously used to store unused furniture and equipment. In its earlier days, the space was dedicated to metal smelting and processing. These past uses left the space with uneven concrete floors but a very usable open space. The roof currently has an array of photovoltaic panels. These panels have a 4-12V battery bank situated on the mezzanine level.

TEAM ORGANIZATION

ANDY KEDZUCH
TEAM LEADER

SOLAR THERMAL COLLECTOR	VENTILATION	ENERGY CART
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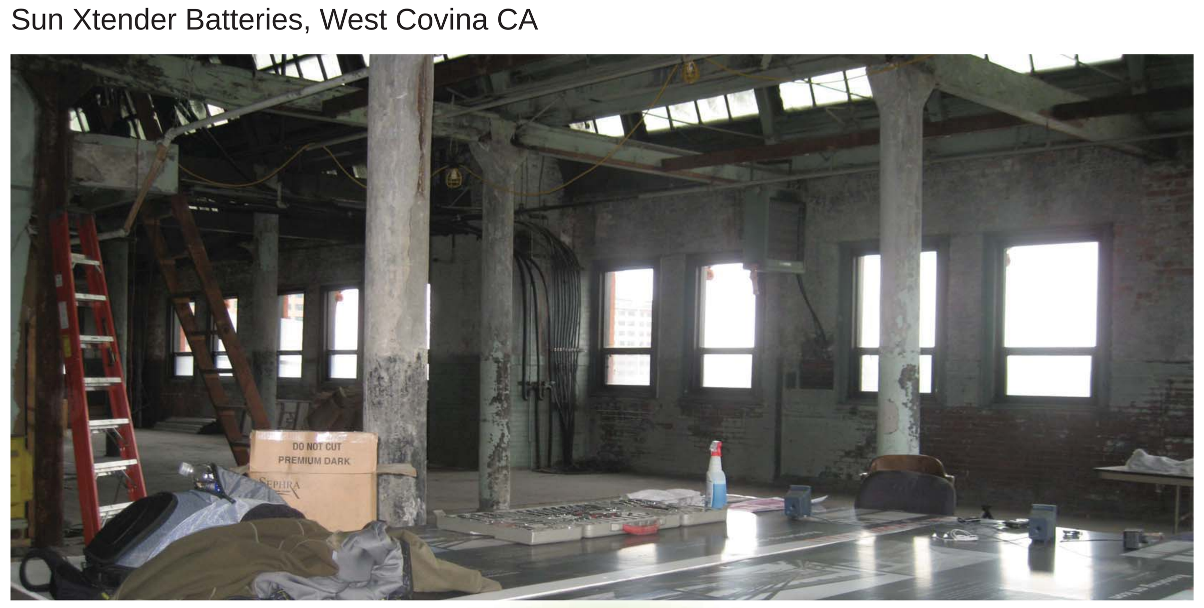
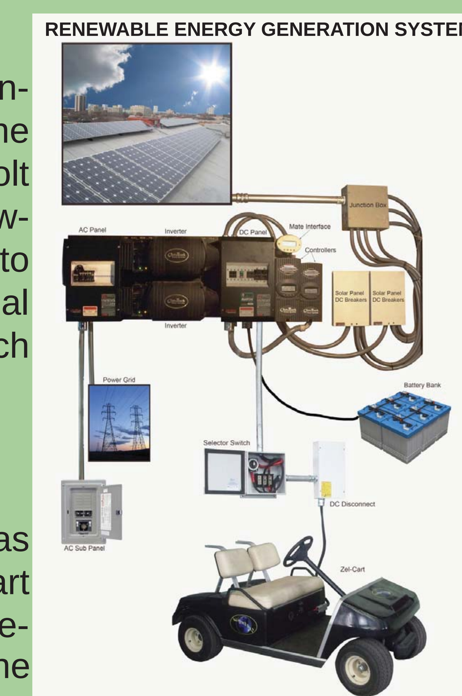


