Electrical Consumption Minimization Through Home Automation

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Introduction

The goal of this project is the creation of a home automation system to monitor and control electronic devices. The system has two primary functions. First, monitoring the levels and times of electricity use in the home. The monitoring will be achieved through non-invasive current sensors, one per AC line in the house, to collect data describing power consumption on each line in the house. Second, a control system to switch power states. The control system will respond to server commands and environmental sensors. Connected relays will switch the power state of devices in the, such as lamps or entertainment devices. The monitoring and control systems will connect to a micro controller fitted with a Wi-Fi module. The microcontroller will run a client software that will allow the server to query status of the power circuit and request a switch of power state. The control server will be a low power computer, Raspberry Pi. The server will run a control software custom written for the task.

Background

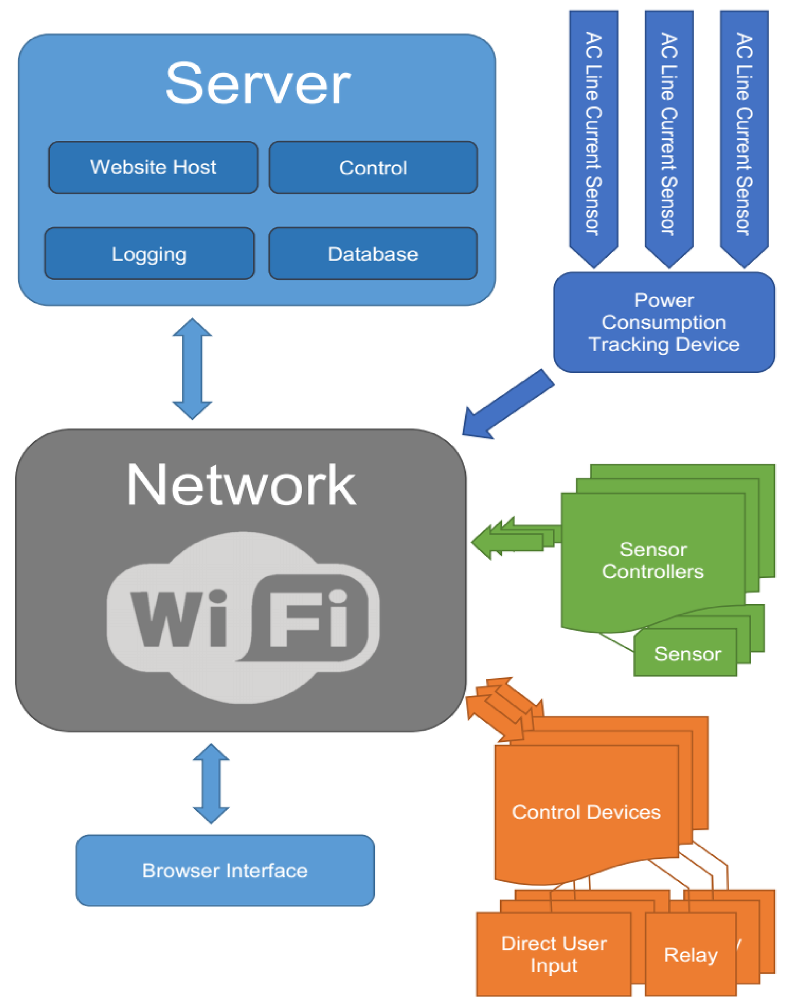
Standby power is electricity used by appliances and equipment while they are switched off or not performing their primary function. That power is consumed by power supplies, the circuits and sensors needed to receive a remote signal, soft keypads and displays including miscellaneous LED status lights. Standby power use is also caused by circuits that continue to be energized even when the device is "off".

According to the Lawrence Berkley National typically 5-10% of residential electricity use in most developed countries and a rising fraction in the developing countries (especially in the cities). Standby power in commercial buildings is smaller but still significant. Altogether, standby power use is roughly responsible for 1% of global CO2 emissions.

In a 2002 study titled “Measurements of whole-house standby power consumption in California homes” Total standby power in the homes ranged from 14 to 169 W, with an average of 67 W. This corresponded to 5–26% of the homes’ annual electricity use. The appliances with the largest standby losses were televisions, set-top boxes and printers.

Taking the average of 67 watts, the average household standby power consumption is 587KWH per year. At an average of $0.12 per KWH, standby power loss equates to $70 a year per household. The financial cost per household is minimal. However, multiplying the cost across the hundreds of thousands of homes across the country amounts to a significant cost. Ignoring the costs, the power must be generated. In the US 66% of power comes from burning fossil fuels (U.S. Energy Information Administration), an unnecessary contributing factor of climate change.

