Exploring Polar Night Energy

DESIGN DOCUMENT

Team 16

Client:
Iowa State University

Advisor:
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Team Members:
Anton Skvoretz – Connector / Gatekeeper / Information Provider
David Iheme – Test Engineer
Dylan Vos – Meeting Scribe
James Stutzka – Meeting Facilitator
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Executive Summary

Development Standards & Practices Used

Our project relies on our ability to obtain renewable energy, store it within the facility, and distribute it throughout the campus. If our request is approved and the system is implemented some of the standards we would need are as follows:

- Electrical Code Power Storage
- NFPA 70, 72, 101 (Electrical, Fire Alarm and Signaling, Life Safety)
    - NFPA 70 is the National Electrical Code which is the standard for safe installation of electrical equipment.
    - NFPA 72 describes the installation standard for fire alarm systems which will be required if our storage is indoors.
    - NFPA 101 defines standards for life safety based on construction, protection, and occupancy.
- IEEC (Iowa Electrical Examining Board)
    - Needed for required permits/licenses.

In addition to construction and design code, we may also implement engineering standards. These engineering standards will follow the principles described by IEEE Code of Ethics. The IEEE Code of Ethics explains the proper way to conduct one's self in engineering. Such standards include work competence, financial responsibility, communication honesty, property ownership, and others. For more information we reference section 7.8 of IEEE Code of Ethics.

There are a variety of other standards that would relate to the implementation and construction of our proposal, however, these are beyond the scope of our project which is to submit a cost analysis and feasibility report for the thermal battery to the university, not the implementation of the thermal battery itself.

Summary of Requirements

- Qualitative aesthetics requirements: We want our system to link into current university steam lines, and possibly be situated near the marching band fields.
- Functional requirements: Current goal is to use the thermal battery developed by Polar Night Energy to reduce pressure drop in the University steam lines. Use energy from the grid to heat sand. The heat stored in the sand will then be used to make steam and offset the current pressure drop.
- Resource requirements: Create design and construction documents by the end of 492. Access to information from the ISU utilities and Polar Night Energy.
- Environmental requirements: The Polar Night Energy system shall produce zero CO2 emissions. Any emissions produced by this system will come from the energy source used to produce the heat. These emissions will come from renewable sources and be significantly reduced compared to current production methods at Iowa State University.
- Economic requirements: Purchase energy from renewable generation plants and from MISO to reduce emissions from other sources. The purchase of renewable energy shall be used to reduce costs that may come from non-renewable sources.

Applicable Courses from Iowa State University Curriculum

ENGL 314, EE 303, EE 455, and EE 456.

New Skills/Knowledge acquired that was not taught in courses

Our team has gained knowledge in project management skills, teamwork, speaking with clients, everyday operations of a power plant, and renewable technologies. Looking towards next semester we will understand processes for purchasing renewable energy through groups such as MISO.

Table of Contents

System Visuals and Images

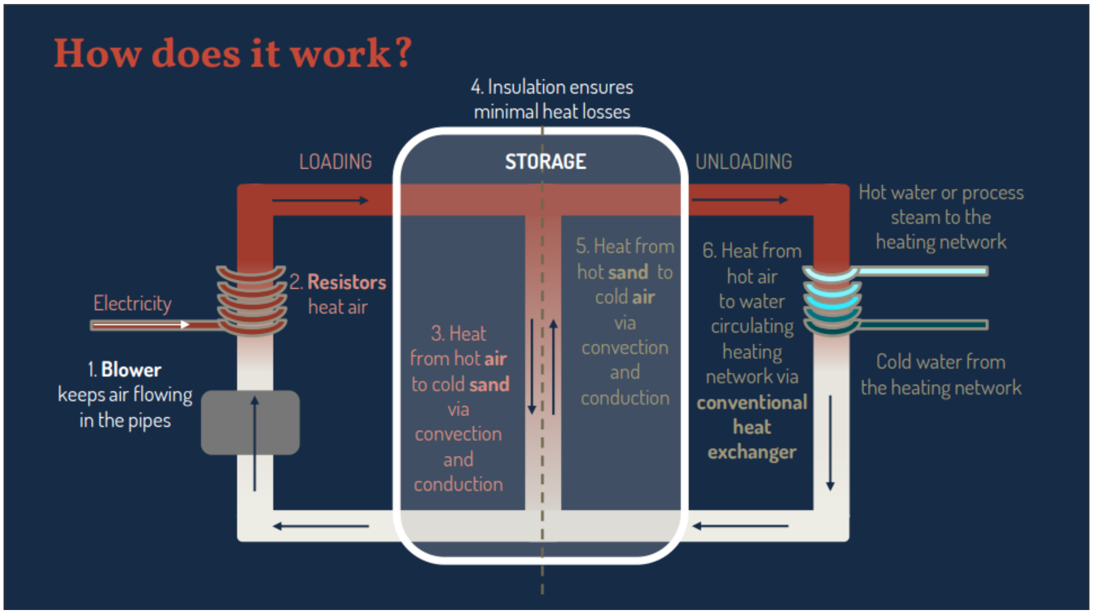


Figure 1: The system takes electricity to produce heat. This heat is stored in sand and can be output to steam. (Source: Polar Night Energy, https://polarnightenergy.fi/)

