Automated Home Energy Management by Controlling ESS and Active Demand Response

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***Abstract*—In modern technology era, new electric device is emerging continuously to accomplish the ongoing demand. Smart home tries to compensate by providing variety of technology with considering cost constraints. The main raises problem for minimizing the energy cost is dynamic demand response of the consumer. This paper describes a comprehensive controller for energy storage systems(ESS) managing home energy based on optimization method organizing different types of domestic loads including shift-able, non-shiftable and adjustable load. By considering threshold(power), the functions of the ESS is controlled to minimizing the volume of daily consumed energy.**

***Index Terms*—Energy storage systems(ESS), energy management, control systems, wireless communication, power flow analysis.**

I. Introduction

In the power systems, dynamic demand response [1] of customers, which is defined as "the changes consumption patterns in response to changes in the price of electricity" is considered as a crucial option to facilitate the connection of low carbon technologies,in particular at the domestic level, without the need for reinforcement. Despite its potential benefits, active demand response may also have a negative impact on load diversity which might potentially result in creating new peaks at least price intervals and overloaded network component. In this respect, although minimization of hourly demand or of the peak-to-average demand ratio may reduce the peak demand, this may not necessarily be below a certain power threshold that could create congestion and voltage issues.

As power grid is a very complicated systems in which power generation and consumption at any moment must be equal, the improvement of dynamic demand response can be possible with integrating energy storage systems(ESS) [2] In addition, ESS can be deployed to provide power(above threshold) for consumers to curtail/defer their electricity cost.

In this paper, three power sources is considered that delivers power to the load of the consumer house such as electricity grid, PV, wind, and ESS, the consumer can connect with one or multiple. Our proposed structure is presented in Fig.1 that is divided in different section. The sensor, by which power consumption [3] data will be collect for analyzing the active demand level for the individual consumer. The incoming energy from the particular scourers will be determined by installed sensor. Similarly, the connected sensor in distributed generation and the load will determines the generation profile and the active demand of the certain houses respectively. All the sensor data will be aggregated and transmit it to the receiver section through the gateway such as Blutooth [4], Lora, Zigbee and wifi. After that the control section will make a signal for controlling ESS [5] based on control algorithm. A threshold value of power demand will be configured in the algorithm [6] based on the traffic plan of certain customer in the function of based load, peak load, shiftable load. The generation volume will be also considered for determining the threshold value that leads the control signal for ESS.

The methodology of this paper describes in section II. In the section III, numerical result and corresponding discussion are illustrated. Finally, the conclusion of this work is presented in section IV.

II. Methodology

To clarify the proposed control scheme to schedule home appliance, a simple electrical arrangement in a house is developed here. In the systems, some light is considered as load and power has taken from the power sources. The Current sensor is connected to the loads that is used for measuring the current via Arduino and transmitted the information through Bluetooth gateway. The loads also is shifted by changing their state. After that, another Arduino is used to receive the transmitted data for further analysis. The given algorithm is implemented in the Arduino which generated a control signal for controlling ESS. From the oscilloscope, we have taken the data, lower signal is the level of power consumption and the upper on presented the control signal for ESS. When the power consumption level is higher than the threshold value then the ESS will provide the additional power to the systems through circuit breaker.

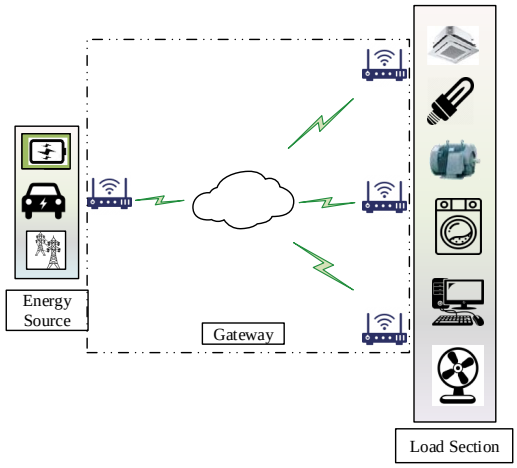

Fig. 1. Communication architecture of the proposed model.

Fig. 2. Implemented hardware arrangement of the work.

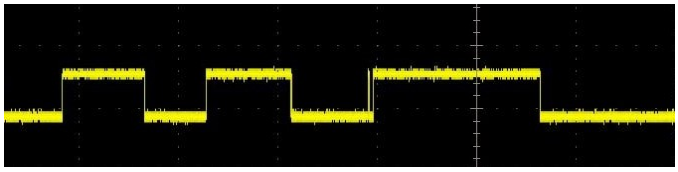

Fig. 3. Control signal for the ESS.

Then, when the demanded power is less than to the maximum power value then the systems will take energy from the grid again.

III. Result and Discussion

To validate the proposed model, the implementation work shows in Fig.2 The main architecture consist of load, power source, control circuit, and gateway systems. The current sensor that is connected to end of the every load determine current. The determined current is multiplied by the power source voltage that is consumption power of the particular load. As we use three same type of load, the total power consumption is the summation of consumed power by each appliance. For avoiding the any destructive condition, we apply a 12 V AC power source for supplying required power. In our experiment, we defined 30 watt as the threshold power for this experiment. When the two load is connected to the systems, the maximum power following in the circuit is less than threshold value. For this reason, the third load was acted as peak load and when this applience is turn on then the total power crossed the prescribed maximum power level. Our experiment execute for five minute where the status of connected load is changed for many times. For checking the status of the consumed energy, 100 ms interval was applied. Every 100 ms later, the transmitter was sending the data to the receiver about the condition of maximum power flowing in the circuit. For better understanding, we turn on and off the load for generating the gate control signal of ESS. Fig.3 showed on/off status of the connected ESS. The high and low position of the signal was presented 0 V and 5 V respectively.

IV. Conclusion

A widespread optimization-based ESS and load controller has been proposed to optimally coordinate the operation of different types of domestic appliances to reduce the consumer's power consumption below a predefined desired threshold whilst maintaining their comfort. The proposed model systems applied to an individual dwelling demonstrates the controlling home appliances and ESS. Finally, the results reveal the importance of control operation of implemented controller throughout the demanded time period.

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