Zer0 Energy Lab

CART SUB-SYSTEM

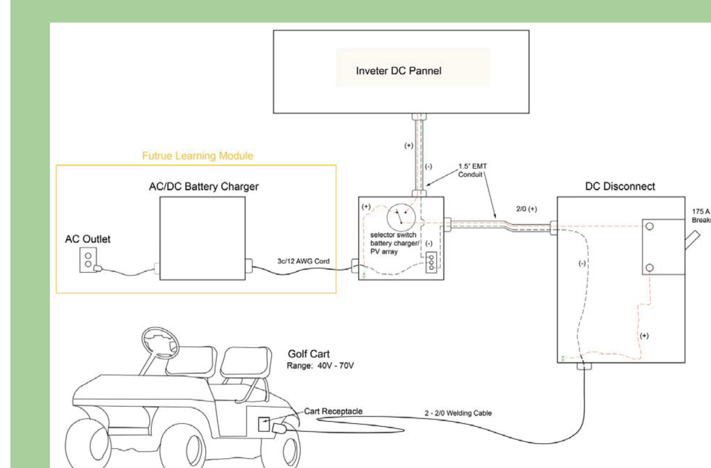
PROBLEM

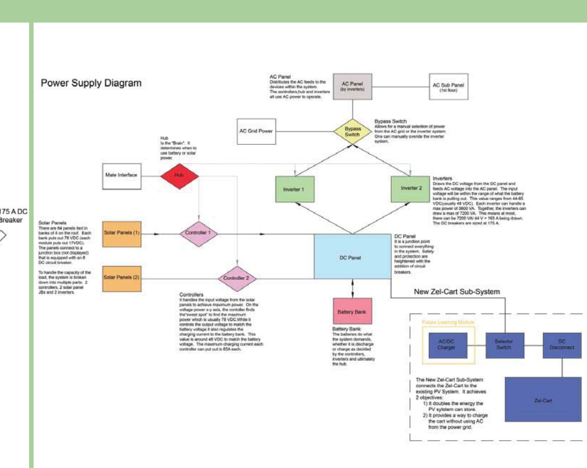


The Zero Energy Lab's renewable energy management system has limited storage capacity. The present storage consists of a bank of four 12 Volt batteries. The lab also has a golf cart which is powered by a 48 Volt battery bank. It currently needs to be recharged using electricity from a conventional AC outlet. Also there are locations in the lab which do not have easy access to AC power.

OBJECTIVE

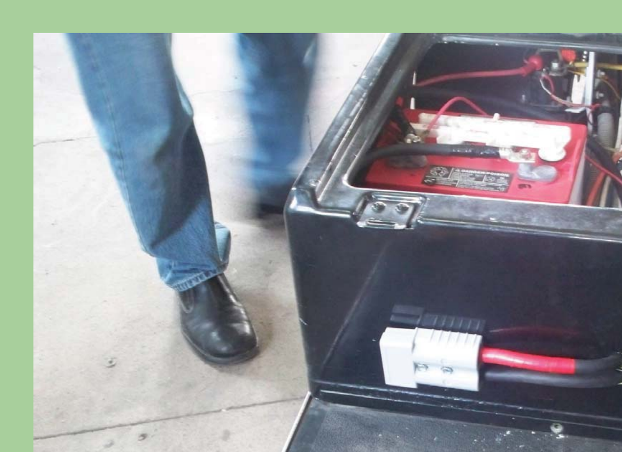
The main objective of the ZEL CART Sub-team was to design and install a sub-system by which the cart could be connected to the system. This would result in experiencing two major benefits: Double the system storage capacity by adding the cart's 48-Volt battery bank to the existing 48 Volt bank, and create a "green" method for recharging the cart. A third benefit, mobile AC power, may be experienced in the future by adding a DC/AC inverter to the cart. Lastly we wanted to create sufficient documentation to equip future IPRO teams to understand the system and continue its development.





METHODOLOGY AND ACHIEVEMENTS

The existing system was analyzed and documented properly for this semester's team to fully understand the system and also for future teams to further develop and improve it easily. Written abstracts and diagrams were developed to help with this goal. A sub-system was designed to connect the cart to the current system. The sub-system was then installed and tested.



OBSTACLES

- Unanticipated high current design issues-cable sizing
- Understanding the cart inter-connect design and specification
- Budget constraints required modifications in design and implementation
- Loss of the sub-group leader during week 10 due to personal circumstances

LONG-TERM GOALS

- To increase the battery storage capacity with batteries designed to withstand uncontrolled current flows.
- A second future goal is to add an inverter to the cart to create a mobile source of AC Power
- Add AC/DC charger to the sub-system to enable selection of cart charging source
- Add additional uses to the existing system.

SOLAR THERMAL COLLECTOR

PROBLEM

One of the major problems of the lab space is that there is a lack of an efficient active heating system. Also currently, there is not a running hot water supply.

OBJECTIVE

The main objective or goal of the solar thermal Sub-team was to design, build, and install a low cost solar thermal collector to provide hot water and heat to the zero energy lab. Also to test the collector and come up with recommendations to improve efficiency or to reduce costs.

METHODOLOGY AND ACHIEVEMENTS

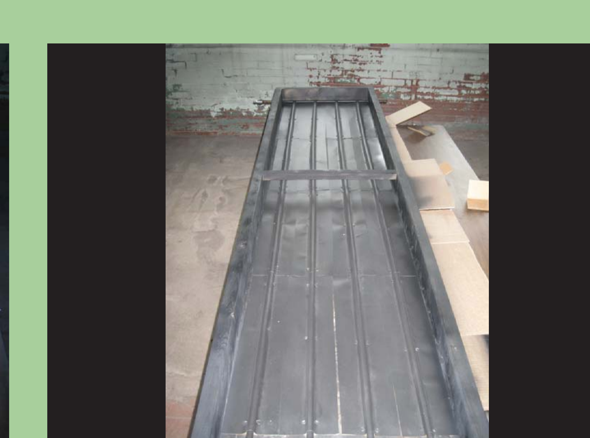
The team's first steps were to research the most economical and efficient systems for the space and the needs of the space. The sun is the main source to develop hot water for a passive heating and cooling system for this application. A solar collector was then constructed from acquired materials. The collector was the most economical and most efficient system for the application. The collector was also set up and tested with input and output temperature data.