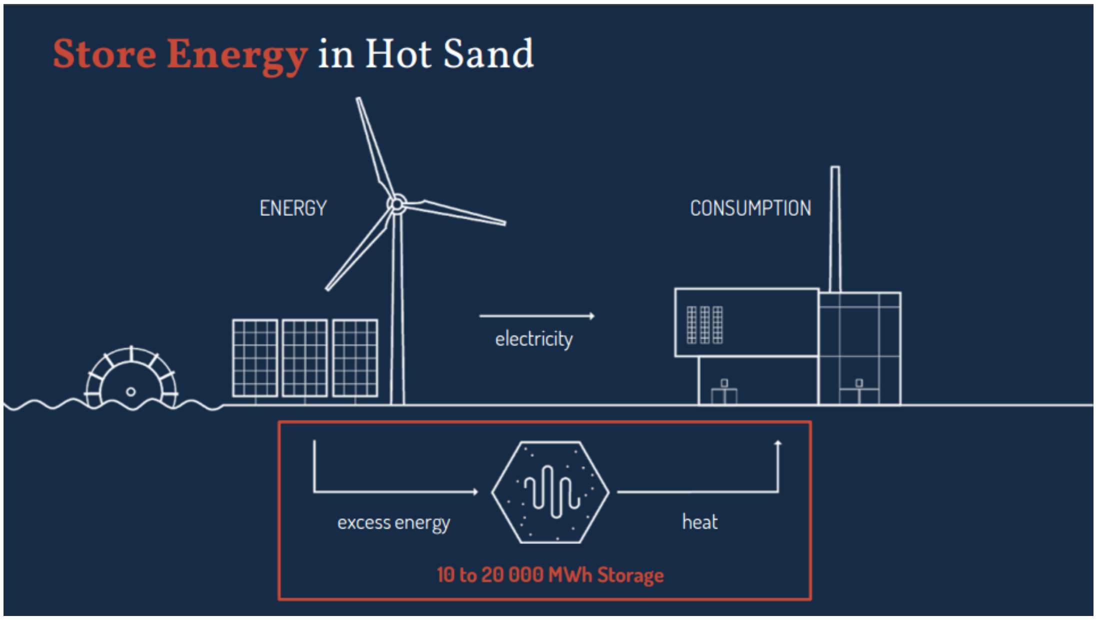
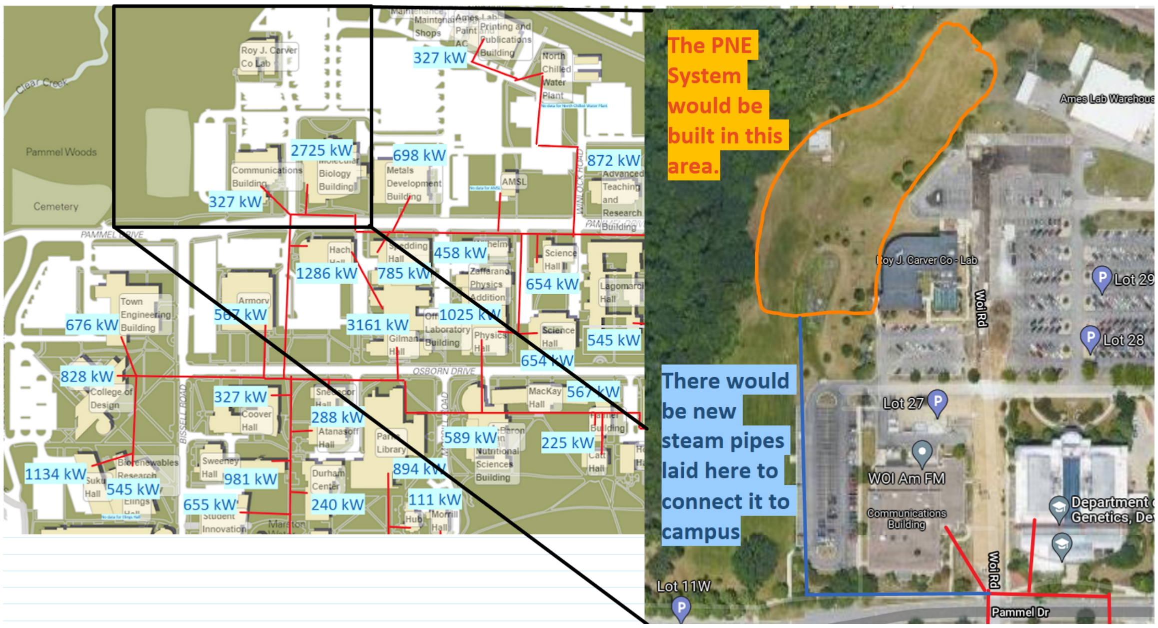


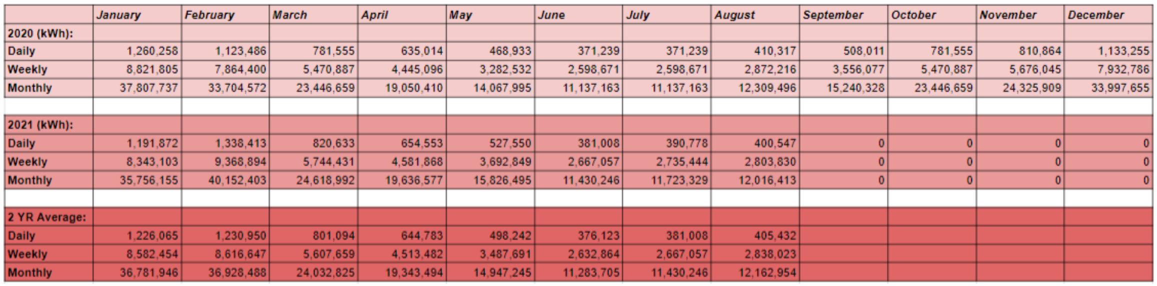
Figure 2: We may store electricity from the grid for a prolonged period of time and output to the load when necessary. (Source: Polar Night Energy, https://polarnightenergy.fi/)



The PNE System would be built in this area.

There would be new steam pipes laid here to connect it to campus

Figure 3: Map of Campus for general location for system installation.



