Pumpable Ice
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Introduction
From May through September the demand for electricity increases as air conditioners are in use and this translates to higher prices for many people. In many areas of the United States, the cost of electricity is higher during the hotter parts of the day (On Peak hours). This also creates a strain on the electrical grid because everyone is using their air-conditioning systems at the same time. This project addresses the issue of the higher cost of electricity during on-peak hours by designing an alternative air conditioning system that uses less electricity during these high cost hours and moves the cost to off-peak hours when electricity is less expensive.

Objective
Develop an air conditioning system that performs similarly to a standard window air conditioning unit and saves consumers at least 5% on their electricity bill by taking advantage of off-peak hours. Ice will be used because of it’s latent heat of fusion; this is the energy needed to change the state of water from a solid to a liquid. Because this requires a large amount of heat, it is much more effective at absorbing heat than chilled (cold) water alone. However, because ice is a solid, it is impossible to pump through a heat exchanger as a solid block. For this reason, we have added glycol to water in order to coat the ice crystals and create a slush that is pump-able. The water-glycol mixture is frozen at night during off-peak hours and pumped through the system during on-peak hours. Unlike traditional air conditioning units, this system surpasses the need to use a condenser during hot parts of the day, saving money.

Design Requirements
1. Cool a 11.61-m² room from 28°C to 24°C Celsius in a span of 40 minutes.
2. Cost 5% less to run than a traditional 4.22 MJ window air-conditioning system during on-peak hours for 60 minutes.
3. Be comparable in size and noise output to a traditional window air conditioner.

Testing and Results
Heat Load Capacity
In order to find the heat load capacity of this design, an experiment was conducted in which the temperatures and humidity were measured before and after the heat exchanger. The volumetric air flow was also measured. These values, as well as values taken from a psychometric chart, were used in the below equation to find the capacity of the system.

\[ Q_s = C_f \times Q_v \times \Delta h \]

\[ C_f \] = total heat factor; \[ Q_v \] = flow rate; \[ \Delta h \] = enthalpy change

Average of Three Tests
\[ Q_s \] = Capacity (Mega Joules) = 4.905 MJ

Cooling Control Room
In order to verify the first design requirement, the prototype was placed in a 11.61-m² room, and was able to successfully cool the room from 28°C to 23°C in 40 minutes.

\[ \Delta T \] = Temperature difference = 5°C

Power Consumption
The power consumption was found by using a kWh meter and measuring how much power was used to cool the control room.

Average of Three Tests
\[ P \] = Power Consumption = 2.65 kWh

Conclusion
The prototype was able to achieve the first design requirement. The third design requirement was partially met. The requirements of safety and noise output were comparable to a traditional air conditioner, but because the machine uses 15 liters of liquid, the size of the machine cannot be made smaller. The amount of power that the prototype consumes is higher than the 1.31 kWh in the ideal design specifications. With such a high power consumption, the prototype will not be able to achieve the second design requirement. To achieve the second design requirement, the prototype was redesigned for efficiency. This theoretical design will meet the requirement and will save some consumers up to 22% on their electricity costs.

Design for efficiency by calculating and choosing:
- Correct pump size
- More efficient refrigerator / freezer
Theoretical power consumption: 1.03 kWh