4 Testing

Testing is an **extremely** important component of most projects, whether it involves a circuit, a process, power system, or software.

The testing plan should connect the requirements and the design to the adopting test strategy and instruments. In this overarching introduction, given an overview of the testing strategy. Emphasize any unique challenges to testing for your system/design.

4.1 Unit Testing

What units are being tested? How? Tools?

1. Kilowatt hours: We will be testing various levels of energy used by the PNE system vs that of the current one. We want to know how effectively and efficiently we can improve the University's heating system.
2. Watts: Input/output power of the storage.
3. PSIG: We need our system to output 90 PSI for the pipes. We will ask PNE about their system.
4. Temperature - Need to keep the temperature high, maximum of 600 degrees celsius, for long periods of time.
5. Prices (cents/KWh): Need to know the cost for renewable energy.
6. Size (meters): Need to measure the dimensions of the PNE storage.

4.2 Interface Testing

What are the interfaces in your design? Discuss how the composition of two or more units (interfaces) are being tested. Tools?

- Our thermal battery requires renewable energy from the grid in order to produce heat that will be stored within the battery. We will have to determine the required amount of energy to heat our system to the desired 600 degree celsius.
- This level of heat will then be used to create steam. The interfaces in this test are the thermal heat to steam conversion. We will hope to determine the required heat transfer to steam. With this metric we will be able to determine energy that needs to be replaced in the system.
- After this metric is calculated, we can measure the energy required or produced from the steam turbine to have 90 PSIG as the outlet steam. This steam will then feed into the heating system.

4.3 Integration Testing

What are the critical integration paths in your design? Justification for criticality may come from your requirements. How will they be tested? Tools?

1. Price: Track prices of renewable energy during cold season to get low spot prices, e.g during off peak hours. Find a dealer from the energy market.
2. Storage temperature: The temperature should be kept between set temps and not fluctuate too much. Placement of the storage will have a significant impact on the temperature.
3. Pressure: measure the pressure of the steam to make sure it's at suitable levels for the university to use
4. Power & Energy: gather all power and energy information from ISU current system and determine how much energy PNE can supplement. Data from this part is also required to calculate the purchasing price of power.

4.4 System Testing

Describe system level testing strategy. What set of unit tests, interface tests, and integration tests suffice for system level testing? This should be closely tied to the requirements. Tools?

We will be comparing the efficacy of different steam replacement systems with the cost of those systems. This directly relates to the size of our system so it incorporates the most central part of the project. We also need to know how much steam we need to provide to the system to make it worth it for the Ames power plant to incorporate our system into theirs.

4.5 Regression Testing

How are you ensuring that any new additions do not break the old functionality? What implemented critical features do you need to ensure they do not break? Is it driven by requirements? Tools?

The main deliverable of the project is to produce a proposal that considers all of the additions in the functionality of the system. We will be working with PNE, ISU utilities, and MISO to ensure that each part of the system can meet any new edge cases that come up in testing. The majority of this testing to find these edge cases will be conducted using Excel and email will be used to contact the relevant party.

4.6 Acceptance Testing

How will you demonstrate that the design requirements, both functional and non-functional are being met? How would you involve your client in the acceptance testing?

The primary goal of our project is a proposal, therefore the acceptance testing will be performed on Polar Night Energy's design. For our project, the design requirements are quantifiable variables such as price, output pressure, storage temperature, storage duration, etc. That makes it easy to determine if they are being met. Since our client is the university the only involvement they will have in the acceptance testing is determination of the design requirements.

4.7 Security Testing (if applicable)

Non-applicable

4.8 Results

What are the results of your testing? How do they ensure compliance with the requirements? Include figures and tables to explain your testing process better. A summary narrative concluding that your design is as intended is useful.

The desired results from our testing will be a system that is economically feasible. This means it can be constructed and integrated into our current heating system at ISU within our determined threshold of $16 Million. With this system in place we hope to see the pressure drop within the current system reduced, and the cost to recharge the system be more cost efficient than the purchase of non-renewable energy sources.

Our group will not be able to see the construction of this project, so we have created deliverables we can measure. The first of these deliverables will be a complete cost analysis. This will include construction cost, monthly/yearly energy consumption cost, and a payback period. These metrics will allow us to propose our system to the university.