	January	February	March	April	May	June	July	August	September	October	November	December
2020 (kWh):												
Daily	1,260,258	1,123,486	781,555	635,014	468,933	371,239	371,239	410,317	508,011	781,555	810,864	1,133,255
Weekly	8,821,805	7,864,400	5,470,887	4,445,096	3,282,532	2,598,671	2,598,671	2,872,216	3,556,077	5,470,887	5,676,045	7,932,786
Monthly	37,807,737	33,704,572	23,446,659	19,050,410	14,067,995	11,137,163	11,137,163	12,309,496	15,240,328	23,446,659	24,325,909	33,997,655
2021 (kWh):												
Daily	1,191,872	1,338,413	820,633	654,553	527,550	381,008	390,778	400,547	0	0	0	0
Weekly	8,343,103	9,368,894	5,744,431	4,581,868	3,692,849	2,667,057	2,735,444	2,803,830	0	0	0	0
Monthly	35,756,155	40,152,403	24,618,992	19,636,577	15,826,495	11,430,246	11,723,329	12,016,413	0	0	0	0
2 YR Average:												
Daily	1,226,065	1,230,950	801,094	644,783	498,242	376,123	381,008	405,432				
Weekly	8,582,454	8,616,647	5,607,659	4,513,482	3,487,691	2,632,864	2,667,057	2,838,023				
Monthly	36,781,946	36,928,488	24,032,825	19,343,494	14,947,245	11,283,705	11,430,246	12,162,954				

Figure 4: Heating Energy Use for ISU. (Source: https://www.fpm.iastate.edu/utilities/energy_dashboard/)

1 Team

1.1 TEAM MEMBERS

1. Noah Sampson
2. Anton Skvoretz
3. Dylan Vos
4. Muhammad Roslan
5. James Stutzka
6. David Iheme Jr
7. Kasey Kellogg

1.2 REQUIRED SKILL SETS FOR YOUR PROJECT

1. Electrical Engineering experience
2. Communication
3. Inclusion
4. Problem Solving
5. Document creation
6. Project management

1.3 SKILL SETS COVERED BY THE TEAM

1. Communication: Anton will represent the group as the connector, gatekeeper, and information provider. He will reach out to any necessary companies/people outside of our team. If someone within our team has questions, Anton will be one person to reach out to.

2. Inclusion: James will be the team's meeting facilitator. The facilitator is responsible for maintaining a friendly and professional environment where all can share their thoughts and be included in discussion.

3. Problem solving: David shall be our test engineer, and the entire team will require problem solving techniques. David will be responsible for reviewing our final design documents to make sure they are accurate, ethical, and without error.

4. Document creation: Dylan will create documents and record meeting minutes for meetings. Muhammad will be the lead for document creation regarding design.

5. Project management: All members are responsible for deadlines. Kasey will manage reports, Noah will act as the arbitrator to manage group conflict.

1.4 Project Management Style Adopted by the team

We will employ the waterfall management style. Our project is more effective with a waterfall approach because we are mainly developing informational documents. We don't have hardware or software to test and iterate on.

1.5 Initial Project Management Roles

Dylan Vos: Meeting Scribe.
Anton Skvoretz: Connector / Gatekeeper / Information Provider.
Kasey Kellogg: Report Manager.
James Stutzka: Meeting Facilitator.
Noah Sampson: Arbitrator.
Muhammad Roslan: Design Lead.
David Iheme: Test Engineer.

2 Introduction

2.1 PROBLEM STATEMENT.

The company we would be working with is named Polar Night Energy. Their product is a thermal battery that stores energy as heat in an insulated box of 500 to 600 degrees C sand. This sand can be heated up when renewables are plentiful, then the heat can be released to heat the university via the existing district heating system.This heat can be stored for months on end, allowing the system to be charged up throughout the year, then discharged during the winter.

As a team we would create a complete cost analysis and feasibility assessment of a Polar Night Energy system at ISU. The end goal would be to submit an installation proposal to the university, if the Polar Night Energy system proves to be suitable for the university's application.

2.2 REQUIREMENTS & CONSTRAINTS

- Qualitative aesthetics requirements: We want our system to link into current university heating, and possibly be situated in the current power plant.
- Functional requirements: Current goal is to use Polar Night Energy to reduce the pressure drop in the university steam lines.. Use energy from the grid to heat sand. The heat stored in the sand will then be used to make steam and heat the university on demand.
- Resource requirements: Create design and construction documents by the end of 492. Access to information from the ISU utilities and Polar Night Energy.
- Environmental requirements: The system's overall CO_2 emissions are significantly lower than the current system's emission.
- Economic requirements: Purchase energy from renewable generation plants and from MISO to offset the costs of natural gas. Installation and maintenance of the heating system.

2.3 ENGINEERING STANDARDS

Our project relies on our ability to obtain renewable energy, store it within the facility, and distribute it throughout the campus. If our request is approved and the system is implemented some of the standards we would need are as follows:

- Electrical Code Power Storage
- NFPA 70, 72, 101 (Electrical, Fire Alarm and Signaling, Life Safety)
    - NFPA 70 is the National Electrical Code which is the standard for safe installation of electrical equipment. NFPA 72 describes the installation standard for fire alarm systems which will be required if our storage is indoors. NFPA 101 defines standards for life safety based on construction, protection, and occupancy.
- IEEC (Iowa Electrical Examining Board)
    - Needed for required permits/licenses.

There are a variety of other standards that would relate to the implementation and construction of our proposal, however, these are beyond the scope of our project which is to submit a cost analysis and feasibility report for the thermal battery to the university, not the implementation of the thermal battery itself.

2.4 INTENDED USERS AND USES

The primary user of our project will be Iowa State University. The thermal battery will be used to reduce Iowa State's dependence on fossil fuels by using renewable energy to store heat for later use. In other words, the battery will be "charged" with heat in the summer when the heating demand is low and it will be released in winter when demand is high.

3 Project Plan

3.1 PROJECT MANAGEMENT/TRACKING PROCEDURES

We are doing a waterfall management style. Our project is more effective with a waterfall approach because we are mainly developing informational documents.