Design

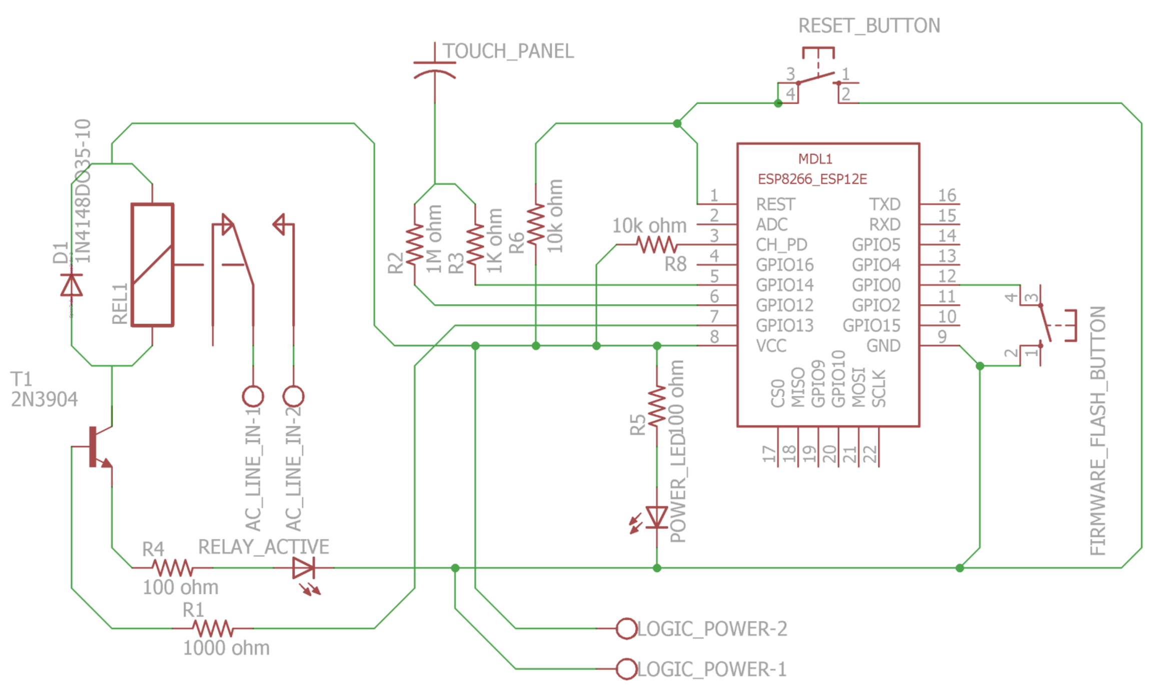


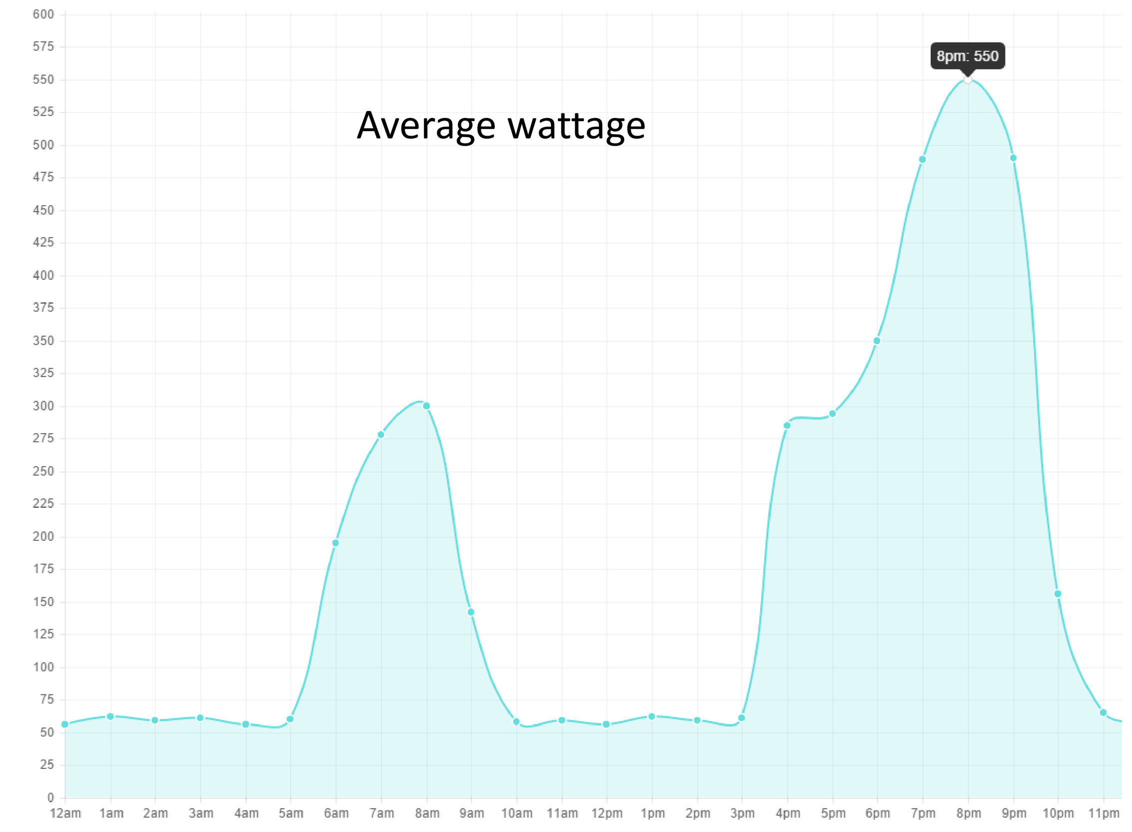
The server is the central command and control of the system. The server serves page requests and receive data from the user experience. The data received is processed or passed on to the proper controller. The server logs current monitor data and prepares the data for storage. The server respond to notifications from the activation sensors and scheduler. The server commands the circuit switches to change states based on notifications.

