Energy Efficient Table Top House

Design Team
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Abstract
The goal of the Energy Efficient (EE) Table Top House Team is to provide a platform on which 6th-12th grade students will be able to build small model houses thereby learning about energy efficiency concepts. In the process of building these houses, the team hopes to inspire more students to join the engineering field. Several sample houses will be provided as well as the means for students to design their own houses. The platform will contain thermistors, ammeters, and a thermoelectric assembly (TEA), designed to provide air to air cooling and air to air heating. These are run by an Arduino programmable microcontroller. Ports and sockets on the platform allow solar and wind energy to be fed back into the system. The difference between energy consumed and energy produced will be its net energy consumption. As the energy required by the TEA to maintain a set temperature within the house will be affected by the material and design, a more efficient design will produce a lower consumption level. The ability of students to alter these will provide room for creativity while engaging with engineering principles.

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The Need for Project

The main objectives of this project are to design a model house that is energy-efficient, functional and aesthetically pleasing to K-12 students and that would teach them the concepts of energy efficiency. In the process of building these houses the team hopes to inspire more students to join the field of engineering and develop an appreciation for science.

The Design Project Objectives and Requirements

The project objective was for the team to design two model houses that are energy-efficient, functional and aesthetically pleasing so that students will want to play with them and learn about energy efficiency. These houses were meant to be replicable by students so they can build it on their own and develop interest in science and engineering. While only the 6th grade in the Massachusetts public school science curriculum has an opening to use such a model, it was also intended to be used by older students who would have access to a larger range of teachers, it became clear that any activity should also anticipate a range of involvement levels from students in the same grade.

Design Concepts Considered

Initially, there were two designs considered. One involved a model that would be thermally cycled with radiant energy. The other involved a model house that would keep itself warm in the winter with an electrical heater. The latter was developed into the final design.

The initial requirement for this project demanded two separate houses, one designed by female members of the team and the other by the male students. The main goal of having female students work independently from male students was to explore gender-based preferences on engineering design approaches and to eventually inspire more female students to become mechanical engineers, as they are currently underrepresented in this discipline. Due to a limited time and number of people working on each house, the team decided to drop that idea and work on just one design.

One system considered was designed to take advantage of photovoltaic solar panels and a wall that independently controlled radiation and conduction. An enlarged south facing roof would allow more solar panels to fit on it and efficiently create electricity for the house. The second major design element was going to include a large south facing wall made of two thick panels of glass separated by a layer of dead air. On the inside on this wall would be an adobe heat wall.
This combination of walls would allow for very little conduction, but freely let radiant energy in.

The team also considered a design involving orientation of the house and the concept of azimuth sun angles. Using reflective surfaces and the angle of the sun, windows on the roof can be placed such that there is more light and heat during the winter and less during the summer.

**Recommended Design Concept**

The recommended design is a platform that will regulate the internal temperature of a model house that is placed on top of it, facilitate adding electrical loads and sinks, and monitor electrical usage as an output.

Final design is a platform which shows the thermal and electrical efficiency of a small scale house analogue that is tested on top of it. Platform is comprised of a TEA that regulates the inside temperature of the house, an electrical system that allows different components to consume or contribute electricity (i.e. lighting or solar panels and wind turbines), and an Arduino PMC to run everything and output the rate of electrical usage (in Watts) to LCD screens. The platform regulates internal house temp to 70°F in environments ranging from nominal Massachusetts winter to summer. The TEA is meant to keep the inside temperature of the house higher or lower than outside. Open electrical system allows for use of future components without changing the The idea is to provide a series of example model houses with varying degrees of energy efficiency to give students an idea of the system functions and what efficiency is. These houses can compare steady state electrical usage in Watts to show which house is more efficient (in comparable environments).

Students will be able to create and test their own models; however, they will have to conform to certain standards. Considering the surface area based on the thermal analysis, the maximum size specifications of the house must be 9”x7”x6”. Since the solar panels chosen for the roof are 4.5”x4.5”, the roof surface is supposed to have a minimum area of 20.25 in² in order to mount one.

The open nature of the platform will allow older students with more building and design skills to use it with more complex models and still output comparable values.
Financial Issues

The total cost of the platform with all the electrical components, including the power supply unit came up to be around $650. After reviewing all the Purchase Orders and removing the products that were either not needed in the process or could be substituted with cheaper ones, the team decided that the Delrin plate could be substituted with a cheaper one available on the market. Also, the parts required for the test chamber build were removed, since the school will no longer need a test chamber to test the house. The number of electrical connectors was also reduced since they were purchased as basis of destruction in case of failure. Finally, it was suggested that only one Arctic Silver was required instead of two. The second one was purchased for re-assembly.

Recommended Improvements

The main future improvement for this project is cost reduction. By substituting some of the components with cheaper alternatives the team is hoping to reduce the cost of the house. Because the prototype allows for the TEA to be disassembled and reassembled, final product could be joined with thermal epoxy, which would limit the structural features in the base plate.

Another idea for the future is providing the house in stencil form. The walls would have serrated edges, which could interlock with each other. Placing the stencil on the material, such as Styrofoam, or any other material that the teachers at the school find appropriate for the age group to safely cut out, students would be able build a house with the correct specifications.

Creating interface that would allow students to change and/or limit energy use and designing a kit that could be assembled by teachers are another two ideas for the future.