Our group will use Google Drive and Discord to record our progress. Discord will be used for communication and announcements, while Google Drive will be used to collaborate on assignments and deadlines.

3.2 TASK DECOMPOSITION

Task 1:

- Find Iowa State University's yearly heat consumption
    - Power plant tour
- Match it with the designs from Polar Night Energy for optimal installation and usage

Task 2:

- Understanding Polar Night Energy design
    - How long it will take to charge the thermal battery
    - The duration of the heat storage
    - Amount & price of renewable energy energy required to fully heat the storage.

Task 3:

- Determine the system specifications for our design
    - Storage volume. For daily/weekly/monthly storage
    - Required renewable energy for each size of storage
    - List of materials

Task 4:

- System design and cost analysis for designed system
    - Fixed costs: Storage, sand, construction, permits, operation and maintenance
    - Variable costs: Renewable energy daily/weekly/yearly

Task 5:

- Create Proposal for Iowa State University
    - Determine optimal design
    - Create final design documents to use for proposal/presentation purposes.

3.3 PROJECT PROPOSED MILESTONES, METRICS, AND EVALUATION CRITERIA

Our milestones revolve around when the parts of the proposal are completed. These milestones include completing the Heat Consumption Analysis, Deciding on optimal Polar Night Energy system size to match our consumption.

Milestone 1: Complete the power plant tour and University's heat consumption analysis.

- To be completed 10/13

Milestone 2: Understand PNE design

- To be completed 10/27

Milestone 3: Determine system specifications

- To be completed 12/1

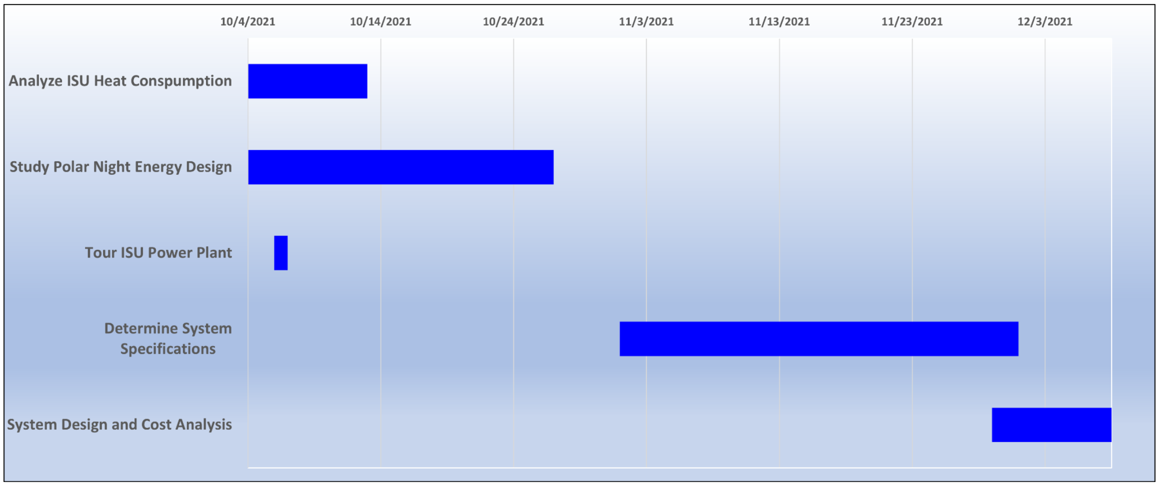
Milestone 4: Complete design and cost analysis of satisfactory system

- To be completed 12/8

Milestone 5: Create a proposal to Iowa State University

- To be completed next semester

3.4 PROJECT TIMELINE/SCHEDULE



3.5 RISKS AND RISK MANAGEMENT/MITIGATION

Task 1: Find Iowa State University's yearly heat consumption and tour of power plant

Risks:

- May not receive adequate information (found out later in the semester)

Risk Mitigation:

- Contact Utility Services for the required information

Task 2: Understanding PNE design

Risks:

- May not receive adequate information on how PNE may size and determine cost for their systems.

Risk Mitigation:

- Reach out to Polar Night Energy for help regarding specific design parameters.

Task 3: Determine the system specifications for our design

Risks:

- System size may be impractical to heat 100% of university demand.

Risk Mitigation:

- Design our system to meet a smaller demand (i.e. daily consumption)

Task 4: System design and cost analysis for designed system

Risks:

- System design requires more material than originally thought and increases design cost higher than anticipated.

Risk Mitigation:

- Decrease system size to meet cost constraints (16 Million).

Task 5: Create Proposal for Iowa State University

Risks:

- Proposal is rejected

Risk Mitigation:

- Determine future possibilities with PNE, and describe to the University the benefits to come from using more renewable energy on campus.

3.6 PERSONNEL EFFORT REQUIREMENTS

Task	Man Hours Needed	Description
1.1 - Heat Consumption Analysis	2 Hours	Compile heat energy data from ISU Energy Dashboard into one document broken into daily, weekly, and monthly energy requirements.
1.2 - ISU Power Plant Tour	2 hr/tour * 7 people = 14 Hours	Participate in a guided tour of the ISU power plant to gain a better understanding of the current heating system as well as how our proposed system will be implemented.
2.1 - Understanding PNE Design	2 Weeks * 2 hrs/weekly * 7 people = 28 Hours	Develop more questions for PNE in order to obtain a greater understanding of the finer details of their system. Ex. How long to charge? How long will it hold a charge?
2.2 - Research on Renewable Energy	1 Weeks * 2 hrs/weekly * 7 people = 14 Hours	Gather data for renewable energies needed to charge the storage such as cost and availability.
3 - Specs of Design	4 Weeks * 2 hrs/weekly * 7 people = 56 Hours	Determine specifications for a PNE system to meet different amounts of the university's heat energy requirements. Such as storing 25%, 50%, 75% of the university's heat energy needs.
4 - Design and Cost Analysis	2 Weeks * 2 hrs/weekly * 7 people = 28 Hours	For each system specification in Task 3 determine the cost to implement and maintain that system and compare those results to that of the current system.
5 - Proposal to University	16 Weeks * 2 hrs/weekly * 7 people = 224 Hours	Finalize and formalize our design documents and compile them into an implementation plan for the university that includes the cost and benefits of instituting the PNE system.

