NAU Solar Capstone

Post Mortem Analysis

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Introduction

During the Spring 2020 semester, the team was instructed to design a solar thermal heating system for the Engineering building on the campus of Northern Arizona University. The goal for the system was to provide heating to the building while reducing the use of the natural gas boilers that currently supply heat. The following report outlines the results of the NAU Solar Capstone team's first semester of work.

Contributors to Project Success

In the original Team Charter, the team's goal was to develop a design, apply for funding via the Greenfund, and implement the solar thermal heating system over the summer term. In the event that these goals could not be met, the team also proposed the possibility of providing a design that could be improved upon and implemented in the future by another Capstone team. The team understood the original difficulty with receiving approval and testing the system in just one semester, which prompted the possibility of the first semester being more focused on the design and testing.

Due to the extenuating circumstances surrounding the Spring semester, the team was unable to meet the goal of implementing the heating system over the summer. Testing became the new priority for the beginning of the Fall semester, so the team designed a test to determine the effectiveness of the solar panel model the team plans to use. The second half of the Spring semester was centered on finalizing calculations for energy output and temperature change, designing a test for the solar panel, and applying for funding from the Greenfund so the test could be conducted in the Fall semester.

Aside from the tangible goals, the team aimed to improve their individual understandings of solar heating and thermodynamics through research and self-learning. Based on the body of work completed during the spring, a substantial development of understanding of these principles can be seen.

The weekly meetings with the project staff contained the project and aided in keeping the group on track, especially through the pandemic. The Solar Capstone team was very reliant on the project staff to provide information on building and piping specifications. The group would use the information discussed in the weekly meetings to run calculations regarding heat transfer and fluid dynamics. This information would be used as far as the team could take it until more information could be requested at the next meeting.

Ground rules and coping strategies were established and detailed in the Team Charter from the Spring semester as well. The team placed emphasis on organization and communication throughout the semester to stay on track; for example, the team collected all documents in one shared Google Drive folder, and formal meetings were held on a weekly basis while informal communication was often present on a daily basis.

The team chose a system that left a lot of freedom to each group member to complete the assigned task. Communication was crucial to the team's success, as each member had individual responsibilities and tasks to complete for each meeting. This led to a

good amount of broad information being reported, but the team could work on deeper information. Therefore, the team should collaborate more with that information so everyone is up to speed.

The scope of the project changed multiple times during the semester, but the initial plan was to have Drew determine the piping system, Cole research and contact possible Solar Panel vendors and Drake research and perform heat transfer calculations within the system. However, getting the vendors' attention became a problem, and contradicting numbers in the heat transfer calculations led to inconclusive calculations. Once the team started sharing tasks, it was determined that the group would use the same solar panels that were on the roof of the HLC, and the correct numbers were used in the heat transfer calculations once the software reference was found. Something the group talked about at the beginning of the semester was to each have a hand in every task so the result is solid. This ideology was not deployed right away, but was rather learned the hard way towards the middle of the semester.

Opportunities for Improvement

The most negative aspects of project performance were team initiative and ability to coordinate with vendors. Consistently throughout the project, the team sought solar panel specifications and prices from multiple vendors unsuccessfully. Most vendors were unwilling to work with the team in lieu of their student status among other characteristics of the team. Similarly, under these circumstances the team was not persistent enough with these companies in seeking the information needed. These problems led to many setbacks for the team and delayed overall construction and design processes. The team also encountered poor performance with their interpretation of data provided through NREL's SAM modeling and solar redbook data.

The data sets were inconsistent and therefore required testing of panels to determine realistic energy and temperature outputs.

Although the team encountered many obstacles, each was overcome successfully. First, the team was able to get specifications and costs for solar panels after analyzing mistakes and altering their approach. To counter their student status, the team mentioned their possession of a large budget in early conversation with companies to display their intent as a project rather than an experiment. The team also began construction on a test set-up for the solar panels to ensure the performance specifications were accurate. The team was able to acquire a solar panel through utilization of prior projects to begin testing and design upon completion. The team also began design of the HVAC systems with a generalized solar farm to expedite design processes and construction when the solar farm would be able to be designed. Many different iterations of the farm were created to be altered simplistically when performance readings were attained.

The most likely organizational improvements for the team are in distinct roles and execution of said roles. The team encountered overlap throughout the first half of the project leading to redundancy in research or design steps which could have been avoided to create a more efficient team. The team also needs to execute their roles

more persistently and efficiently as this led to hold ups in performance and could have resulted in overall team failure. These problems are easily dealt with and will not be seen going forward.

Another improvement the team should make this semester is to prioritize internal deadlines. It seemed on certain occasions that the team would show up to the meeting unprepared and there was often a lot of overlap in the meeting discussions from week to week. With more strict internal deadlines and discipline, more information will be taken away from these meetings. The information collected in these meetings is crucial to meeting the team's weekly objectives and not being prepared beforehand led to missing information. A simple fix to this issue would be to hold a brief team meeting before the staff meeting in order to get the talking points and objectives outlined. Not having enough information between meetings is what held the team back the most last semester, and slightly different practice could lead to different results.

The team learned more about time management and initiative during the last semester. It is important for the team to reflect on mistakes made and alleviate them going forward. By not managing their time effectively, the team was unable to fully design their solar farm by the anticipated deadline. This has held the project back exponentially and

serves as a lesson learned. The team also needs to be more proactive in developing designs and attaining materials. The team consistently reacted to circumstances leaving them unprepared. After experiencing these setbacks, the team is now more proactive and able to cope more effectively.

With all this in mind, the team is going to approach this semester with a head of steam. What worked well for the team last semester will be employed, as well as improvements that the team will implement to improve upon last semester. This is the final class of our undergraduate careers, and the group is going to head into it with a lot of focus and patience. Last semester, the team was tested with unhelpful vendor practices and inconsistent results from the irradiance modeling. That is why the team is starting the semester with an experiment designed to determine the amount of heat a solar panel will provide, and reference it back to the System Advisory Model to compare results. The results of this experiment will determine the scope of the project going forward.