The user experience serves as the link between the user and the rest of the system. The user experience displays user requested information retrieved from the server. The user experience also sends user data, schedules and configurations, to the server for processing.

The current monitor unit sends average RMS wattage usage over a five second time period to the server, for each electrical line connected to the system.

The endpoint control devices are the part of the Helios system which users will interact with most frequently. They are assembled with a low cost, Wi-Fi connectable microcontroller and a relay module. The microcontrollers control the relay state and respond to commands from the server and from direct user input by switching the relay. This allows the Helios system to keep a record of what devices are using power on a current line and control the power state of those devices remotely to reduce power waste.





The usage graphs serve to display the power usage in an easily readable form. The daily, weekly, and monthly graphs allow the user to make decisions on when to disable a circuit.

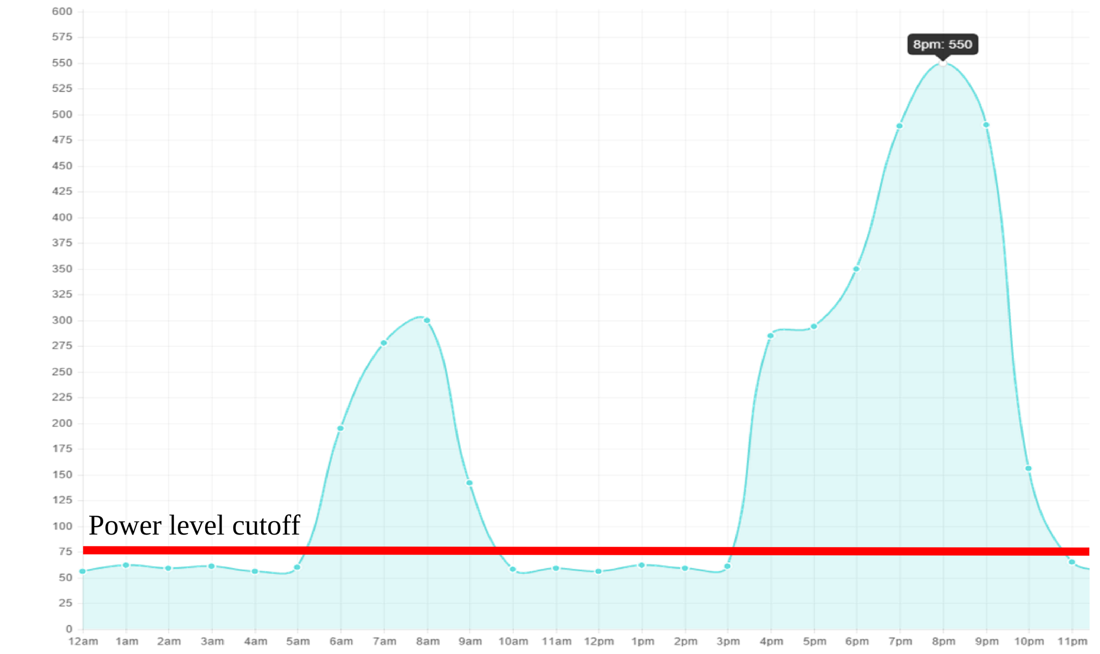
The daily graph allows for hour by hour representation of usage. The user can decide at what hour to turn on or off a circuit.

The weekly graph allows the user to find usage patterns. These patterns can be used to schedule repeating events.

The monthly graph allows the user to track daily use over long periods of time. As the schedules are implemented, the monthly graph will show the power savings.

Conclusion

The system was applied to the living room of a traditional house. A graph of hourly usage was generated to display usage trends. From the graph, a trend of inactivity is shown between the hours of 11pm to 6am and again between 10am to 3pm. These time correspond with sleeping and work schedules inside the house.



By scheduling a closure of the power circuit through the scheduling system, the Helios system reduced the power usage of the house 0.55 kilowatt hours daily. The 0.55 kilowatt hours translates to about 200 kilowatt hours yearly. In financial terms, the system saved the home about $25 a year and reduced the carbon footprint by 400 pounds yearly.

While the savings are small, these results are of one room in one house. If applied to multiple rooms, the savings could reach 500 kilowatt hours per year. Further, implementation of the Helios system into a fraction of American homes would significantly reduce the carbon footprint of the country.

Literature cited

Gram-Hanssen, Kirsten. "Standby Consumption In Households Analyzed With A Practice Theory Approach." Journal Of Industrial Ecology 14.1 (2010): 150-165. Academic Search Complete. Web. 8 Apr. 2016.

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