4 Design

4.1 DESIGN CONTEXT

4.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address?

List relevant considerations related to your project in each of the following areas:

Area	Description	Examples
Public health, safety, and welfare	The public health and safety will be increased due to the decrease in fossil fuels consumption.	Reducing exposure to pollutants and a reduction in operations and maintenance.
Global, cultural, and social	Our project reflects the values of the city and Ames and of the University. Both groups are working to reduce their dependence on fossil fuels.	Convincing the university to implement this technology would need a strongly backed proposal.
Environmental	The project is intended to reduce the negative environmental impacts of the university's power plant.	Decreases energy generated using non-renewable sources.
Economic	Helping the school reduce oil and gas purchases. Helps the power plant reduce steam output across campus.	Buy renewables off MISO and store heat for steam. This allows us to decrease the amount of steam that the powerplant has to generate and also saves us money from oil and gas purchases.

4.1.2 User Needs

- Iowa State University
    - The "thermal battery" will be used to reduce Iowa State's dependence on fossil fuels by using renewable energy to store heat for later use. In other words, the battery will be "charged" with heat in the summer when the heating demand is low and it will be released in winter when demand is high.

- The students, faculty, and visitors at Iowa State University
    - This group relies on the current heating system in place at Iowa State University. They need a way to have heating at all times, no matter the circumstances. Our design will revolve around the idea of a secure heating source under all conditions.
- Ames Electrical Power Plant Faculty
    - This group needs a way to connect to and control the input, output, and interior conditions of the system. They will be maintaining and operating the system, so we will need to conform to their design requests as well.

4.1.3 Prior Work/Solutions

We are working with Polar Night Energy, who primarily works in Finland. They are building their first two systems for public use in Kankaanpää and Tampere. These are finnish cities. These require less power than the system our school needs, but these projects show that they work, are sustainable, and cost effective.

https://polarnightenergy.fi/references

4.1.4 Technical Complexity

The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles.

1. Engineering & Mathematical Principles involved:
    - Economic calculations on capital and ongoing costs.
    - Power plant engineering
        - embedding PNE into the current system.
        - Space and heating load estimation.
    - Emission reductions/environmental impact of the system

The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

Solution complexity and challenges:

This system would be one of the first in use. It would provide a new outlet for renewable energy, and energy conservation. The implementation of this project would also be a model for heating large communities with low carbon emissions.

4.2 DESIGN EXPLORATION

4.2.1 Design Decisions

1. Where the system will be located on campus or near campus.
    - The system will be located in the northwest corner of campus. This will place it in the grassy area north of the Band Practice Field and the Communications Building.
2. How large the system will be.
    - This will be finalized further in our talks with Polar Night Energy. We are aiming for a size that places the cost of the system in the ballpark of 16 million dollars to match the price of the current planned boiler transition.
3. How much energy our system provides the university.
    - This decision is still under consideration. The goal is to provide enough steam to offset the pressure drop in the steam lines. The amount of steam needed to achieve this offset is still under investigation.

4.2.2 Ideation

Design Decision	Observation	Ideation
ISU heating load	Our original design revolved around implementing our system at the ISU Power Plant.	This design had multiple options. First, we had hoped our system would have the potential to produce 100% of the university's steam. This design turned out to be very large and expensive. So, we further split that idea into 75%, 50%, and daily steam production.
Location	We then went on our power plant tour, and this led us to design a system further downstream in the district heating system.	As our PNE system can produce steam at 90 PSIG, we can connect our system where the campus uses 90 PSIG steam to increase efficiency. This system will also reduce the pressure drop that occurs far from the source, the Ames Electric Power Plant.
Costs	The university needs a way to decrease their fuels costs while continuing to	The installed PNE will be powered by renewable energy to be purchased at low prices during off-peak hours. The cost of purchasing renewables is cheaper than buying coal and gas

	provide steam for the university	through the addition of renewable energy credit.
Size	ISU Power Plant planned to eliminate all coal generators in 4 years time leaving a huge empty space at the power plant.	The first plan to place PNE at the power plant replacing the current coal boilers. However, the director suggested a location at the parking lot on the west side of the campus. The size of the storage can occupy the suggested location which includes the decision to place the storage either above ground or underground.
Hooking into the steam lines on the other side of campus from the power plant.	The pressure in the steam pipes currently drops off as you get farther from the power plant.	Our PNE system would be able to reduce that pressure drop by providing an influx of steam in a different location. This would allow the whole district heat system to run more efficiently.

4.2.3 Decision-Making and Trade-Off

Our first option was to design our system to meet 100% of the University's heating demands. This system would be located at the Ames Power Plant, and connect to the current district heating system. We decided as a group that meeting 100% of the University's demands was semi-impractical as the size of the system would need to be very large, and in turn expensive. We decided to take into consideration the thoughts of the university and ask the director of the power plant what his thoughts are. This collaboration allowed us to get insight into where the ideal location would be for our system. Weighing the pros and cons of these initial designs, we concluded that a smaller system downstream would be best for the University and our group.

4.3 PROPOSED DESIGN

Currently, we have collected the heating energy use data from 2020-21. This will give us a baseline for the size we would like to design our system around. We have also gone as a group and received a tour of the power plant that supplies ISU with heating, cooling, and electricity. During this tour we asked our guide, Mark Kruse, what the best location may be for a system such as ours. This led us to designing our system downstream and not located within the power plant itself. While these are not directly tests on a system, we are incorporating decision making and trying to find the most effective solution to the problem at hand.

