Problem Definition and Requirements Review: Greener Living

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Abstract— Our client approached us with interest in understanding how much energy the utilities and various appliances in her home use. Our group had decided to create a user-friendly web application that provides the user with useful information regarding the utility and appliance usage within her household. First, the application will record the utility usage data and display it graphically. In addition, the application will provide analysis and suggestions to help the user reduce their energy costs and carbon footprint. The web application will also detect and send notifications to the user when abnormalities in usage are detected.

Furthermore, there will be an energy monitor system installed in the user's household to provide data on the energy usage by the household's major appliances. The user will not be required to understand how the system retrieves and analyzes the data, however some knowledge about the household such the square footage will be required to properly install and input data into the energy monitor system. Greener Living is intended to provide the user insight into how their utilities are spent so that the user can easily make eco-friendly and cost-efficient decisions.

1 Need for this project

With the concerns of climate change growing every day, the need for a major change in society becomes more apparent as the frequency of natural disasters, droughts, and fires increases. Despite all the tangible evidence of dangers related to climate change, there is a surprisingly large lack of action to address this issue, from world leaders to the average citizens. According to a survey conducted by the AP-NORC, 68% of Americans would not pay $10 more a month on their electricity bills, even if the $10 fee would go towards combating climate change. However, the average American is not fully to blame. Eco-friendly products and decisions are often more expensive than sticking to the status quo, and requires large changes in behavior that not everyone can afford.

Currently, around 80% of energy used by Americans comes from fossil fuels, a major known contributor to the increase of greenhouse gas emissions. Furthermore, a large portion of energy use is wasted, which not only produces more greenhouse gases, but raises the prices of utility bills each month.

Thus, rather than having average homeowners directly spend money to help combat climate change, it would be a better approach to help homeowners make energy efficient decisions that will not only reduce their carbon footprint, but their utility bill as well. Research shows that without innovations in energy efficiency, energy consumption in the U.S would be 60% higher than it is today. By obtaining data at a faster frequency, Greener Living takes advantage of these innovations by providing an energy monitoring system that will give its user a more detailed insight into how energy is being used rather than simply telling the user how much energy is used each month. By allowing the user to have updated information at their convenience, homeowners can reduce energy wastage and save money at the same time.

While the government and energy industries have made strides towards making this data more available, Greener Living hopes that one-day energy monitoring systems will become a standard in most households.

2 Problem statement and deliverables

Our objective for this project is to give our client the ability to view information about their energy usage in a simple and convenient way without having to wait every month for the energy bill. This allows them to identify problems with their energy usage and implement and necessary behavior changes. Utility companies often provide little information about how energy is being consumed and leave homeowners to guess where they are wasting energy. Monthly updates on energy consumption also makes it more difficult for homeowners to keep track of the exact behavior that is wasting their energy. By providing a product that can provide a higher frequency of logging, as well as log specific appliances, we hope to

display this information to the user so that they can quickly identify problems without the trouble of waiting and guessing. To achieve these goals, our deliverables will consist of an energy monitoring system and a web application.

In order to display and analyze the data regarding the user's energy usage, a system for obtaining relevant information is required. In order to obtain data on electricity usage, we decided to use a device called IoTaWatt, an open WiFi electricity monitor project. IotaWatt has passive sensors that clip onto the insulated wire. The clips measure the magnetic field generated by the current passing through the wire. The outputs of the current-transformers (CT) in the breaker are then connected to the IoTaWatt device. By also inserting a wall transformer, a low-voltage reference is provided for the IoTaWatt device which then determines the voltage and frequency, allowing it to interpret signals for each CT. Once the IoTaWatt is configured correctly, data collected can be stored into a database for our web application to access. Other data, such as solar production, will be retrieved through company web-servers/APIs.

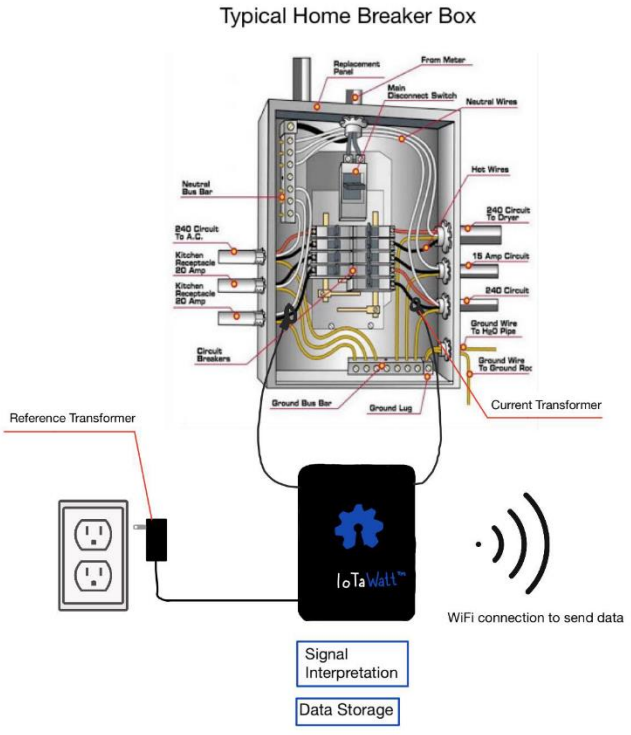
Once the relevant data has been collected, the user will be able to use our web application to view the information about their usage in a way that is easily digestible. The user will be able to graphically view their energy usage over time, with the ability to change the time scale at which the data is being viewed. Comparisons between relevant data will also be displayed to give the user further insight about how energy is being consumed. The web application should also send a notification to the user when abnormalities occur regarding energy consumption.

