



Energy, Environment and Society (5.92)

Student Project Results

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Nuclear Reactor Heat Recovery Study

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ABSTRACT: The Massachusetts Institute of Technology's (MIT) nuclear reactor gives off 4.2 megawatts of energy; as a research facility, the energy is not used for any application and it is released to the environment through a water cooling system. The heat produced by the reactor core is absorbed by radioactive water on the primary loop through a heat exchanger. The heat from the primary loop is absorbed by a secondary loop of entirely safe, non-radioactive water using another heat exchanger. The temperature of the water in the secondary loop is 95°F (33°C); this temperature qualifies the water as low-grade, which means it is difficult to make use of. However, the secondary loop has a large volume of water flowing through its pipes (approximately 2200 gallons per minute) which adds to its potential as an energy source. This project researches a variety of applications for the secondary loop water with optimistic results.

The nuclear reactor is currently running at five megawatts, but is seeking approval from the Nuclear Regulation Committee (NRC) to operate at six megawatts. This could positively affect the scenarios analyzed because more energy would be available in the form of hotter water. The analysis for this report uses 4.2 megawatts as the power produced by the reactor because it does not run continuously all year; it runs for five weeks and then is shut off for one week while the core is refueled. This shortage of energy for 1/6 of the year is fully taken into account in the analyses.

Energy recovery at the nuclear reactor has been studied previously, but the previous reports found no cost effective ways to use the energy. With improved technology and more information available, more options were available when this study was conducted. The team's focus on this project was to maximize the benefits for the nuclear reactor—the original stakeholder—while at the same time making a contribution to MIT's energy initiative. When selecting scenarios for the project, the team took into account the existing infrastructure available, the potential to displace a non-renewable energy source and the importance of the system to the primary stakeholders. Once scenarios were chosen and analysis performed, validation of feasibility was based on its monetary benefit to the Institute, present value analysis and potential for carbon dioxide displacement.

Over the course of the semester, many scenarios were presented to use the nuclear reactor's heat and were initially analyzed under the guidelines of the methodology. The team decided to focus on four scenarios and complete comprehensive studies on them. The scenarios were preheating condensate makeup, heating domestic hot water, heating the NW35 graduate residence and heating the Zesiger Center pools.

All of these scenarios can run concurrently without exhausting the energy produced from the nuclear reactor or the exceeding the output water flow of the cooling water in the secondary loop. The makeup water to the Cogeneration Facility requires the least amount of effort to implement because piping already exists between the buildings and the only purchase required are water softeners for the cooling

water. The Z-Center pool heating scenario requires approximately 0.2 miles of piping construction costs and the purchase of water heaters, all of which adds up to a steep initial cost. The space heating in the new graduate dorm is a very good scenario because the heating system for the buildings have not been installed yet and the system proposed by this project costs approximately the same as the heating system originally planned for the building; the initial cost therefore is meaningless in comparison to the initial costs of the other projects that require additional construction/purchases for existing situations. Heating the domestic hot water of the dorms on campus has the highest costs due to pipe construction and the purchase of heat exchangers and storage tanks; it also has a very high annual savings that quickly offset the lofty upfront cost.

After analysis was completed, it was found that each of the four scenarios presented have a reasonably short payback period and will save the Institute significant amounts of money, energy, and carbon emissions over the scenario lifetimes. These savings could considerably contribute to MIT's attempt to reduce energy costs, energy use and greenhouse gas emissions.