Senior Design Team 517

Making the MagLab Greener: Optimizing the HVAC

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# **Abstract**

Team 517 will help Trane redesign the cooling system at the MagLab to lower the energy consumption and carbon footprint of the Innovation Park. The Innovation Park houses world record holding magnets within the National High Magnetic Field Laboratory, commonly referred to as the MagLab. These magnets produce an enormous amount of heat and require an equally high amount of energy to cool. The HVAC system in charge of keeping the magnets cool results in the MagLab’s carbon footprint being extremely large and Trane is the company in charge of supplying the Maglab’s HVAC.

This team will accomplish this goal with two methods: cooling the magnets and sharing the MagLab’s cooling ability. The magnets are cooled under the assumption they operate at full power; however, this isn’t always the case since the magnets often use less power to run. The team will design a system that cools the magnets based on the percentage of power used. This will ensure the MagLab does not waste energy by overcooling a magnet. As a result, the less energy the MagLab consumes, the lower its carbon footprint. When the magnets aren’t in use, the MagLab has a vast cooling potential sitting idly. The second way the team will reduce carbon emissions is using the MagLab’s idle cooling ability by sharing it with the rest of Innovation Park. The new building coming to Innovation Park will rely on the MagLab’s cooling capability for its air-conditioning. This team will design a way to transport the chilled water in the MagLab to the new building two hundred yards away. By relying on the MagLab’s chilling ability, the new building will consume far less energy. Running one system will use less energy than two, and the overall energy consumption of the Innovation Park will decrease thus lowering its carbon footprint.

# **Introduction**

Tallahassee’s Innovation Park is a campus that houses many research institutions. One of which is the National High Magnetic Field Laboratory, commonly referred to as the MagLab. The Innovation Park is constantly improving. One large component that can be improved is the cooling system. The Heating, Ventilating, and Air Conditioning (HVAC) company Trane is a partner with the FAMU-FSU College of Engineering and solicited the help of Senior Design students to explore the options for making the cooling system of the Innovation Park more energy efficient. The team must explore many options and propose a technical solution to decrease total cost and increase efficiency of the system.

The Senior Design Team sponsored by Trane will explore options to lower the energy consumption and carbon footprint of the Innovation Park by redesigning the cooling systems within its laboratories.

## **Key Goals**

The following goals will focus the project objective to be more specific and expand the scope of the project lower the energy consumption and carbon footprint in Innovation Park.

* Conduct research for this project by collaborating with the different building faculties and Tallahassee Utility Company to gather existing information.
* Explore the current expenditures for Innovation Park
  + Innovate potential solutions for improving the HVAC efficiency at the Innovation Park
* Determine if the solutions are cost effective.
  + Conduct research for this project by collaborating with the different building faculties and Tallahassee Utility Company to gather existing information.

## **Assumptions**

The assumptions for this project help outline the limitations of what the project entails. All information and data that we need is assumed to already exists. It is a matter of retrieving the data rather than collecting it. The energy usage of the Innovation Park is assumed to not go through any unexpected changes in the future such that the data can be used to interpolate the data usage in the future. Any new buildings will have an energy usage estimate based on previous similar facilities. The project will not include any information on energy use besides HVAC systems.

## **Critical Targets**

The critical targets of this project are difficult to define. Systems should strive to be as sustainable as possible. This target is hard to tabulate before examination of the system. Improving the efficiency of the system can yield results that range from a small percentage to a massive reduction in energy usage. For this project, the team researched what is a typical reduction in energy usage for large HVAC system. They determined that a reduction of 10% of energy usage would be an appropriate target.

# **Method**

## **Concept Selection**

The team began to brainstorm to determine where they would reduce the energy usage, and thus the carbon emissions, of the Innovation Park. The laboratory that uses the most energy at the Innovation Park is the National High Magnetic Field Laboratory referred to as the MagLab. It immediately was one of the main considerations. Furthermore, the sponsor of this project, Trane, is responsible for cooling the MagLab. These two observations led the team to consider redesigning the cooling system of the MagLab to reduce the Innovation Park’s carbon emissions.

The cooling system of the MagLab is composed of several main components. The main components that the team looked at were the chillers, the heat exchanger, and the water pumps that push cooling water into the powerful magnets. Because the chillers are manufactured by Trane, the team took an interest in them. They were found to be already fully optimized with little room for improvement. The heat exchanger is a similar story. It is not serviced by Trane but there were few energy losses in its operation. All passes were properly insulated and it underwent routine inspection to ensure efficiency. The final subsystem was the magnet cooling pumps. After speaking with the lead engineer of the cooling system at the MagLab, the team found that the magnet cooling pumps could be significantly improved. The pumps are run with the assumption that the magnets are drawing 100% power. This is often not the case. Most of the time, scientist at the MagLab run draw less power for their experiments. Sometimes it can be as low as 25% of their maximum power. Drawing less power means that the magnets are giving off less heat. Even at this lower temperature, the pumps will cool the magnets as if they are operating at their maximum temperature.

