The S.P.E.C.I.A.L. Project

(Technical Topic)

The Engineering Design Process

(STS Topic)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Solar-Powered Electronic Cooling In Any Location, or The S.P.E.C.I.A.L Project, is a portable, low-cost, durable, solar-powered fan to be used primarily in developing countries. This project will be designed to be affordable, to withstand everyday use, to be easy to repair and maintain, and most importantly, to efficiently provide cool air to those around it. The fan is designed primarily for outdoor use and is intended to provide simultaneous charging and cooling; where cooling is defined as the redistribution of air directly and autonomously induced by the fan.

My STS research project of the technical topic will be about the design process. There are three main topics I want to go into detail: real users and imagined users, the problem lines on the power grid, and the nonusers affected by this product.

Technical Topic

The S.P.E.C.I.A.L. Project was chosen to provide a solution to developing countries' cooling issues. "Cooling in developing countries is a major problem that affects health, disease treatments, and hunger… Many developing countries do not have access to electricity and consequently do not have proper cooling systems either… Although air conditioning ownership has gone up from 2 million in 2006 to 5 million households in 2011, that number still only represents around 3 percent of Indian households. Restricted energy access prevents many from being able to purchase air conditioners."

There are other solar-powered fans available on the market, but they don't properly address the needs of these developing countries and impoverished locations. The other options on the market are either too high priced, with several unnecessary features that drive the cost upwards, or so inexpensive that there is no durability; and the product isn't worth repairing when it inevitably breaks. The project will only feature aspects that are required to provide cool air without normal means of electricity. This allows our product to be more affordable than the majority of the quality, solar-powered fans on the market. The project will be ease of maintenance. This allows the users to carry on with their everyday lives without the fear of damage to the product. In addition, if the product were to be damaged, disassembling the product would be a breeze. The low-cost parts allow for replacement by the user, and the design allows for simultaneous solar-powered charging and power to the fan.

There are three members in our group: Hieu, Kristian, and Jack. Hieu is an Electrical Engineering major and he has experience with solar panel technology and he is also familiar with AutoCAD software. Kristian is also an Electrical Engineering major who has some AutoCAD experience and 3D printing experience as well. Jack is a Computer Engineering major who will be using his programming skills with the MSP430 that will be used in our project. All of the members in this group have experience with designing a PCB with MultiSim and UltiBoard. In addition, we are all capable of testing with the Virtual Bench, and programming in Code Composer Studio.

