IPRO 337

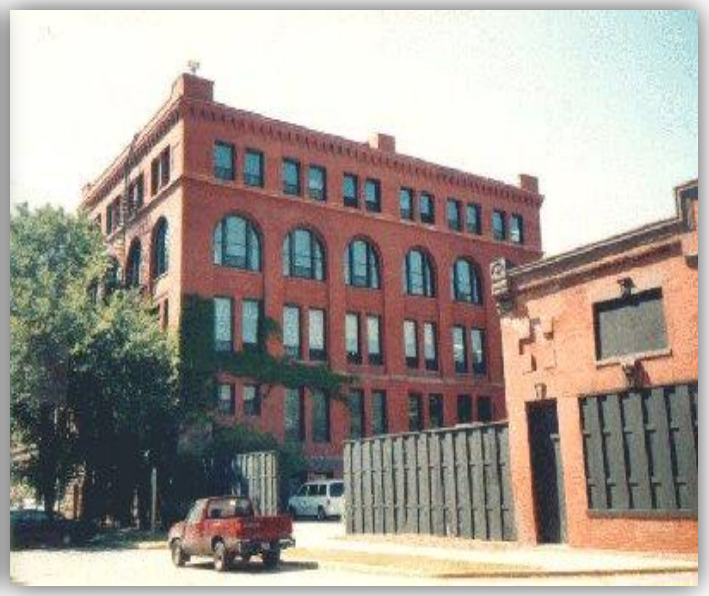
ZERO energy Lab

What is Zero Energy Lab?

- A universal format for occupying laboratories that simultaneously use multiple forms of renewable energy and minimize energy consumption
  - Place for examining new ideas for energy consumption and management.
  - Design low energy consuming products not currently available commercially.

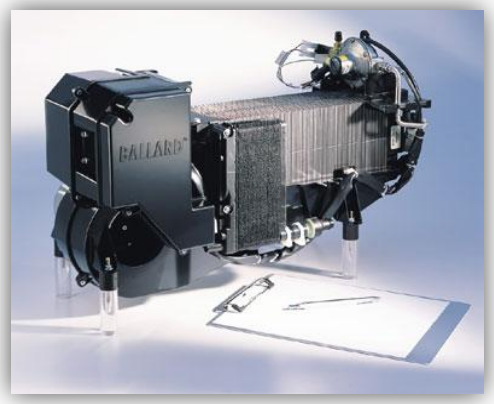
Purpose

Create a plan for renewing and transforming the 4th floor of the Machinery Hall into a lab space for future energy and lighting technology, functioning independent of the energy supplied by the grid.



Background

- Hydrogen fuel cell system
  - Power creation and storage system charging the battery bank when the solar array is inactive.
  - Production: From excess energy not used and unable to be stored in the battery bank.



Background

- Fluorescent Lighting
  - Zone equipped with motion and photo sensors along with efficient fluorescent lighting.
  - A computerized automation system
  - Lighting fixtures attached centrally and mobile

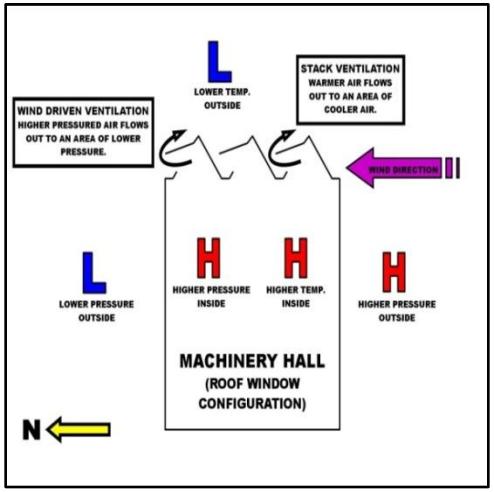
Background

SOLAR THERMAL COOLING SYSTEM:

- Thermal energy ⟶ hot water ⟶ absorption chiller.
- Independent of electrical energy
- Requires negligible power from the battery bank.

