Home Energy Management

*EML 4911C-Senior Design- Fall 2015*

**PRODUCT SPECIFICATION AND PROJECT PLAN**

*Sponsor: FEEDER*

*Foundation for Engineering Education for Distributed Energy*

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# Abstract

In recent years, the power industry has started to implement the use of smart grids. Smart grids, a complex electrical system for the generation and distribution of energy, with distributed generation (more than one source of generation i.e. renewable + nuclear + gas), control, metering, and energy efficiency. With this advancement, utility companies are incorporating ‘real time pricing’, when the price of electricity is dependent on the usage and generation. With available technologies such as microcontrollers, residential and commercial buildings will now have the ability to control and manage their own energy system in accordance to the utility’s real time pricing, in means to increase energy efficiency, reduce cost, and become more eco-friendly.

# Introduction

The concept of a viable energy management system is a topic that is gaining momentum on the different economic and social sectors, in which high technological companies are aiming to design a very economic and viable way to control, monitor and manage the energy provided to users and commercial companies. The notion behind a home energy management system relies on the idea of controlling, via user interaction or automatic real time calibration, the different loads present on an average home or a simple SOHO (Small Office/Home Office). This system will benefit users and companies by providing critical information to and from the main energy systems that will allow a full control of the energy usage in the industrial and residential customer’s part of the electrical grid.

# Project Definition

## Needs Statement

The design requirements of the project must be fulfill in order to achieve the goals proposed by this design. The essential needs for the Home Energy Management System are:

1. Control of different loads around the space depending on user interface or automatic response.
2. The preferred communication technology between controller and loads is RF/Wireless.
3. Controller must make decisions according to an energy efficiency algorithm that will receive information from real time pricing.
4. System must be energy efficient and have low power consumption.
5. Controller must be in constant communication with the cloud (internet).
6. The algorithm must discern from critical and non-critical loads.
7. If possible, information of power consumption of each load must be provided to the main controller in order to gain important information.
8. Communication link between controller and devices must be reliable and have good distance of action.
9. If possible, an application must be developed in order to give the user a GUI access to the main controller.

## Objective and Goals

The primary objectives of the project cover the completion of all the design requirements proposed on the needs statement. The primary goal of the project is to design a viable way to control and manipulate critical business and household loads, which will favor the save in energy and create a better network control system for energy manipulation.

The Home Energy Management System must be designed to automatically control the loads by accessing the information given by the utility company in real time. Essentially, a real time pricing controller for energy management. By the same vein, the design must consist of a reliable network system which could be implemented in any layout in both household and business environments.

# Constraints

## Design Specification

In order to fulfill all the needs explained, the project will focus on the next requirements:

1. Control the different loads using MSP432 and nRF24L01P trans-receiver as the communication link.
2. The trans-receiver will use wireless RF/Wireless protocol in order to communicate back and forth with the main controller Beagle Bone Black.
3. An algorithm will be written to control all the loads according to real-time pricing provided by the utility company. Algorithm will process the information and decide which loads can be turn off.
4. The use of microcontrollers and small low energy devices that will be energy efficient and low powered.
5. The Beagle Bone Black (Controller) will be communicating via Ethernet or Wi-Fi with the cloud in order to obtain the settings and most recent information from the utility company.
6. Algorithm must discern, using special settings given by the user, between the critical and non-critical loads.
7. Meters connected to the loads and MSP432 will measure the power consumed by the load and sent back to the controller in order gain important information for decision making.
8. The RF wireless technology used by the Nrf24l01P has a distance between 100 and 400 meters place of action.

An Android application or website will be developed in order to control the Beagle Bone Black controller and all the loads connected to the network.

## Performance Specifications

On the performance aspect, the project must consists of a reliable design that will allow the continuous flow of information between the controller and the controllable loads using high performance 2.4 GHz wireless technology.

According to the information obtained from the sponsor the priorities for performance evaluation are listed here:

1. High Performance
2. High Reliability
3. Power Consumption
4. Low Cost

# Methodology

## Schedule

|  |  |
| --- | --- |
|  | **Dates** |
| **Task Name** | 08/31/15 | 09/07/15 | 09/14/15 | 09/21/15 | 09/28/15 | 10/05/15 | 10/12/15 | 10/19/15 | 10/26/15 | 11/02/15 | 11/09/15 | 11/16/15 | 11/23/15 | 11/30/15 |
| **Research load data and real time pricing** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Needs Assessment** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Web site design**  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Order necessary hardware** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Develop algorithm for application** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Midterm Presentation I preparation** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Assemble prototype** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Midterm Presentation II preparation** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Test and debug application** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Prepare final design for demonstration** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|  | Deliverables |   |   |   |  |  |  |  |  |  |  |  |
|  | Project Work |   |   |   |  |  |  |  |  |  |  |  |
|  | Others |   |   |   |  |  |  |  |  |  |  |  |

Figure 1: Displays the approximation of dates for project milestones/task



Table 1: Hardware BOM

## Resource Allocation

As seen above from Table 3, the financial constraint for the project is a budget of $1500.00 which is provided by the Foundations for Engineering Education for Distributed Energy Resources (FEEDERS). Staying within the budget will not be a challenge when compared to the hardship of the actual time the project will take. The hours of work will be distributed amongst the personnel responsible for the completion of the project. The estimation is per team personnel, not including the Dr. Omar Faruque, the Senior Design Project Advisor. Between both semesters the estimated time of completion is about 752 hours.

# Conclusion

The successful completion of the project will be based on the completion of the design requirements and creating a viable design that will allow a reliable control of the energy consumption in a household or business environment. If the schedule timings are followed as explained on the project plan, the design must be completed on time and many features of it must available for deployment at the end of the design year. Any changes on the schedule will be immediately updated and all the people involved will be informed as soon as possible of any change made in the final design.