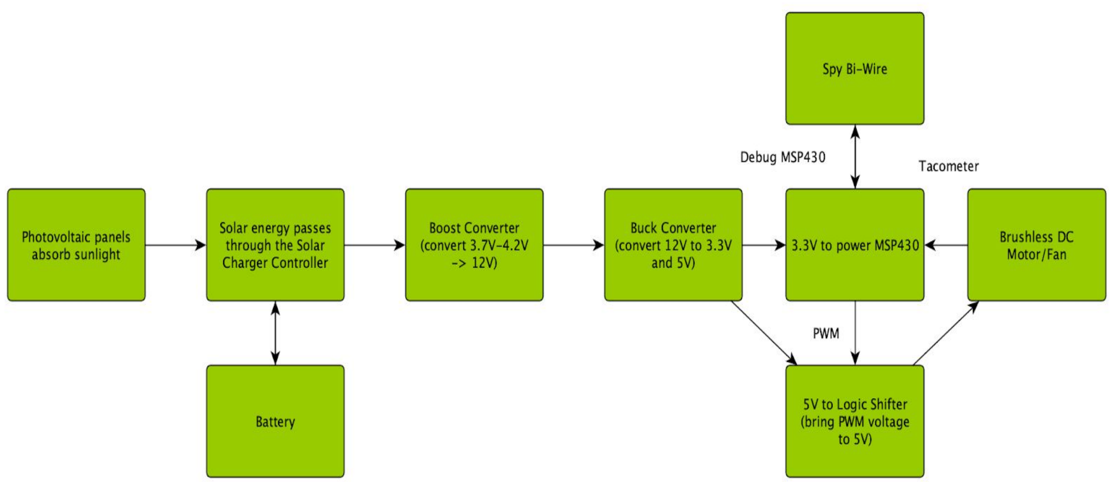

Figure 1: Power distribution block diagram

The Solar Powered Electronic Cooling In Any Location, S.P.E.C.I.A.L, is a solar-powered fan that is also portable, low-cost, and highly durable. The device will be designed to be affordable, to withstand everyday use, to be easy to repair and maintain, and most importantly, to efficiently provide cool air to those around it. The device is designed primarily for outdoor use and is intended to provide simultaneous charging and cooling. The design will have two primary components: the main housing and the fan. The main housing contains five photovoltaic panels, a power management PCB, and a battery. When the user places the device into an open space and opens up all the foldable, solar panel wings to face directly towards the sun, the energy collected from the solar panels will be processed through the power management PCB then power the fan and store accessible power within the battery. The other part of the device is the fan which contains a button, the 4 wire fan, MSP430 PCB, and LED indicators. The fan is designed to be detachable from the whole unit and is connected to the main housing with wires. When the user clicks the button the fan will turn on, and it will turn off after four clicks. There are three LEDs on the fan, one will indicate whether there is a sufficient amount of power input to power management PCB, another will indicate if the battery is charging, and the last one will indicate if the battery is low.

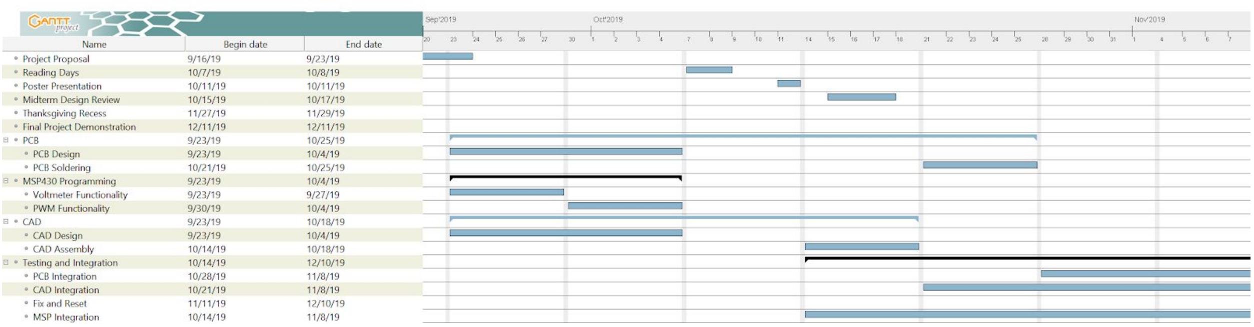

Figure 2: Gantt Chart

The Gantt chart shown in Figure 11 illustrates the original schedule for developing the final product. The three main systems of the product are Mechanical Engineering, Electrical Engineering, and Computer Engineering. In order to achieve maximum efficiency, these systems were started in parallel and then integrated together to form the final product. The project started with the programming being implemented and with the PCB and CAD models. The models were then created remotely and then assembled together with the MSP430 to create a working fan. When creating the initial Gantt Chart, the team made sure to consider the important deadlines for the project, specifically the Midterm Design Review on October 15th and the Final Design Presentation on December 11th. In addition, the dates of school breaks were considered so as to not overestimate the amount of work that could be completed during those times

STS Topic

The capstone project was a success, grade-wise at least. We put in so much time and effort, we completed what we set out to achieve, to have a working prototype. The project came together nicely and it worked at the end. However, there was a feeling and a deep disappointment that I couldn't shake it off, "No one would buy this product, it's so impractical" I told myself. But why? We designed it to be easy-to-use, highly durable, and most importantly, practical. So what went wrong during the design process?

The Actor-network theory being introduced in "Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts" was written by Bruno Latour[1]. To understand how technology develops within societies, actor-network theory (ANT) look into not just individuals (Solar-powered fan) but at all the other factors that went into that contribution (3D printer, Solar panels, Lithium-ion battery, engineering department that funded the project, the capstone group). All of these elements are actors in the network, and they can be both human or nonhuman. ANT goes deeper into how these networks come together, work, and fall apart.