4.3.1 Design Visual and Description

Following the diagram below, the steps are as follows. They are also illustrated in Figure 1 on Page 6.

1. A blower, one of the only moving parts in this system, keeps air moving through the system.
2. Renewable energy purchased from the grid is applied to resistors in order to heat the air going into the storage container.
3. Heat is transferred from the air to the sand by convection and conduction.
4. The insulated storage reduces heat loss which is pivotal in that it allows us to store the heat for longer periods of time.
5. The same way the heat is stored it is extracted from the hot sand to the air.
6. The heat in the air is then transferred to water by a heat exchanger. In our case, we want it to be used to make 90 PSI steam to heat the campus.
7. Lastly, the steam is pumped into the existing steam system to meet campus needs.

4.3.2 Functionality

Polar Night Energy's system uses electricity to heat sand in an insulated enclosure. This heat can then be extracted to generate steam which can be used for heating or power. In Iowa State University's case the idea is to purchase renewable energy from the grid at night and in the summer when energy demand is low, store that energy as heat in the "thermal battery", and expel that heat energy during the day and in the winter when demand is high. Polar Night Energy's design fulfills all functional and non-functional requirements.

4.3.3 Areas of Concern and Development

There are two points of possible concern. The first is whether or not we can get the cost to be a net positive after reducing our gas and coal costs. The second would be whether or not the university will be willing to implement it should we find that the system is economical. The immediate plan is to find the sweet spot where we can maximize the reduction in fuel costs with a minimum investment cost. This would make the university more likely to build the system. We have already gathered a ton of information from PNE, ISU, MISO, and our adviser. The next step is to consolidate that information into a strong argument.

4.4 TECHNOLOGY CONSIDERATIONS

The strengths of this project coincide with the necessity to use renewable energy. The system we are trying to implement reduces the amount of natural gas and coal that the university consumes in order to heat the university.

The system will also provide Iowa State University's powerplant with a lessened load. By strategically installing this system on the west side of campus, we can increase the overall steam pressure which will mean the powerplant has to use less energy in order to pump steam to the west side. By reducing the amount of work for the machines we will hopefully be able to increase efficiency and save money while doing so.

Our main weakness is that we are working with an international company. Unfortunately there aren't any American companies that are doing what PNE does, which has complicated our communication with them.

Additionally, the reliance on renewables means that we are buying off of the grid, that means that if renewables go up in cost, we are going to have to pay more to heat the university.

This last point does have a trade-off, we can save money if we are able to secure a deal under the market rate, and supposing that we have already bought our energy and stored it within this system, we can provide the school with heating when the main system is out of service.

4.5 DESIGN ANALYSIS

The proposed design from 4.3 is adopted from the Polar Night Energy system therefore the system will work. From the power plant tour that we did, the only concern is to complement the 90 PSI steam to heat the campus. However, this issue is not significant as the output of the system is customizable. Also, Mark Kruse, the director of ISU Utilities Services, suggested placing the system downstream to help with the pressure drop away from the ISU power plant (the main steam producer).

4.6 DESIGN PLAN

The intention for this design project is to have the Polar Night Energy system installed as a way to reduce the University's use of natural gas and coal. It will provide a renewable heat source for the campus, and assist the powerplant in providing steam at 90 psi.

The Polar Night Energy System needs to link with the existing district heating system that runs through the Iowa State University campus. The location this system would be built on is shown in Figure 4 on page 7. The system will not take up the entire selected area, this is a general plan for the location. This location was chosen to meet our functional requirements to balance the pressure drop as the steam pipes branch away from the existing power plant.

5 Testing

5.1 UNIT TESTING

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.

5.2 INTERFACE TESTING

1. 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.

2. 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.

3. 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.

5.3 INTEGRATION TESTING

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.

5.4 SYSTEM TESTING

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.

5.5 REGRESSION TESTING

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.

5.6 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.

5.7 RESULTS

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.

6 Implementation

Prior to the implementation of our design we will need to contact multiple sources. First, we will need to contact an energy group such as MISO. The implementation of our system will require a contract regarding the purchase of renewable energy. This contract will be used to determine rates ($/kWh) which will be used in conjunction with our cost analysis.

Secondly, we will communicate further with Mark Kruse and determine the area of success within the current heating and cooling system at Iowa State University. With this information directly from a knowledgeable source, we can describe the effect our system will have on the district heating system. Including reduction of pressure drop, use in blackout conditions where other energy sources are unavailable, and other benefits such as reduction in emissions. Lastly, we will need to contact PNE. We hope they can be a source of information regarding the one time cost of construction. With this information, we will be able to create a final cost analysis to use in our proposal to the university.

With the completion of a cost analysis, estimated payback period, and description of the designed system, we hope to produce an expressive proposal for the university. Our goal as a team is to describe the numerous benefits that are included in the installation of a renewable energy system such as Polar Night Energy.

7 Professionalism

This discussion is with respect to the paper titled “Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment”, *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

7.1 AREAS OF RESPONSIBILITY

Pick one of IEEE, ACM, or SE code of ethics. Add a column to Table 1 from the paper corresponding to the society-specific code of ethics selected above. State how it addresses each of the areas of seven professional responsibilities in the table. Briefly describe each entry added to the table in your own words. How does the IEEE, ACM, or SE code of ethics differ from the NSPE version for each area?