OBSTACLES

- The sub-group had to understand and research existing designs and how to modify them according to the constraints of the space and budget.
- Acquiring cost effective materials from local businesses in a timely manner
- Initial design was not practical for transport and research purposes so the decision was made to make two smaller collectors
- The initial intention was to test efficiency levels of an already built collector versus a built from scratch collector but due to budget limitations only a built from scratch collector was acquired

LONG-TERM GOALS

- Acquire a large thermal storage capacity with several tanks to allow for several days worth of heat storage
- Use solar hot water for hot running water as well
- Develop a solar thermal powered air conditioning system
- Design a back up system to provide surplus for day with little to no sun



VENTILATION

PROBLEM

The zero energy lab space does not currently have an energy efficient means of cooling. However, the configuration of the windows provides an opportunity for both stack and wind driven ventilation.

OBJECTIVE

The objective of this sub group was to create a design for an automatic window system for the Zero Energy Lab roof windows. This involved designing the mechanical system for opening the windows, as well as creating an electronic program that would dictate the opening and closing of the windows based on inside and outside conditions. We also aimed to make our design cost-effective so that it would be realistic for actual installation.

METHODOLOGY AND ACHIEVEMENTS

The group began by researching natural ventilation methods in order to determine its effectiveness in this particular application. Information was found from past IPROs determining the windows to be on the leeward side. This is optimal for both stack and wind driven ventilation. Stack ventilation is produced by temperature differences inside and outside the building. Window driven ventilation is created by pressure differences between the leeward and windward sides of the building. A mechanical system was then designed for opening the windows, with consideration to the current window mechanics. The design consisted of an actuator, which would move in and out based on a program. The program was then designed to tell the actuator when to open and close based on outside/inside temperature, dew point, and barometric pressure. A mock up of this design was then created. Lastly, a cost analysis of the installation of our system design found that the straight cost of parts of installation could be less than the annual cost of cooling.

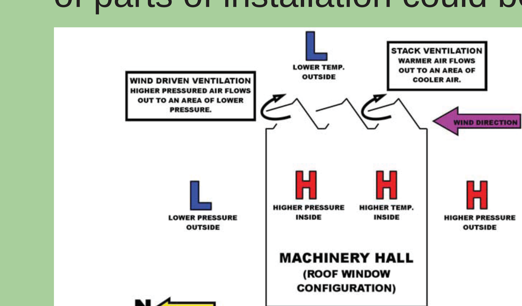


Figure 1: Previous IPRO research on seasonal wind direction.

Figure 2: Current roof window system in Machinery Hall.

Figure 3: Rendering of new mechanical system design.

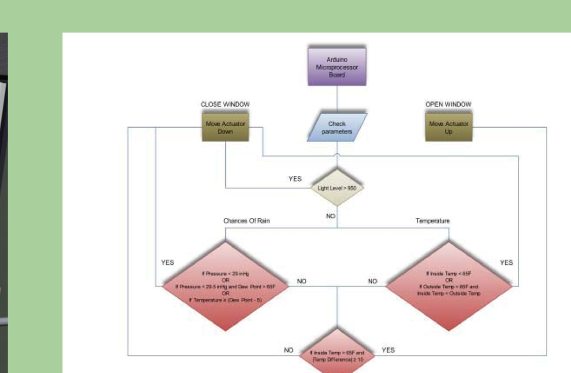


Figure 4: Code of electronic program

OBSTACLES

- When the current windows were investigated, it was found that they needed repair before continuing with the initial design
- Determining and defining parameters for opening and closing the windows proved difficult without previously done research and case studies.

LONG TERM GOALS

- Conduct more research to improve upon the parameter designation in order to improve effectiveness of the design
- Consider the possibility of additional means of cooling, such as a chilled ceiling, in order to make system most effective, even in times of extreme heat where no stack ventilation will exist.
- Determine the best solution for the repair or replacement of the windows, so that this design can be made feasible for real installation

Figure 6: Pay off Timeline for Window Installation

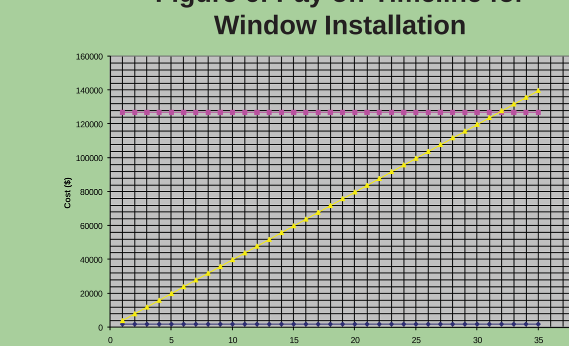


Figure 5: Mock up of window system design