Team Georgia Techtricity

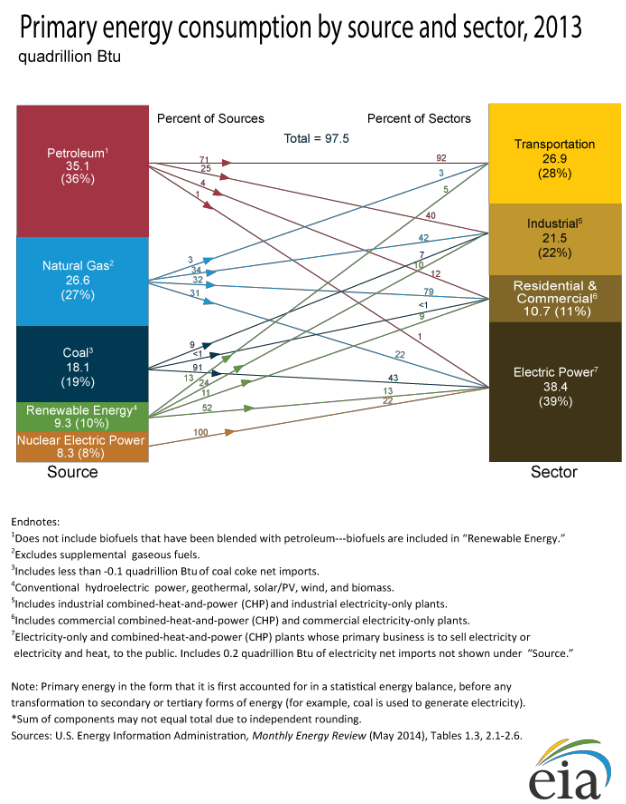
Proposal Overview GT 2201

Team: Abhi Bhardwaj, Amy Foertsch, Anirudh Joshi, Nishul Juneja, Kaylie Naghshpour

How might we:

How might we diversify our renewable energy sources to supplement Georgia Tech campus energy requirements.

Description of background of problem:



As the population of Earth continues to grow, concerns about providing energy to this massive population grow as well. Presently, 90% of the energy sources within the United States are non-renewable [2]. Of these 90% of non-renewable resources, there are further issues within the subdivisions. For example, the oil industry is facing the depletion of its reserves in approximately 40 years. The natural gas industry projects complete resource exhaustion in approximately 85 years. The coal industry predicts it can run for about 150 more years [3]. While these timelines may appear to offer a lengthy period of time for problem solving, it is essential that efforts to diversity the alternative energy interests are put into effect to avoid a true energy crisis.

In response to this need, there are many forms of alternative energy coming to the forefront of energy resource research, yet all of them have their strengths and weaknesses. Wind energy harnesses the energy that is typical lost in wind gusts, but it can be unreliable and unsightly [4]. Solar power is another leading technology that is improving, but it also has highly variable reliability [4]. Geothermal energy is bound and highly influenced by the geography of the area it is implemented in [4]. Hydroelectricity can have a harmful impact on local ecosystems [4]. There are, however, two more sources of alternative energy that are not yet implemented in widespread contexts but are showing a lot of promise in research settings [4]. Piezoelectric technology is one technology that captures and stores or makes use of mechanical energy. Piezoelectricty works by converting the energy created from a charge differential born out of the deformation of the material. This technology is relatively new, but has the potential for many applications from door frames to highways to anywhere there is a high amount mechanical energy being wasted. Previous attempts at using this technology have encountered difficulties because the materials were made of PZT (lead-zirconate-titanate) which were very inefficient. Currently new compounds like Zinc-Oxide have been used which has significantly improved efficiencies. Complementary to that, advances have been made to convert commonly available materials like plastic and metal into triboelectric materials. This has lowered the cost of production and makes it a very viable energy resource.

