Whole Home Energy Management System

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Project Motivation & Objectives

Energy is crucial in today's society, but harnessing it sustainably is increasingly challenging.

Canada aims for net zero emissions by 2050, and Solartility Inc., based in Calgary, offers a solution. Through a Virtual Power Plant (VPP), users utilize solar energy from panels installed at home, selling excess power back to the grid.

Integrated with a Home Energy Management System (HEMS), this setup optimizes energy usage and efficiency. Sensors and meters monitor consumption in real-time, allowing load management controls to minimize waste and maximize savings. Together, these innovations support a greener future by leveraging distributed energy resources effectively.

Purpose of Whole Home Energy System

- Manage and reduce electricity consumption within a home
- Lower the cost of monthly electricity bills
- Reduce strain on the electrical grid during peak times
- Understand residential daily electricity consumption

Hardware

The Arduino shield is installed on our Arduino to control (On/OFF) any load connected to it

Along with the shield we are able to monitor the power usage of our load using the ACS712 CT sensor

And the ambient light sensor combined with PIR sensor and DHT11 temperature & Humidity sensor provide our model with the environmental data necessary to further optimize the power usage

Part - Make/Model	Description
ACS712	CT Sensor
HC-SR501	PIR Motion Sensor -Infrared
TSL25911FN	Ambient Light Sensor
A000110	Arduino Relay Shield
ESP8266	WiFi WLAN Wireless Module
DHT11	Temperature Humidity Sensor Module
Xbee3	Zigbee Development Tools

Communications

The HEMS features a network using the Zigbee communication protocol. The hardware components used to establish this network include:

Xbee 3 Zigbee

This module serves as the main communication module within the HEMS and has been used to create the mesh sensor network.

Raspberry Pi 4

Used as a gateway, this component also contains the software for data processing and management of the communication network.

Software

The HEMS software stack consists of two components: the main software stack, which is used for data storage and visualization, and the communications-side stack, used for establishing and managing the communications network.

Main Software Stack

InfluxDB

Serves as the primary database within the HEMS and responsible for storing and managing timestamped data collected from various sensors.

Grafana

The primary tool used for creating the HEMS dashboard.

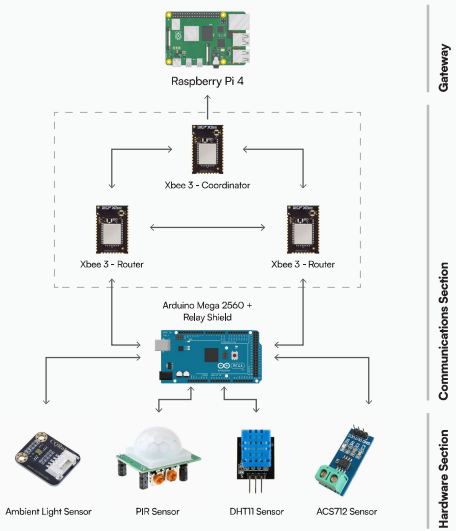
Comms-Side Software Stack

Mosquitto

An MQTT broker that facilitates sensor data transmission to the cloud via MQTT topics.

Node-RED

A visual programming tool used to retrieve data from any MQTT topic created by Mosquitto.



Simulation

Modeled 5 residential loads (Fridge, Dryer, Washer, Dishwasher, and Electric oven) to simulate typical home energy consumption. 3 Loads modeled are controllable and dispatchable (Washer, Dryer and Dishwasher)

Simulation Procedure without HEMS

Gathered Pool Prices ($/MW) from AESO historical data for January to June 2023.

Modeled typical residential consumption (MWh) in those months, assuming controllable loads ran at common hours for the typical home, washer and dryer at 5:00 pm weekly, and dishwasher daily at 7:30 pm.

Calculated monthly electricity cost (CAD) by multiplying pool prices by consumption.

Simulation Procedure with HEMS

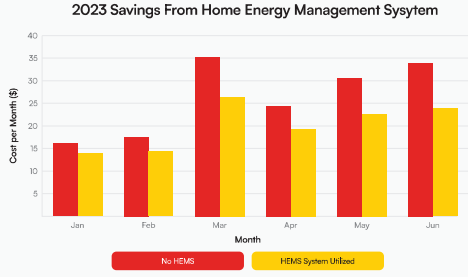
Utilizing previous results and by using similar day forecasting approaches, lowest electricity demand periods were determined, and controllable loads were set to run during those hours.

Calculated monthly electricity cost (CAD) by multiplying pool prices by consumption.

Results & Observations over the 6-month period

Utilizing the HEMS resulted in a total of savings for the user of $36.1, which is a 23% of savings from the initial cost.

Without the HEMS, the total electricity billing was $156.9
With the HEMS, the total electricity billing was $120.8



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