The team concluded that they would reduce the carbon emissions of the MagLab by redesigning the magnet cooling pumps to operate on the basis of the power the Magnet is drawing. If a magnet is only using 25% of its total power, the pumps would only provide 25% of their total cooling power.

The final selection was brought to the team sponsor who purposed an additional piece of the project. He asked the team to consider the cooling system of a new building that was coming to the Innovation Park. The Interdisciplinary Research and Commercialization Building, IRCB, will be built without an HVAC system in place. The current idea is to cool the building with the cooling capability of the MagLab when the magnets are not in use. The team agreed with Cameron took the responsibility of designing a way to bring chill water to the new building. This will allow IRCB to borrow the MagLab’s cooling equipment. Running one cooling system will consume less energy than running two. This will allow the team to lower the carbon footprint of not just the MagLab, but the whole Innovation Park.

## **Calculating Values**

The first step of implementation was to determine the current energy expenditures from the pumps in kilowatts. This was done by taking the power usage from the month of February, 2019. The MagLab can determine the power usage of the pumps independently of the other electric systems. This information was provided to the team. Once the usage was found, the team found the cooling need during that month. This information was provided as a measure of Btu per hour. The team assumed that the maximum cooling need reported was the maximum cooling that was required. Dividing the amount of cooling used by the maximum cooling amount returned a percentage of the cooling that was required. This amount varied throughout the month. Using the percentage of the cooling required the team found the power that was required in kilowatts. This value was compared to the value that was used. The difference was the savings that would be recovered if the system was optimized according to the team’s plan. The MagLab provided the price that the city of Tallahassee charges them for electricity. This value was used to determine the financial savings of reducing energy consumption.

For the plan to move chill water to IRCB, the MagLab provided a study was provided to the team written by Affiliated Engineers. This study examined the cost and energy savings of moving chill water to IRCB versus building a chiller plant at the new building site. The team used the information provided about the cooling need of the new building to determine the power required to pump the chill water to satisfy that need.

# **Results and Discussion**

The team found that the power usage was 449 kilowatts for the month of February. Extrapolating out meant that 5,390 kW of power is used to cool the magnets in a year. The maximum cooling required was roughly 115 Btu per hour. However, the average required cooling was only around 12%. This meant that on average nearly 88% of the power that is being used to cool the magnets is wasted. Multiplying the percentage of cooling required by the amount of power that is used in a year returns the power that is required to cool the MagLab magnets. Only 644 kW are required annually. This is a savings of nearly 4,725 kW over the course of a year. The city of Tallahassee charges the MagLab $1.88 per kW of power. This equates to an average savings of $8,884.06 per year.

The plan to move water to IRCB found that 1371 gpm of chill water was required to meet the new building cooling requirement. Using standard 6.5 inch diameter PVC pipes, 9.5 kW is required to pump that amount of water to IRCB. The Affiliated Engineers study evaluated the savings over a 30 year period and found the plan would save 16 million kWh of electricity and $2 million (Affiliated Engineers, 2019). The original plan for the study was for the team to confirm these numbers. Unfortunately, the study did not disclose where they found the information that was used for the study. The team could not locate key documents including a building blueprint and the number of people that were expected to occupy the building daily. This information is required to determine the cooling requirement of a space.

# **Conclusion**

The next step in this process is to develop an implementation plan. This plan and the values that the team found would be presented to the MagLab and Innovation Park facilitators. The facilitators will then decide if the savings are worth implementing this plan. This project concluded before a plan to implement the design was made. The future work of this project would be to determine a way to limit the pumps at the MagLab.

The next step for the plan to move chill water to IRCB would be to design a piping network. The goal of this network would be to minimize the construction time and cost. The team would then determine if the MagLab had the pumping power to provide the water to IRCB. If not, an additional pump would need to be purchased. Like the magnet cooling plan, the MagLab and Innovation Park facilitators would need to decide if this plan is worth implementing or if it is more feasible pursue another plan.

The team achieved the goal of determining a way to save 10% of the energy of a system in the Innovation Park. The current plan saves nearly 90% of the power for the magnet cooling pumps. This is a significant achievement, and the team is proud of their accomplishment. However, the team failed to determine a way to implement this plan. At this point, no savings have been made. The team provided evidence that energy saving is possible in the MagLab and at IRCB. More time and resources must be contributed to reduce the energy consumption and carbon emissions of the Innovation Park.

There are several reasons why Team 517 failed to reach the conclusion of this project. The main reason was the failure to work quickly enough given the scope and the time constraints of this project. The team did not properly budget their time to finish their objectives before a final conclusion was due. If the team were to continue this project, they would be able to formulate a complete plan to reduce the carbon emissions of the Innovation Park and present it in its entirety to the Innovation Park facilitators.

# Bibliography

Affiliated Engineers. (2019). *Florida State University Research Park Central Utilities Study.* Tallahassee.