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Modeling of a Heater Load in Residential Buildings for Demand Response

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***Abstract*—Intermittent renewable energy resources such as, wind and photovoltaic (PV) plays a considerable role in today's power generation. In order to compensate this highly variable generation demand response is employed as a part of demand side management instead of costlier generation side spinning reserves. This capability can be achieved through responsive electric devices such as electric water heaters. Simulation model of the DR loads (heater) is mainly focused in a building considering the indoor and outdoor conditions. This paper presents a new approach for modeling flexible loads and aims to create further knowledge on the potentials of residential demand response concepts. The simulations are performed in MATLAB software.**

***Keywords*—Demand Response(DR),DSM,MATLAB**

I. INTRODUCTION

Future grid requires greater penetration of renewable capacity integrated in to the system. In the power system, the system load keeps changing from time to time according to the needs of the consumers. The electricity system must continuously be balanced to maintain a secure operation. Today, mainly generation is used to achieve the balance, while electricity demand has a passive role. The electricity demands can be used as a new measure for fast reserves. Grid friendly appliances, such as refrigerators, water or space heaters ventilation systems and air conditioners help to manage energy imbalance. Potential for demand response is vast and there are many loads which can be used with this technique. The participating loads can self adjust their use of electricity i.e. they can be turned off for a short duration without any inconvenience to the customers.

Regulating the use of energy has recently become critical due to the concerns of the energy crisis. Demand response enables customers to adjust their electricity usage to balance supply and demand. Demand response is a DSM solution that targets residential, commercial, and industrial customers, and is developed for demand reduction or demand shifting at a specific time for a specific duration. In the absence of on-site generation or the possibility of demand shifting, the consumption level needs to be lowered to comply with a DR event. The non-criticality of loads at the residential and commercial levels allows for demand reduction with relative ease. Combined with their cyclic ON/OFF switching behavior, they present ideal solution for frequency controlled reserve and flexible implementation of the DR technique.

II. LUMPED THERMAL MODEL OF A BUILDING

Assumption in the lumped model is that indoor air temperature and the temperature of all internal layers are the same.i.e,

Lumped thermal capacity of the building = sum of the internal capacities of all internal layers

Temperature change in a building due to transmittive and ventilation heat losses,

$$C\frac{dT_{in}(t)}{dt} = UA[T_{out} - T_{in}(t)] + \frac{n(\rho c_p)V}{3600}[T_{vent} - T_{in}(t)] \quad (1)$$

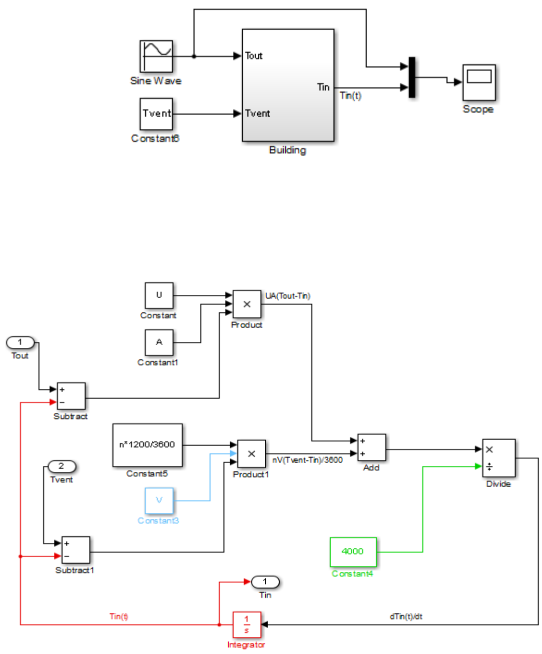

Fig. 1. Thermal model of a building.