Shareholders:

The major shareholders that we have identified are energy companies both in the public and private sector such as Georgia Power as well as the general electrical energy consumer and institutes like Georgia Tech. Georgia Power would care about this because it will bring down the cost of electricity in high trafficked areas of the city due to the high amount of mechanical energy that could be harnessed in these areas. It may also lead to a lesser dependence on the traditional electric companies since newer companies may implement this or it could be a public venture from the government. Georgia Tech would care about this since it increases their array of renewable technologies and makes the campus more sustainable. It would also lower their cost of energy every year. The same reasons would be an incentive to the general electric consumer like us students.

Project Goal:

The scope and goal of this project is to research the energy output of piezoelectric and triboelectric materials in a wide variety of settings to determine ideal uses of this new technology. Much of the work done specifically with piezoelectric material in the past has been focused on its application in the transportation industry, targeting roads, train tracks, sidewalks, etc.[5]. The rationale for this research is to expand the applications of these technologies to common settings like door frames, gym equipment, and furniture to name a few. The implementation of these technologies in areas where they would undergo a low stress many times throughout the the day would have a positive effect on the renewable energy market [6]. The diversification of renewable energy interests can only allow for a more sustainable lifestyle which is beneficial for all in the long run. Furthermore, this will open to door to further research in even more inventive and effective implementations.

External Advisors:

1. Dr. Zhong Lin Wang is a professor in Material Sciences and Engineering at Georgia Tech. He is a leading figure in the field of piezoelectric and triboelectric nanogenerators. We intend to use him as an advisor by leveraging his vast experience with the technology. We hope that he and his lab can guide us in terms of appropriate materials and establishing a theoretical backing to our project. We are also open to working with other researchers in his lab.
2. Dr. Robert Butera: Dr. Butera is a professor in the Biomedical Engineering Department and Electrical and Computer Engineering Department at Georgia Tech. As a professor

in the Grand Challenge Program and Electrical Engineering, he has expertise in our problem space.

3. Marcia Kinstler: She is the Sustainability Director at Georgia Tech and has experience with sustainable technologies. She can help advise us with regards to policy considerations while implementing piezoelectric technology.

Objectives:

1. Program a microcontroller (Arduino) or microprocessor (Raspberry Pi) to collect and log data from a piezoelectric force sensor.

Firstly, we need to obtain a piezoelectric sensor and build a device which will be capable of collecting and logging data from the sensor because without any of these, our research is futile and will yield no results. The device to be built is extremely important because currently there is no way by which we can actually determine how much electricity is generated from the experiment and thus determine the feasibility of the technology. If we can't achieve this objective, then all our research will be mere speculation and we won't have figures to back it up which could result in the yield being much lesser or more than the estimated value which will be of no use in our proposed applications. An effective way to measure the success of this objective would be in the successful gathering of data from one application and comparing it to known trials with an acceptable error of 10%.

Anticipated Issues: As a team lacking in electrical engineers and a machine level understanding of programming force sensors/detectors, it will be a challenge for us to program and use a data collector like a Raspberry Pi/ arduino in the manner we aim to. To respond to this challenge, we could to utilize one of our external resources, Dr. Butera, to assist us in calibrating our device to our needs.

2. Testing and Analysing the voltage data from different scenarios using our Raspberry Pi/Arduino device.

Using the Raspberry Pi/ Arduino device we intend to test the force sensor in various scenarios. The aim is to figure out in which scenario can we generate maximum energy. The scenarios that we are looking at are door hinges, chairs and gym equipment.

We need to analyze the resulting data carefully and draw concrete conclusions from it. We will analyse data based off the values for force and frequency of force. We plan to analyze data from 3 different experiments using three different prototypes including the stair stepper, a treadmill and a door strip placed under a door in Howell. These experiments will all be run with three trails. The sample size is not yet known as volunteer availability is not yet known. These data points will give us the total amount of energy that each scenario will produce.This will allow us to apply this technology into feasible applications. In case we don't analyze these results carefully, we won't be able to justify uses for this technology and the energy generated from it. An effective way to measure success of this objective would be in a completed decision matrix with the test results and the metrics we are using to quantify them. Each application will need to be thought out really well in order to maximise efficiency of the energy generated.

