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Final Report

How might we harness energy from everyday activities to decrease reliance on non-renewable energy sources such as fossil fuels?

The Problem

- *The Problem*

The existing infrastructure of energy distribution in well-developed countries presents obstacles to the incorporation of new energy sources such as renewables. The current infrastructure is heavily reliant on energy based upon fossil fuel consumption which has been and still is more cost-effective than any new possible sources of energy [2]. These new, renewable sources of energy are too expensive to implement on a large scale, leading to continued reliance on fossil fuels. If this is continued, there will two major problems: first, fossil fuel sources are being depleted rapidly, and as the supply dwindles, this will cause financial difficulties as everyday tasks become too expensive to perform due to increased energy costs [4]; second, the continued burning of fossil fuels will be extremely harmful to the environment [3].

- *Context of Problem*

The primary cause of modern energy infrastructure being developed around fossil fuels is simple to see: cost-effectiveness. When this infrastructure was first implemented, fossil fuels were the most cost-effective energy source, and they still are. In terms of current technological capability, the world has “most of the technology needed to shift” the energy infrastructure of the world from fossil fuels to renewable energy sources that could result in a “30% decrease in global power demand.” However, new sources such as these are still difficult to utilize given the current infrastructure due to stringent energy regulations, inefficient cost implementation of new resources, and an infrastructure heavily dependent upon fossil fuel consumption [1]. Renewable energy sources are currently too expensive to be practical, and the infrastructure has been so heavily developed with fossil fuels that a shift to renewable energy is extremely difficult and complex. As such, the implementation of renewable energy sources “requires complex design, planning, and control optimization methods”[5]. Due to this complexity and cost ineffectiveness, the current infrastructure must be optimized until developments occur that make the implementation of renewable sources both plausible and practical. A form of optimization is to obtain energy from areas where energy is otherwise being lost.

The Solution

- *Goal*

Our goal is to design, prototype, and develop a product that will obtain energy from everyday activities where energy is otherwise lost in order to find ways to optimize the current energy infrastructure so that our reliance on energy from fossil fuel sources may decrease. We decided to focus the scope of our project on a personal means of energy generation rather than a large-scale power generator, for several reasons. First, we believe that if a person has an opportunity to get involved in renewable energy without significant change to their everyday life, they will be more inclined to participate [6]. Second, there are many everyday tasks through which energy is lost; when this energy loss is tallied for all people performing a task in a day, the loss is significant enough to warrant a possible solution [5]. Finally, by linking the energy saved back into a device which the person can then use, we can provide a tangible incentive for that person to get involved in renewable energy by demonstrating its usefulness and accessibility. It is our hope that, should this project be successful, we will be able to reduce everyday reliance on fossil fuels by providing a viable alternative that is easy to use and convenient. in addition, we hope that the users of this alternative will be inspired to search for other simple, accessible ways to reduce everyday energy consumption.

- *Solution Description*

Our solution is a keyboard that will harness energy from the act of typing and charge a battery through triboelectric power generation. We have chosen to focus on the renewable source of triboelectricity, which is the method of generating an electrical voltage based on the charge separation between two different materials (in our project, Kapton and Teflon) created when the two materials come in contact and separate. Once they separate, the charge difference is then converted to a current which travels to a battery.

- *Objectives and Status Update*

1. <u>Research Triboelectricity and Test Feasibility</u>
    a. Research triboelectricity to determine how it works and how to best implement it in our solution space
    b. Contact a professor with experience in triboelectricity
    c. Perform calculations to determine the feasibility of our project
2. <u>Test Experimental Models Under Ideal Conditions</u>
    a. Research models for testing electrical output and gathering data
    b. Determine which triboelectric materials will be the most efficient for our project
    c. Design system electronics
    d. Design experimental protocols to measure electrical output of the system as a factor of typing speed, typing force, and spread on the material
    e. Perform the experiments
3. <u>Model the Application Space and Design Product Solution</u>
    a. Design system hardware
    b. Integrate system hardware and electronic components
    c. Test prototype for maximum efficiency using experiments outlined above

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Over the course of the semester, we have addressed many of the tasks involved with the beginning of a new project. First, we contacted a faculty member, Dr. Wang, and established a working relationship with one of his grad students, Xiaonan Wen. With these resources, we we first determined that a triboelectric system would be better for our solution space than a piezoelectric system, which was our original intention. These resources have also aided us in the formation of the design of our prototype in many ways, such as in deciding which materials and electronic components to use.

We have determined what triboelectric materials we plan to use, as stated earlier, based on information given to us by Xiaonan Wen. He suggested using a system with two layers of polymers (Teflon and Kapton) that will generate a substantial amount of charge when rubbed together, and then placing layers of conducting material such as aluminum foil on the other sides of each of the polymers. This means that we do not need to experiment with different kinds of materials, as we had planned for in our objectives. This has been completed to our satisfaction.