This project will be deployed at the client's household. Additional features and analysis will be included upon the client's request.

3 VISUALIZATION

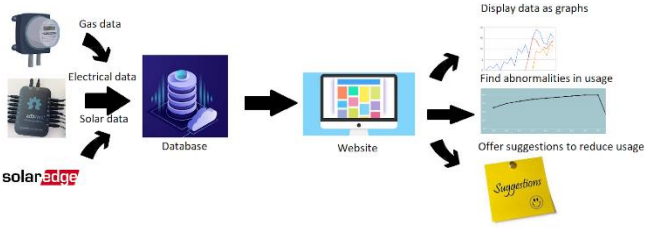
3.1 Hardware System

The hardware visualization is displayed in the diagram below. The IoTaWatt is connected to the breaker via current-transformers with passive sensors that clip onto the desired wires. The magnetic field created by the circuit induces a low-voltage current in the current-transformer. By plugging in and connecting the reference transformer to the IoTaWatt, it is then possible for the IoTaWatt to interpret the signal from each respective current-transformer. IoTaWatt can store and send out data which can be accessed through its integrated web server/API interface. Our web application will then utilize this data.



3.2 Software System

Below is a general overview of our software and how different components communicate with each other. The IoTaWatt can send data to our database through its in-built functions, the SolarEdge can send solar panel data through its API, and the gas data will either be read or supplied by the utility company. Our website will access the database and use it to display the data through graphs. It will also try to find spikes and abnormalities in utility usage and offer suggestions to reduce it.



5 COMPETING TECHNOLOGIES

The technologies currently existing that would compete with our product are from Eversource, Utility API, and Sense. These companies offer energy tracking solutions for different kinds of clients. Out of these companies, the most comparable technology comes from Sense

as they monitor and track energy usage through the circuit breaker. Both Eversource and Utility API are great alternatives to tracking energy information, but our project is more centered around homes.

Sense

Sense is a company that makes power monitoring devices and APIs for homes. The device itself is powered by a monitor that installs in your electric panel, it reads the electrical current one million times each second and processes that data to present a whole-home view of your electricity usage. The electrical panel allows the device to pinpoint devices throughout a home as the circuits map to different rooms. The device uses machine learning to determine what devices are on and off. By knowing the amount of electricity usage of a household item, it can show you when that item is in use.

Eversource

Eversource provides electricity to homes and buildings alike in New England. Their Energy Savings Planning Tool allows users to monitor their energy usage to better manage their spending on electricity. The planning tool is free and an online resource for Eversource clients to take advantage of. This tool uses client's account information and answers to a few short questions to build them a customized plan to lower energy usage which in turn saves them money. They have a usage wheel that shows the electricity usage of the entire house. The company allows clients to compare their recent bills with previous months as well as compare the energy efficiency to similar homes nearby.

Utility API

Utility API is a energy monitoring application geared towards big companies and vendors to manage their energy usage. Companies use Utility API for feasibility analyses, quote generation, asset management, and measurement and verification. Companies like General Electric and Mitsubishi Electric rely on Utility API to support their endeavors. By using Utility API, these companies can run efficiently while saving money, energy, and time to focus on their tasks. Their Utility Data API can be integrated into any existing analysis software and sales platforms and it allows for requesting data to be easy and automated. It is used to building in Customer Relationship Management (CRM) and sales tools.

We will be mostly incorporating the ideas from Sense into our requirements. Due to it being very similar to our client's requests, we will be trying to read energy from the circuit panel in order to monitor the client's energy usage data as well as let her know when something is not working properly. We will also take into consideration, Eversource's approach to being user friendly and allowing the user to compare energy usage habits to allow them to take reasonable steps to lower their bill.

6 ENGINEERING REQUIREMENTS

After discussing with our client, we have decided on these criteria to guide the design and implementation of the Greener Living Project:

1. We must provide a system that measures electricity usage of major appliances in real time, measured with a minimum sampling rate of 1 Hz.
2. The system must be able to measure the, at least, hourly energy generated by the client's solar panels, and show how much it offsets the energy she consumes and how much money she saves daily by using solar panels.
3. All data collected must be displayed on an online dashboard where the client can sort the data by daily, weekly or monthly to analyze their energy usage.
4. The specific energy consumption of each appliance throughout the day should be recorded and displayed to the client, showing when energy usage spikes during the day and when its low.
5. The client's daily carbon footprint should be calculated and displayed on the dashboard.
6. Daily, the dashboard should display advice and suggestions to how the user can reduce their carbon footprint and energy usage.
7. The whole system must cost less than $500.

7 APPENDIX

7.1 References

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