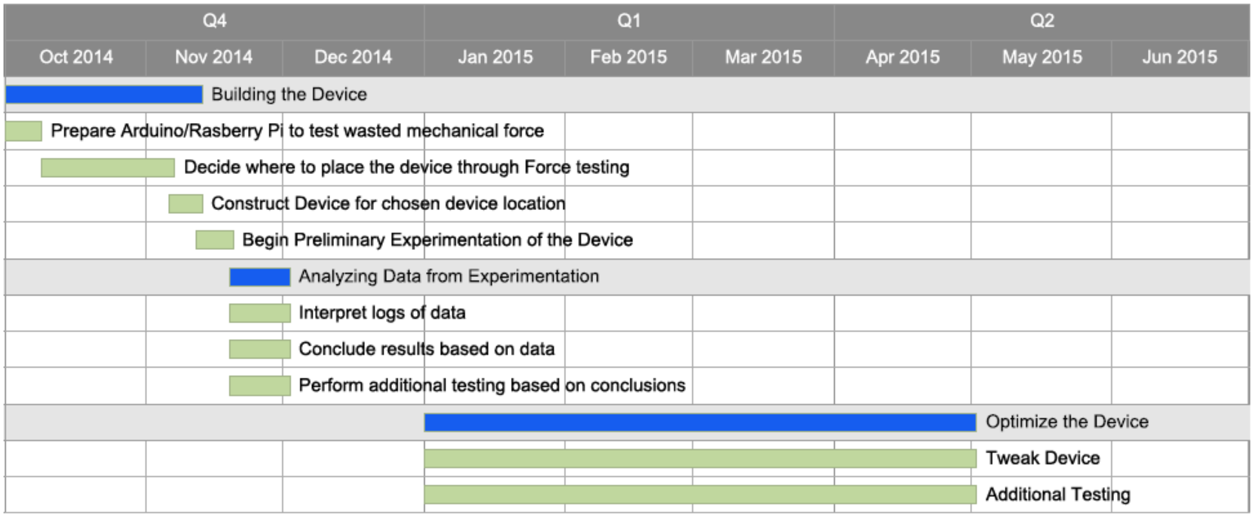
Anticipated Issues: The biggest issue that could arise from this objective is choosing the way in which we analyze our data for maximum effectiveness. For example, if there is one method that offers an extremely high energy output at a low frequency and another that offers a moderate to low energy output at a very high frequency, which is the better option? Beyond the consideration of energy output and frequency, the durability, maintenance, cost, and feasibility must be examined. To circumvent this, we will decide as a team which qualities are of the greatest importance to us and make a decision matrix to assist us in narrowing all of our data down to its most significant parts.

3. Develop and tailor a method of harnessing and storing the mechanical energy from the application determined to be the best in Objective 2.

We need to tailor the device/generator to suit the requirements of these applications because every application will require a device of different size and specifications. The stair stepper for example will require a sensor which is about 4 square inches and shall be placed on the step with the raspberry pi under the stepper. A way to measure success of this objective would be to actually have a working prototype of a sensor on a stair stepper by the end of January 2015. We should be able to record data including the electrical yield of the technology, the life of one such sensor (the time that the sensor can take the constant change in pressure while recording data correctly.) This will give us a strong foothold to start looking at the technology on a larger scale and will give us a good case to present at conferences.

Anticipated Issues: As a team lacking in electrical and mechanical engineers, it may be difficult for us to alter/tailor the design of the device to a way more suited to our final application without significantly altering the energy output. However, we do have one material science engineer, and with the help of some additional outside resources/contacts(MSE professors, grad students and researchers) he will provide, we will be able to successfully accomplish this task.