We have also performed calculations based upon Dr. Wangs experimental data. On his design, he obtained 300 Watts per square meter. We assumed that our model would be around a third as efficient as his generator, as his model is much more developed than ours, having specialized surfaces that maximize surface area contact between layers. This assumption is purely an estimate and has no mathematical backing. This equates to .01 Watts per square centimeter. Assuming each key is 1 centimeter by 1 centimeter, and an average typing pace of 40 words per minute and 4 letters per word, this equates to about 1.6 Watts generated per minute of typing.

We have also developed a protocol for the tests that we will run on the materials. This protocol lists detailed methods and procedures for each experiment. The tests will first be done by the team members and, if the results are not statistically significant, with a larger sample size. If we need to ask other people to participate, then we will need to create an IRB with our protocol in order to run the tests. We are satisfied with the protocol as of this moment because it has all of the tests that need to be run and graphs which will tell us how to analyze it.

We have contacted Dr. Greco about the force sensors needed to run force tests. Though it took longer than expected, Dr. Greco provided us with the force sensor and the interpretation equipment. We have also been in contact with the grad student to speak to him about our protocol and use of the materials. We would like to create molds in order to test the effect of bend on power output. The designs for the molds need to be created and then printed on the 3-D printer. We have not yet begun work on the molds.

We have also obtained suggestions from the grad student we’ve been in contact with on the electronic components of our system and how to harness the energy from the system. He also has suggested ways of determining energy output from the system, both qualitatively and quantitatively. In addition, we have contacted several power systems professors about the electronics that will be implemented, and they corroborated the information given to us by the grad student.

We have yet to perform the experiments we have designed for our model, but we plan to do so within the next couple of weeks.This tests will be performed on a triboelectric generator that is outside of the keyboard model so that it can be optimized outside of the keyboard first. For this objective, we still must put together the model, which we have all of the components for, and attach this model to the system we have designed for measuring energy output.

Once the experiments have been performed, the model will be modified based upon the data received from the experiments. Then it will be placed in the keyboard with the electronics placed so that they do not interfere with the electronics of the keyboard itself. Once placed in the keyboard, this prototype will go under further testing and optimization. This will begin as soon as the earlier experimentation is completed and should take a couple of weeks.

We had hoped to complete all of these objectives by the end of this semester, but delays due to us being busy, late shipping, and snow days has pushed us a few weeks behind schedule, as all experimentation on the model, both in and out of the keyboard, has yet to be performed. More detailed descriptions on what has yet to be done is mentioned in the next section.

The final objective of our project has not changed but our method on how to achieve that goal has changed. We first came up with the idea of harnessing energy from typing on a keyboard at the beginning of the semester, but initially we wanted to use a piezoelectric system as we had never heard of triboelectricity before. Our initial paper was written for piezoelectricity. Once we met with grad student, however, we decided to shift to triboelectricity because it is more efficient at obtaining energy and triboelectric materials tend to be less fragile than piezoelectric materials, which means it will be better able to withstand the direct force of the keys pressing down upon it.

Future

- *Future implications and next steps*

Our future implications consist of continuing our four different tests. We will run the first test again, where we developed a control by pressing down a key in the center of the material at a constant kpm on a metronome with a constant force. In the second test, we will vary the force applied, but have the same kpm and position. We'd like to be able to plot a force vs power graph to see how the force affects the power output of the triboelectric keyboard. For the third test, we'll go back to a constant force, but adjust the kpm. We want to plot a kpm vs power output graph. We'll type for a constant time as to not skew results. The fourth test will vary the position of the keys on the material. We will have a paragraph utilizing keys over the entire keyboard, without correcting mistakes made while typing. In order to account for differences in typing speed, we will run a typing speed test before each experiment. We will also test whether the amount of bend in the material makes a significant difference in the power output. We will test the material unbent and bent with an optimal curve using all of the tests above.

Once we have performed all of the tests, we will analyze the data to determine the best implementation of the keyboard. This analysis will involve making graphs to compare energy output to other variables such as force, typing speed, and distance from the material's center. Once we have determined how much energy we will get, we can explore options for storing or using the generated energy. Some of these options include storing the energy in a battery and returning the energy to the keyboard so it is self-sustaining.

Once we have determined how to use the energy we generate, we can begin to implement the material into a prototype keyboard and, if feasible, continue to improve the product design. During this product design stage, we will decide which type of keyboard we would like this system to be implemented in. For example, we could place it in a wireless keyboard where our generator recharges the battery in the keyboard while it is being used. One of the factors we will have to taken into consideration is how consumers will react to this system and how enthusiastic they will be. We have to make sure that adding the generator to the keyboard doesn't make typing on the keyboard harder or less comfortable. Also, we have to make sure that the system doesn't increase the cost of the keyboard drastically so that people will still be willing to purchase it. As of now, we have not identified any future sponsors or collaborators.

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