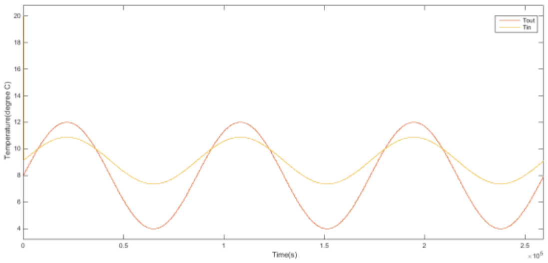

Fig. 2. Indoor and Outdoor temperature variations.

III.HEATER WITH P CONTROLLER

The control logic behind the heater is given below.

$$\begin{cases} Q = 0\ if\ T_{in} > 18 \\ \quad = 1 if\ T_{in} < 18 \end{cases} \qquad (2)$$

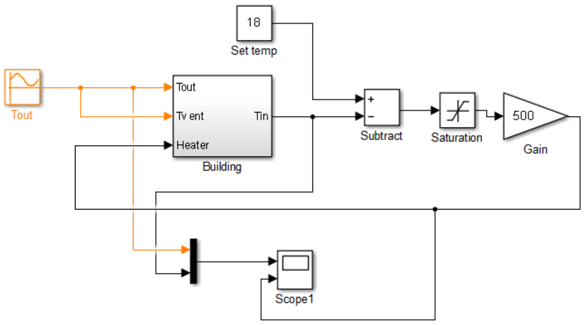

Fig. 3. Heater load in a building with P controller.

Fig.3 shows the thermal model of a building with a heater load. Outdoor temperature is periodically varying in nature. Heater load is included in the category of thermostatically controlled loads. They can be switched off for a short period of time without any disturbance to the consumers. The set temperature value is compared with indoor temperature of the building and the resulting error signal is given as a feedback to the heater load in the building and the necessary control action is performed. When the indoor temperature is greater than the set temperature point there is no heat flow, otherwise heat exchange takes place. Fig.4 shows the indoor and outdoor temperature variations and gain with the heater load.

TABLE 1 BUILDING PARAMETERS

T_{out}	T_{vent}	U	A	V	n
0	10	0.3	312	360	1

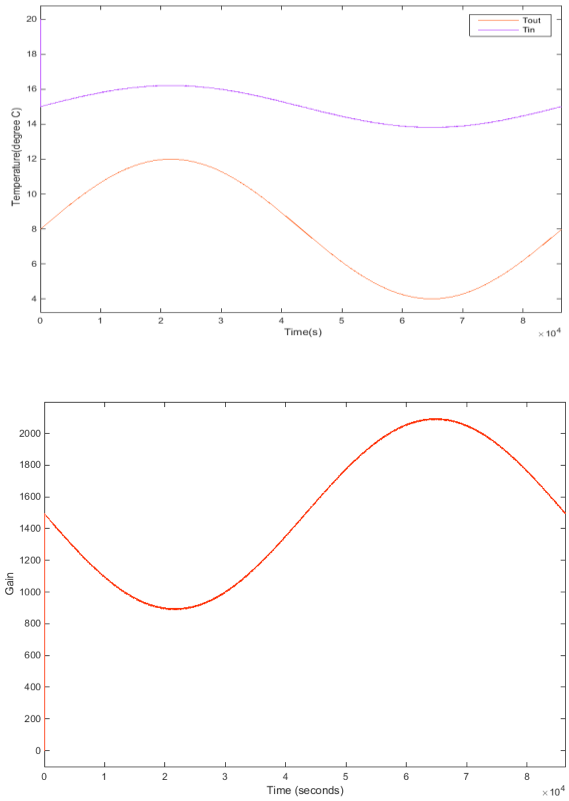

Fig. 4. Indoor and Outdoor temperature variations and gain with controller.

IV.CONCLUSION

This paper develops thermal model of a building with a heater load to accurately capture their behavior for demand response. The simulation results show that heater loads are best suitable for demand response programs. This is tested under both steady state and dynamically varying conditions caused by temperature set point changes. It also accounts for the dynamics of the solid mass of the buildings.

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