Project Timeline with Gantt Chart:



Task Name	Start Date	End Date
Building the Device	**10/01/14**	**11/12/14**
Prepare Arduino/Rasberry Pi to test wasted mechanical force	10/01/14	10/08/14
Decide where to place the device through Force testing	10/09/14	11/06/14
Construct Device for chosen device location	11/06/14	11/12/14
Begin Preliminary Experimentation of the Device	11/12/14	10/19/14
Analyzing Data from Experimentation	**11/19/14**	**12/01/14**
Interpret logs of data	11/19/14	12/01/14
Conclude results based on data	11/19/14	12/01/14
Perform additional testing based on conclusions	11/19/14	12/01/14
Optimize the Device	**01/01/15**	**05/01/15**
Apply data to make changes to the device	01/01/15	05/01/15
Perform additional testing as needed	01/01/15	05/01/15

The budget for Team Georgia Techtricity will be comprised of two parts. The first is the cost of the required materials to build and test how piezoelectric devices work. The second is the cost of travel if the team sees it necessary to go to a conference to better our understanding of piezoelectricity.

Materials and Supplies:

The team plans on running several experiments to determine how much energy a piezoelectric material can generate when placed on an everyday device. To do this, we will need to purchase a Raspberry Pi Model B+ Basic Startup Kit [7] which costs $70. If the experiments are successful, the team may decide to purchase an additional Raspberry Pi.

This will allow us to measure the energy output to determine where we should put our piezoelectric device.

Equipment:

The previously mentioned Raspberry Pi Model B+ Basic Startup Kit may also be classified as equipment. A force sensor will also need to be purchased. This will cost $10 [8]. If the experiments are successful, we plan to purchase an additional force sensor. We plan to use material in Howell for our testing. This equipment may include: gym equipment, doors, chairs, or stairs. At this point, it cannot be determined what will be the equipment used, but it will be something that is already inside the Grand Challenges community.

Services:

No outside services are likely. The only services that may be required are people to test the materials. This will be on a voluntary basis and will not require any funding.

Travel:

Team Georgia Techtricity is currently not looking to travel to a conference. At the moment we do not think we are ready to present our findings. Once we have concrete results we will look into attending conferences.

Cost Breakdown:

	Description	Fall 2014	Spring 2015	Total Cost
Materials and Supplies	Raspberry Pi Startup Kit [7] (Objective 1)	$110	$50	$160
Equipment	Force Sensor [8] (Objective 1)	$20	$10	$30
Services	None will be needed.	$0	$0	$0
Travel	No anticipated travel.	$0	$0	$0
Total				$190

References:

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3. Ecotricity. The End of Fossil Fuels. *Ecotricity*. https://www.ecotricity.co.uk/our-green-energy/energy-independence/the-end-of-fossil-fuels (Date Accessed: 4th October 2014).
4. F. Bengston, A. Bharwaj, A. Foertsch, A. Joshi, and R. Narayan. “Georgia Techtricity Proposal”. https://docs.google.com/document/d/1MiDIzd0rIsXDQVAigEBDnSGGnKJQIYSJJv0ge-d1RHs/edit (Accessed 4th October 2014).
5. L. Edery-Azulay. “Innowattech: Harvesting Energy and Data A standalone technology”.
6. H.Sodano, D.Inman. “Estimation of Electric Charge Output for Piezoelectric Energy Harvesting”. *Strain Journal.*
7. Raspberry Pi Model B+ Basic Starter Kit, *Amazon* [online] 2014*,* http://www.amazon.com/Raspberry-Model-Basic-Starter-Kit/dp/B00LAAKNHY (Date Accessed: 6th October 2014).
8. Force Sensor, *Amazon*[online] 2014, http://www.amazon.com/SENSING-RESISTOR-SQUARE-1oz-22LBS-SPACING/dp/B00B887DBC/ref=sr_1_3?ie=UTF8&qid=1414359752&sr=8-3&keywords=force+sensor (Date Accessed: 26th October 2014).