Background

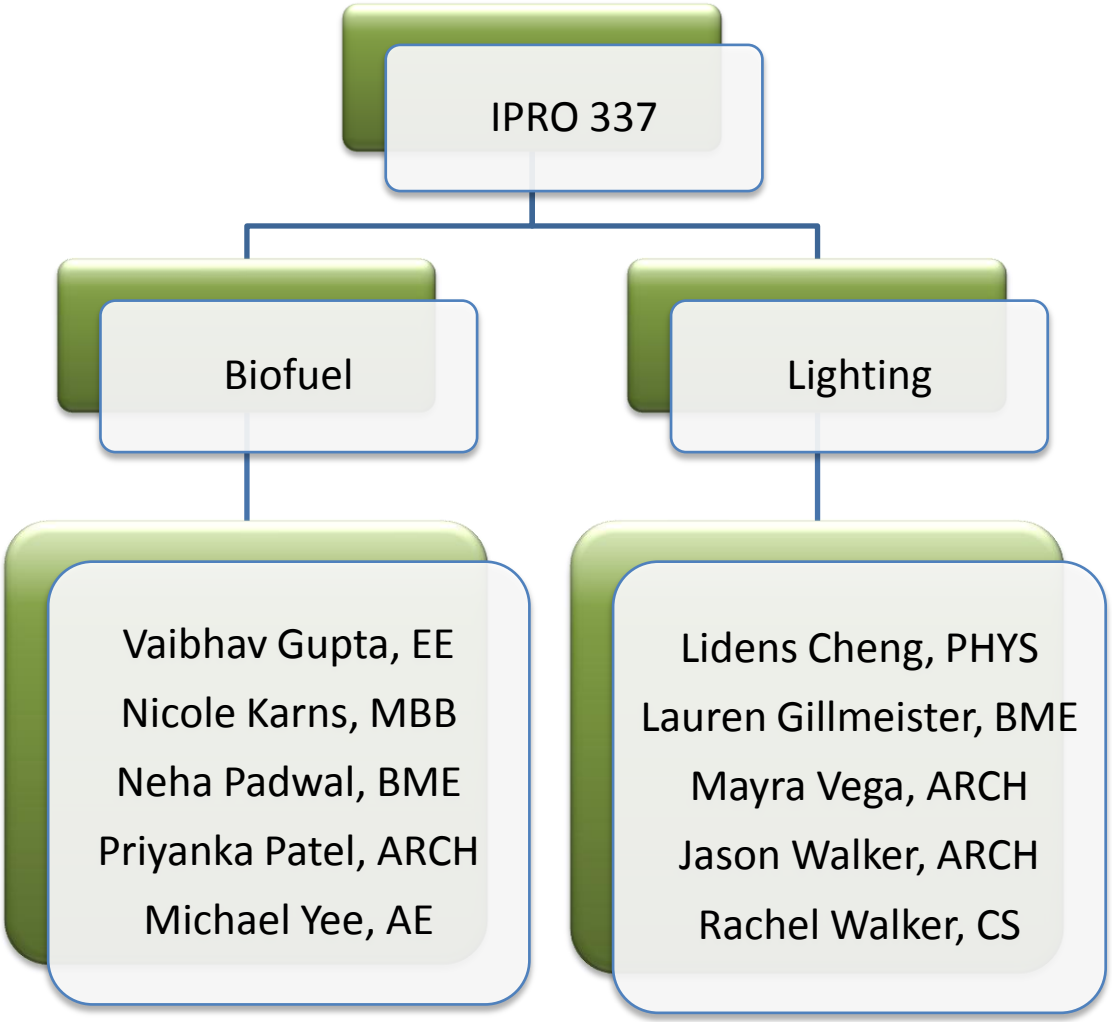
- VENTILATION:
  - A steady wind from the south create an area of lower pressure outside the roof windows.
  - Potential temperature difference causes warm air to be removed
  - The air conditioning on the lower levels of the building create flow of air upwards and out of the building.