Area of Responsibility	**Definition**	**NSPE Canon**	**IEEE**	**IEEE vs. NSPE**
Work Competence	Perform work of high quality, integrity, timeliness, and professional competence	Perform services only in areas of their competence; Avoid deceptive acts.	Maintain and improve technical competence while only undertaking projects that fit our qualifications.	IEEE talks of giving and accepting criticism and NSPE focuses on overseeing projects and giving signatures and stamps of approval.
Financial Responsibility	Deliver products and services of realizable value and at reasonable costs.	Act for each employer or client as faithful agents or trustees.	Always act honestly in giving estimates and stating claims. Also never accept bribes.	IEEE and NSPE don’t differ when it comes to finances.
Communication Honesty	Report work truthfully, without deception, and understandably to stakeholders.	Issue public statements only in an objective and truthful manner; Avoid deceptive acts.	When making estimates and proposals, be honest with your calculations and estimates. Avoid personal conflicts of interest, and disclose them to involved parties.	IEEE and NSPE have similar standards regarding honesty.

Health, Safety, Well-Being	Minimize risks to safety, health, and well-being of stakeholders.	Hold paramount the safety, health, and welfare of the public	Improve technology and technical competence to reduce chance of injury and misuse. Increase well-being by treating all colleagues equally and fairly. Avoid injuring others reputation and property.	In addition to public safety, IEEE also involves upgrading technology features for safer use.
Property Ownership	Respect property, ideas, and information of clients and others.	Act for each employer or client as faithful agents or trustees.	Avoid diminishing one's property. Whether it be your own property, or a colleagues. Said property may be one's property, reputation, body, etc.	NSPE has a focus on respecting one's career, while IEEE determines property to be career and all belongings.
Sustainability	Protect environment and natural resources locally and globally	Meet the human needs for natural resources and land use while conserving the resources for positive environmental quality and future development	Publicly and promptly disclose factors that might endanger the environment. NSPE determines sustainability as catering towards resources that cause no harm to nature and the public.	IEEE includes an honesty factor in this category as you must disclose possible harm to the environment and act to avoid this harm.
Social Responsibility	Produce products and services that benefit society and communities	Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession	Assist colleagues in professional development. Conduct yourself in a manner that benefits safety, health, and well-being of the public and peers. Treat all fairly and as equal.	IEEE includes conducting one's self as honorable to the profession, and also includes acting for the benefit of others.

7.2 PROJECT SPECIFIC PROFESSIONAL RESPONSIBILITY AREAS

For each of the professional responsibility area in Table 1, discuss whether it applies in your project's professional context. Why yes or why not? How well is your team performing (High, Medium, Low, N/A) in each of the seven areas of professional responsibility, again in the context of your project. Justify.

1. **Work Competence:** Our project's outcome is creating a proposal for the university. We need to be certain that our figures are correct. If we were to make a proposal that does not accurately represent what the system is capable of we could mislead those involved in reviewing our proposal.

   High: We are currently wrapping up gathering the data and information we need to begin determining the size of our project as well as possible installation locations. On top of this we are also completing objectives in a timely manner and are currently on track.

2. **Financial Responsibility:** This ties into our work competence because of our proposal's reliance on cost benefit analysis. We have to maintain that what we say the system will cost in investment and operation/maintenance is true. We are trying to truthfully save the school money while also reducing emissions.

   Medium: We haven't begun pricing our project yet, however, financial responsibility remains an important pillar in our project. We hope to keep our project under budget and provide a financial benefit for the university.

3. **Communication Honesty:** We have to be completely honest in our communication for the proposal. So far, we have stayed in contact with PNE and the powerplant in order to have full transparency with what our project is capable of doing.

   High: Our need to communicate our proposal accurately and truthfully is of the utmost importance.

4. **Health, Safety, and Well-being:** Since the scope of our project is contained in a proposal, health, safety, and well-being do not apply as strictly as if we were working with the construction as well. However, since our project aims to reduce emissions of fossil fuels it certainly won't hurt the health, safety, and well-being of the public.

   N/A: Our group will not need to perform heavily in health, safety, and well-being as we are working outside of construction and lab environments. However, our project will have a positive impact on the well-bring of the public through reduction in emissions.

5. **Property Ownership:** Property ownership applies because Iowa State University would be owning all of the hardware, the point of this project is just to propose the construction. Our group would own all of the intellectual property involved.

   Medium: We need to be careful with the intellectual property of our team, Iowa State University, and Polar Night Energy.

6. **Sustainability:** One of the main goals of our project is to reduce the university's fossil fuel emissions which plays directly into sustainability. This will be done by storing energy from renewable sources in order to partially heat the campus.

   High: Again, the primary goal of this project is to reduce the university's use of fossil fuels which plays directly into sustainability and is a major factor in our decision making.

7. **Social Responsibility:** The intent of this project is to use energy systems that are more safe for the environment. We are attempting to bring a renewable energy system to the school.

   High: Reducing the university's emissions will only benefit the members of the campus as well as the surrounding communities and remains an important influence in our project design.

7.3 Most Applicable Professional Responsibility Area

We are concerned with communication honesty. We are creating a proposal for the university that requests the building of a renewable energy system. We are confident that the technology in this system will adequately improve the school's energy usage. It will also reduce the amount of greenhouse gas emissions. For these reasons we have to have total honesty in our proposal. The need to communicate how and why our system is a good investment is paramount to our project. If we were to act in bad faith it would show in our work once the system is implemented. This will also reflect badly upon the company who is building the system. By acting in accordance with the IEEE code of ethics, we are confident that we will be able to create a truthful and accurate representation of the energy system we want to have on campus.

8 Closing Material

8.1 DISCUSSION

Our project is coming along very well and we have met most of our goals for this semester. In our case the project product or deliverable is a cost analysis and feasibility assessment for the university in the hopes that a PNE system is installed in the future. While the requirements for this deliverable aren't met yet we are on track to finish our final product by the end of next semester.