The actor-network theory is a great tool to look deeply into what causes the design to succeed or fail. Latour uses the seat belt example to demonstrate how ANT is very helpful. To be more specific, he points out that cars used to not come with seatbelts, nonhuman actors reduced the safety of driving, encouraging human actors to develop new technologies to compensate. I want to use the same method to look closely into the solar-powered fan. What causes the idea? Who are the human factors in place? How non-human factors shape the design?

Engineer-sociologists term being introduced in "Society in the Making: The Study of Technology as a Tool for Sociological Analysis" by M. Callon[2]. Callon describes engineer-sociologists as engineers who have acquired a unique skill set combining the technical knowledge of an engineer with the skills found commonly in social scientists.

Callon used the example of an electric car project from France in the early 1970s. He pointed out that the engineers who worked on the project couldn't just think of the best way to produce the most efficient product but they also had to think about the consumers, social movements, and ministries. Technological advances go hand in hand with the way society is structured, so in order to innovate, engineers also need to think like a sociologist. I want to relook at the technical project in an engineer-sociologist's perspective to further examine the disconnect in the design process.

The non user's term is being introduced in "Non-users also matter: The construction of users and non-users of the Internet" by Sally Wyatt[3]. Wyatt explains that nonusers are the one who does not make use of something. She uses various examples, including her life experience, to explain that analyzing the users is important and it is also important to include non-users into the conversation because they also have a role to play in shaping the way our society progresses.

Analyzing who are the users and who are the nonusers is very important during the design process; not just for profit purpose but it's also about ethics. I want to identify who are the users and the nonusers that will be affected by the project? And how can I account for them into the design process?

First, I want to discuss who are the "imagined" users? Who are the real users? And the disconnection between the 2 during the design process. The imagined users are the ones we hypothesize would be the consumers of this product. To be more specific, they are the "people from the underdeveloped countries" who are in need of a cheap and self-sustainable cooling device. The reason is that the electric bill is too high and the cooling cost is a big part of it. It's difficult to explain who the real users are since we've never met them. We can only do online research and figure out who they are. However, there are flaws in this process. The data is not "up to date," we still have to "imagine" what their needs are based on the data. That reason alone already speaks value about how disconnected designers and consumers are. That's something I'd like to dive deeper into the STS Research Paper.

Second, I want to talk about human and non-human factors when it comes to connecting to the power grid and this is more than just for cooling purposes. One of the human factors is the electricity user. In our daily life, we rely upon electricity for many things such as cooking, cleaning, entertainment, and of course, improve our living comfort. Using electricity for cooling is one of the musts for our modern life. One of the non-human factors is the power grid. The power grid is one of the most advanced and complex designs we've ever created. However, it has a limit, depending on different countries, that limit could look every differently. In the STS Research Paper, I'd like to go deeper into more human and non-human factors in play, and how they are all interconnected together. All these factors should be accounted for in the design process.

Last but not least, I want to go into detail about how this product is solving problems with commercial goods instead of relying on the government and what will be affected by and to nonusers? There are many unanswered questions about how we are going to provide the product to the consumers and who are going to pay for it? If the consumers from the under-developed country decide to buy it because it's an alternative to their expensive electric bill, will the government stop putting in an effort to improve the situation and leave it to the private organizations to deal with the issue? The nonusers will definitely be affected by this product and not in a positive way.

Conclusion

The theories and frameworks were used are Actor-network theory, Engineer-sociologist, and Users and nonusers. We also talk about all the factors to account for during the design process such as real and imagined users, human and non-human factors, and nonuser's consideration. It's important to consider all these factors in the design process.

For the project itself, one area of improvement is in durability. In order to be successfully deployed to developing regions for outdoor use, the fan must be significantly durable and waterproof, which the current prototype is not. It was difficult to create a sufficiently durable prototype given the constraints of the 3D-printer, and a future study on creating a strong outer shell and securing the interior wiring would greatly improve the quality of the product.

Although they still need to be improved greatly, I think my analytical ability has come a long way. It's unfortunate that I couldn't take this class at the same time as my capstone due to schedule conflicts. I have a chance to learn about important theories and concepts that would shape my future design for years to come. This research paper will help improve future my and other engineering students' designs to be more considerate, well-thought-out, and even have a better chance to succeed in the market.

References

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