Objectives this Semester

- Design a **BIOFUEL SYSTEM** that will supply additional power to the energy bank.
- Install a **LIGHTING SYSTEM** in a section of the lab and use the results to expand system to the rest of the lab space.

Team Organization



Biofuel

- **Problem Statement**
  - How can we be more self sufficient in the space we have?
    - Photovoltaic Panels
    - Wind Turbines
    - Solar Thermal
      - Biofuels

- **Objectives**
  - To design and propose a biofuel system that would supply the additional energy needed to the existing battery bank.

Biofuel

- **Methodology:**
  - Visit to Loyola
    - Up and running BIOFUELS lab
    - How can we use this for our problem
  - Use the Existing Technology
    - Add a design element
      - Solar Thermal?
  - Produce Usable Energy
    - Biodiesel, Vegetable Oil or Waste Vegetable Oil?
  - Location?
    - Visit to Co-Gen Facility
    - New theory of the Boiler system.

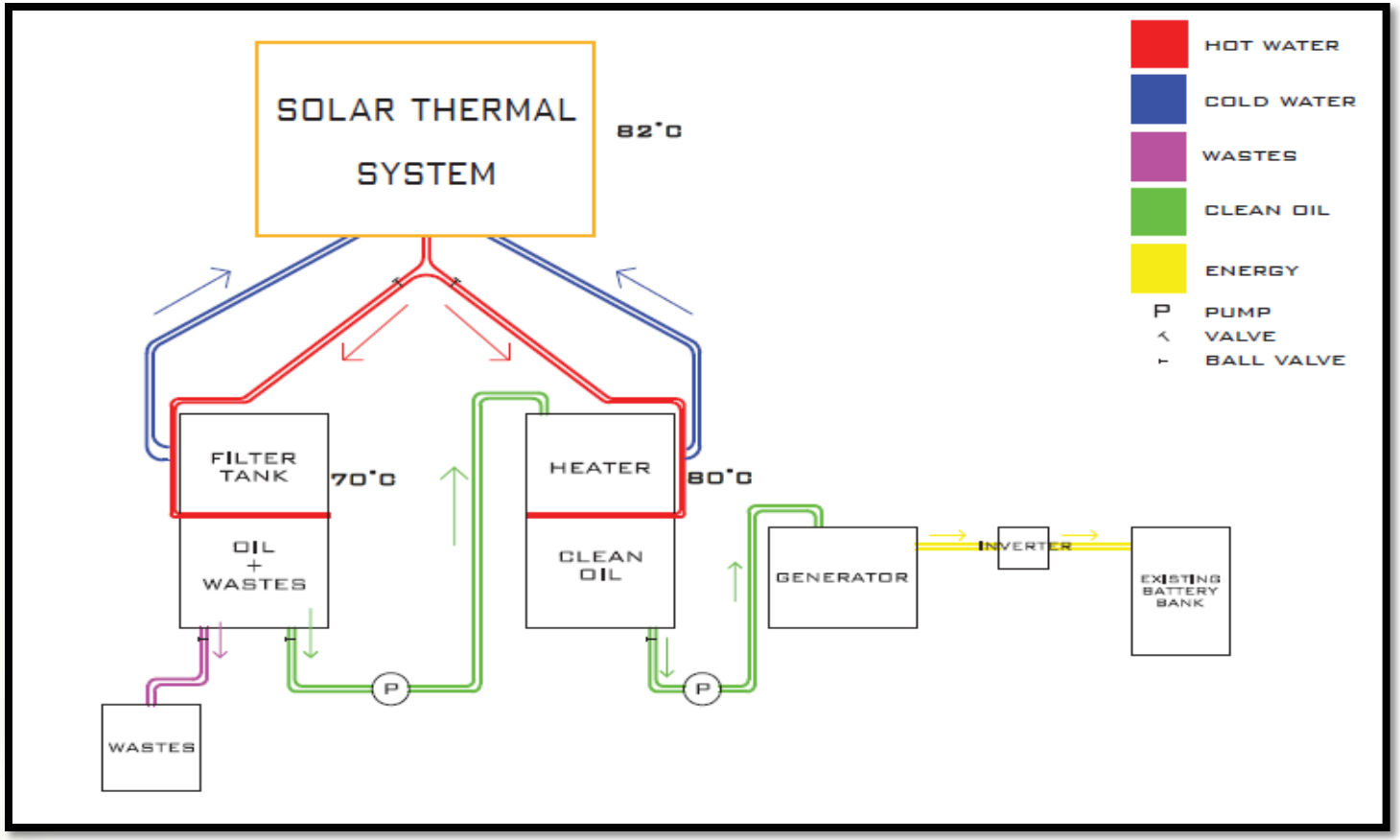
Biofuel

- **Obstacles:**
  - Developing an energy efficient method for heating
    - Came up with two systems
      - Solar Thermal
      - Waste heat from boilers in the Co-Gen Facility
  - Location of the System
    - Decided on two different locations
      - 1st floor of Machinery Hall
      - Co-Gen Facility
  - Liability issues with using Co-Gen facility
  - Cost of components