8.2 CONCLUSION

As the semester comes to an end we have accomplished a great deal and met the majority of our goals set for the first half of the course. We were able to achieve our goals of gathering important background data for the project as well as participating in a power plant tour. We are currently in the process of meeting our final goal of determining the size of the system for the university. The primary constraint on meeting this final goal is working with an international company as we are still awaiting some final details from them in order to determine the size of our system. This issue could be avoided in the future by contacting Polar Night Energy earlier in the semester and utilizing a more direct form of communication rather than email, a voice call for example.

8.3 REFERENCES

"IEEE Code of Ethics." IEEE, https://www.ieee.org/about/corporate/governance/p7-8.html.

"Technology." Polar Night Energy, https://polarnightenergy.fi/technology.

8.4 APPENDICES

ISU Utility Services. *Power Plant Presentation*. Oct. 2021, https://bit.ly/31vFz7x. PowerPoint Presentation.

Polar Night Energy. *Sales Deck_v1.9*. Oct. 2021, https://bit.ly/3rDW9g0. PowerPoint Presentation.

8.4.1 Team Contract

Team Members:

1) _Anton Skovretz_________________ 2) _David Iheme___________________

3) Dylan Vos______________________ 4) _James Stutzka_________________

5) Kasey Kellogg___________________ 6) _Muhammad Roslan_____________

7) _Noah Sampson__________________ 8) ________________________________

Team Procedures

1. Day, time, and location (face-to-face or virtual) for regular team meetings:

   Wednesday 5:00-5:30pm we will meet as a group with TA Jacob Betsworth. After this meeting, our group will stay together and talk about necessary objectives for the previous and following week. If necessary we will hold a second meeting on Saturdays at noon.

2. Preferred method of communication updates, reminders, issues, and scheduling:

   We will be utilizing Discord for team communication and When2Meet for scheduling meetings which will be virtual on Discord.

3. Decision-making policy:

   Any future questions and decisions will be brought to the attention of the group for deliberation. Whatever seems reasonable and agreed upon will be the outcome i.e. consensus.

4. Procedures for record keeping:

   Dylan Vos will take minutes and they will be archived and sent to all group members via the group email.

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:

All are expected to attend our Wednesday 5:00pm meetings. If someone is busy and can not make it, they will inform the group at least an hour ahead of time so we do not wait on them and can relay the information.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:

All deadlines will be put in writing and are expected to be met. The team will hold an additional meeting 2 days before each deadline in addition to the normal Wednesday meetings, if necessary.

3. Expected level of communication with other team members:

Team members should check the discord once per day to maintain communication. During our weekly meetings all members can share their progress with deadlines, and share any concerns.

4. Expected level of commitment to team decisions and tasks:

All team members can freely share their opinion when it comes to team decisions. If team decisions come to a vote or consensus, all members should share their position. You are expected to meet all deadlines, if you believe you are behind the deadline reach out to other team members for help.

Leadership

1. Leadership roles for each team member:

Dylan Vos: Meeting Scribe
Anton Skvoretz: Connector / Gatekeeper / Information Provider
Kasey Kellogg: Report Manager.
James Stutzka: Meeting Facilitator
Noah Sampson: Arbitrator
Muhammad Roslan: Design Lead.
David Iheme: Test Engineer

2. Strategies for supporting and guiding the work of all team members:

Gather input from all team members. This supports the group as all members can share their input freely, and this information will help guide the group to meet deadlines and provide exceptional documents.

3. Strategies for recognizing the contributions of all team members:

> Reflect the perspectives of team members in design documents. If someone feels they are not being represented, they can speak freely to the group to resolve the issue. Team arbitrator, Noah Sampson, will also help resolve these issues.

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.

> Every team member possesses an electrical engineering background.
>
> Anton: Worked for a transmission utility in the planning department
>
> Dylan: Worked in a PE,PC design company for 3 years on multiple projects.
>
> James: Worked at KFI Engineers as facilities engineer intern.
>
> Noah: Worked on protection and control of substations
>
> Muhammad: Worked as a TA for entry level EE classes (EE201,230) for 2 years
>
> David: Worked as a Project Engineer for a construction company for 1 year
>
> Kasey: Worked to institute lean principles in a production environment.

2. Strategies for encouraging and support contributions and ideas from all team members:

> The meeting facilitator, James Stutzka, will encourage all members to participate in group discussions and activities. During meetings, everyone will be allowed to share their ideas without being interrupted.

3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)

> The arbitrator will ensure that any issues surrounding collaboration and inclusion are resolved amicably. Any team member with issues can contact the arbitrator to seek a resolution.

Goal-Setting, Planning, and Execution

1. Team goals for this semester:

    Gather information relating to the project from PNE and the University such as power consumption, storage capacity, available space, etc. Tour the university power plant to gain a better understanding of how the PNE design will be integrated into the existing system. Use available information to determine which sized system is the best fit for the University.

2. Strategies for planning and assigning individual and team work:

    Plan out deadlines ahead of time in meetings so that it is clear when each item needs to be completed. Make reasonable timelines for finishing the project to allow each member to complete their assigned work. Work will be assigned based on best fit related to team role.

3. Strategies for keeping on task:

    Regular weekly meetings and consistent team communication through Discord will ensure individual members and the group stay on track to complete goals.

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?

    Meeting with team members to discuss resolution to the problem.

2. What will your team do if the infractions continue?

    If infractions continue, the group will consult TA Jacob Betsworth to help resolve the issue. Other team members should step in to complete the remaining work, if applicable.

****

a) I participated in formulating the standards, roles, and procedures as stated in this contract.

b) I understand that I am obligated to abide by these terms and conditions.

c) I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.

1) Anton Skovretz DATE 9/18/21
2) David Iheme DATE 9/18/21
3) Dylan Vos DATE 9/18/21
4) James Stutzka DATE 9/18/21
5) Kasey Kellogg DATE 9/18/21
6) Muhammad Roslan DATE 9/18/21
7) Noah Sampson DATE 9/18/21