Biofuel

- **Results:**

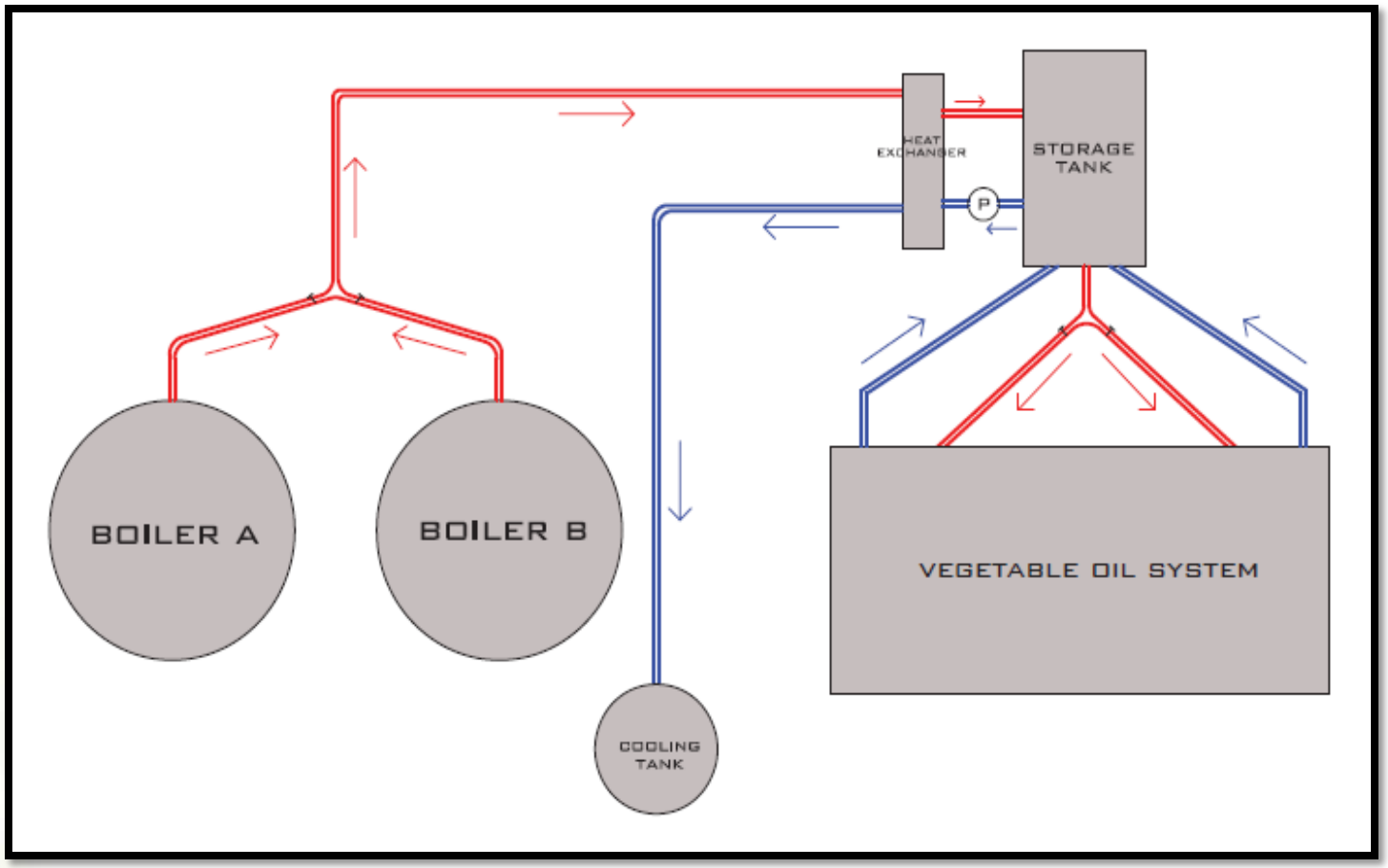
Solar Thermal System



Biofuel

- **Results:**

  Boiler System



Biofuel

- **Future Work:**
  - Running tests to find out:
    - How much diesel is required to start the generator.
    - Just how hot the oil needs to be
    - How much energy can be achieved from the system
  - Selecting a location and building the vegetable oil system
  - Building a biodiesel production lab

Lighting

- **Problem Statement:**
  - Lack of a proper lighting system to illuminate non-daylight hours.

Lighting

- **Objectives:**
  - Determine which material scatters light most efficiently.
  - Determine which kind of lighting produces the highest intensity and the lowest wattage used.
  - Determine which light fixture worked with the angle of the ceiling and the applied material to create the most amount of intensity.

Lighting

- **Methodology:**
  - In order to simulate a night time setting, a model of the ZEL's ceiling was created, which allows the measurement of light intensity
  - Materials were tested to disperse light, maximizing light intensity
  - Materials were tested:
    - Photoluminescent Paint
    - Projection Screen
    - White Sheet
    - White Paint
    - White Paint with Glass Beads

*All test run used a HOBO device

Lighting

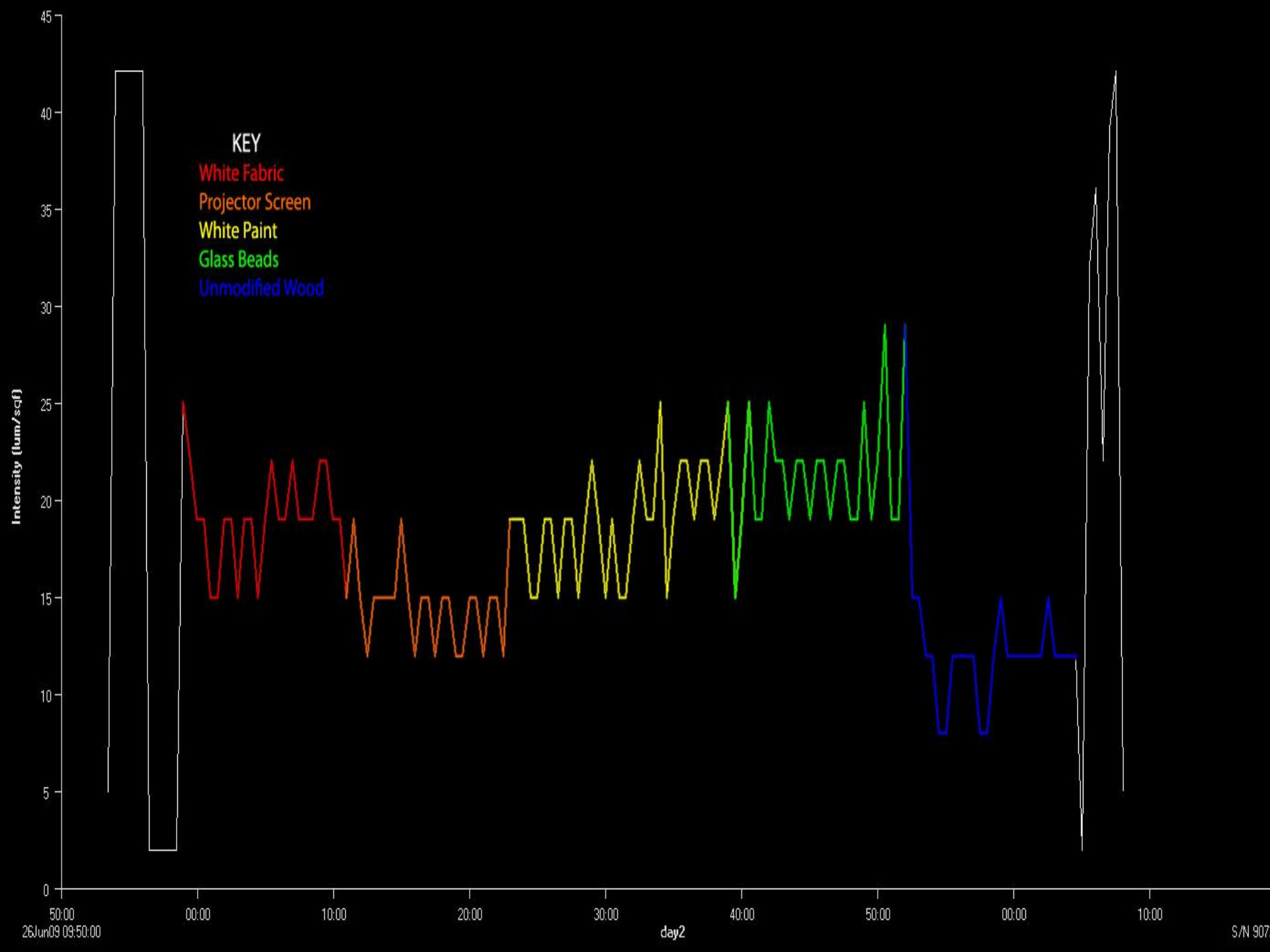
- **Methodology:**
  - LED light fixtures versus fluorescents
  - Measured the light intensity created by each lighting unit with similar wattage
  - Painted a section of the ceiling white and applied glass beads on another section

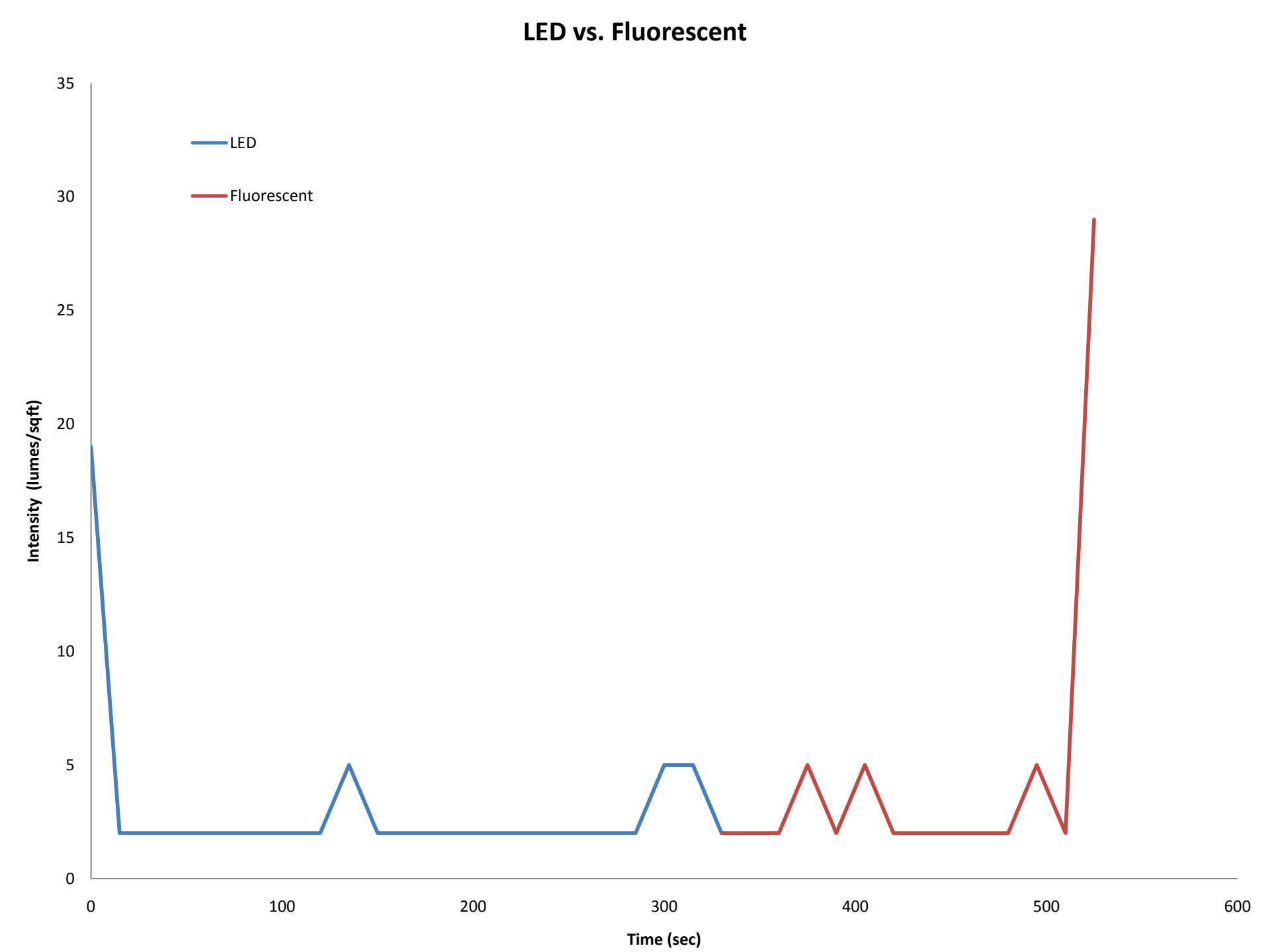
Lighting

- **Methodology:**
  - Measured the light intensity of each section with different LED light fixtures
  - Measured the light intensity of each section during a night time setting

Lighting

- **Major Obstacles & Challenges:**
  - Creating the model of the ZEL ceiling and transporting it to the ZEL
  - Painting the ceiling
  - Attaching the glass beaded boards to the ceiling
    - Only successfully attached one board to the ceiling with the available equipments and time


KEY
White Fabric
Projector Screen
White Paint
Glass Beads
Unmodified Wood
Intensity (lum/sqf)
45
40
35
30
25
20
15
10
5
0
50:00
00:00
10:00
20:00
30:00
40:00
50:00
00:00
10:00
26Jun09 09:50:00
day2
S/N 907


LED vs. Fluorescent
LED
Fluorescent
Intensity (lumes/sqft)
0
5
10
15
20
25
30
35
0
100
200
300
400
500
600
Time (sec)

LED Trials

29.7W test on glass beads

39.5W test on glass beads

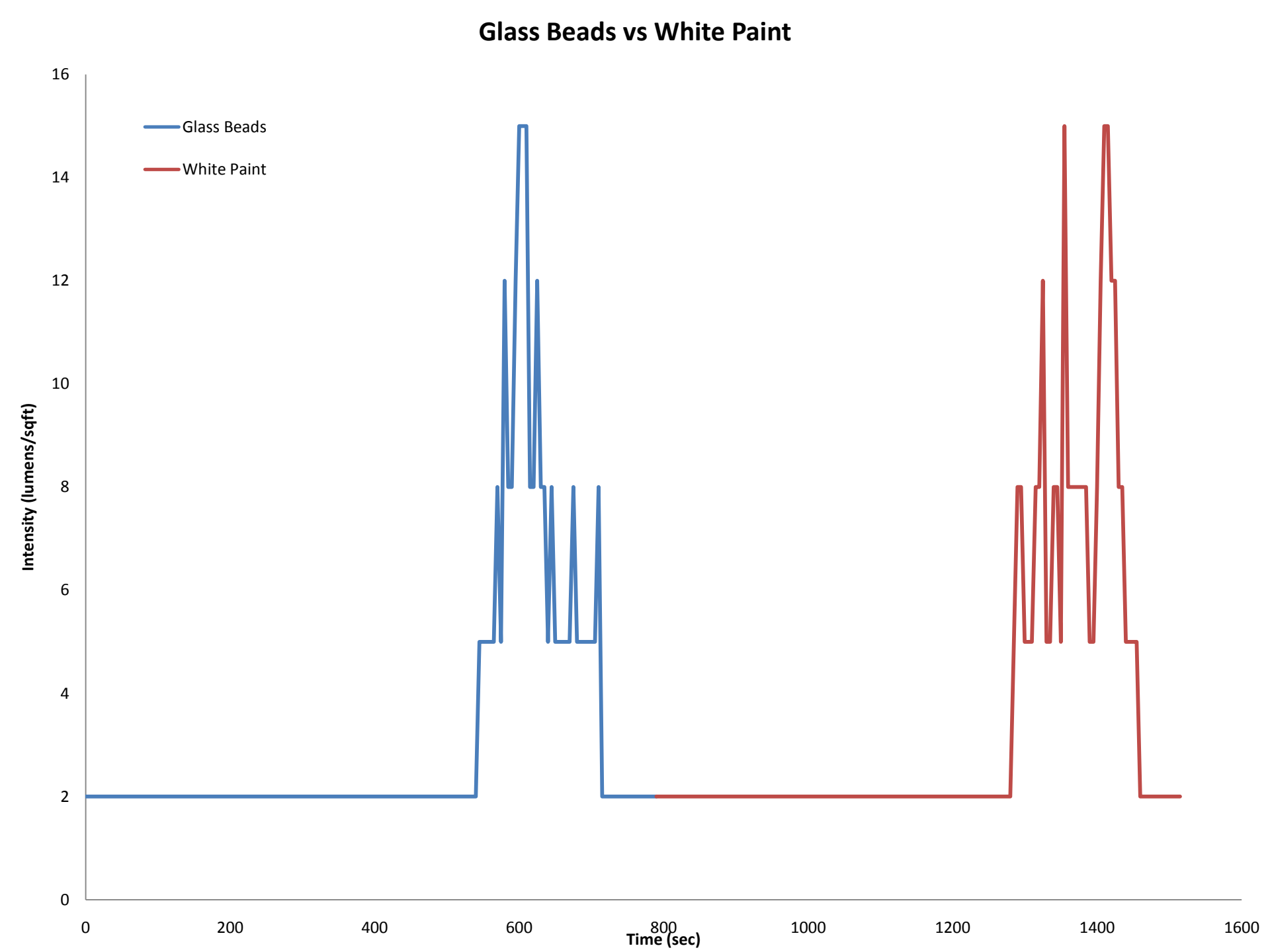
LED Trials

56.7W test on glass beads

LED Trials

39.5W test on white paint

56.7W test on white paint


Glass Beads vs White Paint
Glass Beads
White Paint
Intensity (lumens/sqft)
Time (sec)
0
2
4
6
8
10
12
14
16
0
200
400
600
800
1000
1200
1400
1600

Lighting

- **Conclusion:**
  - White paint and glass beads were both used in the painting and installation process
  - LED was chosen since intensity is similar to fluorescent but appeared brighter in the lab space
  - Glass beads are even more effective than white paint since a small area of glass beads gave the same intensity as a larger area of white paint

Lighting

- **Future Goals:**
  - Apply glass beads and/or white paint to the rest of the ZEL ceiling
  - Determine which LED fixture is the most energy efficient
  - Create a light sensor and dimmer system
  - Determine a way to organize the electric wiring of the LED light fixtures
  - Avoid the use of the inverter and use DC straight from the battery bank

Acknowledgements

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- John Smith - CoGen Operator

Questions