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Assessment of Demand Response capability with Thermostatic loads in Residential sector

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***Abstract*—In competitive electricity markets with deep efficiency concerns, demand response gains significant importance. Moreover, demand response can play a very relevant role in the context of power systems with an intensive use of distributed energy resources, from which renewable intermittent sources are a significant part. During the effort to accommodate larger shares of renewable sources, while maintaining the power balance and ensuring the reliability of the power system, the implementation of demand response mechanisms may provide considerable options to reshape the supply of electrical energy. As demand response levels have decreased after the introduction of competition in the power industry, new approaches are required to take full advantage of demand response opportunities. Here, the study presents a new approach for modeling flexible loads and aims to create further knowledge on the potentials of residential demand response concepts.**

***Keywords*—Demand Response;DSM; Matlab**

I. INTRODUCTION

Electrical grids are getting smarter due to tight integration of computation and communication with the physical power grid and significant research efforts are being dedicated to make them more efficient, green and economical. One key feature of the smart electric grid is the ability to shift or directly control the demand to improve system efficiency and reliability under challenging operation scenarios. There is a tremendous global push towards using renewable energy from various sources, e.g. Solar, wind etc. However, the usage of renewable energy comes with its inherent challenges including intermittency, high cost, unreliability etc.

Most of the renewable energy, e.g. solar energy is intermittent such that the electricity produced is not flat and changes during the day according to sun diffuse, cloudiness etc. Therefore, many utilities have provided the consumers with a service that they may feed their extra electricity back into the utility through the same electrical grid. Moreover, the electricity demand of the residential and commercial consumers is not uniform and constant, considering time, day and seasons of a year. The electricity demand changes dramatically during a day based on various reasons including consumer commute pattern, life style, weather etc. Due to the intermittent nature of renewable electricity production may peak during the day, i.e. solar energy. Therefore, to reduce the Electricity and make the most out of the renewable energy, energy storage is being used. The energy storage stores the extra energy to be used during the peak time when might get more expensive. To further reduce the electricity demand peak, are also exploring various mechanisms to make with the consumers that may enable the utility the consumer's electricity consumption. Demand response (dr) and direct load control (dlc) are with incentives of changing the electricity consumption. A microgrid behaves differently in various scenarios in which different energy resource sizing would be needed to be efficient and economical.

II. LITERATURE SURVEY

The electricity demands can be used as a new measure for fast reserves. Different dfr control logics and considerations have been made to address concerns of both power system and customers. The dfr control logic type i disconnects and reconnects electric appliances when system frequency falls and recovers respectively, whereas type ii logic is specially designed for thermostatically controlled loads by adjusting the temperature set points [1].to respond to volatility and congestion in the power grid, demand response mechanisms allow for shaping the load curve compared to a base load profile. this paper introduced a stochastic hybrid model to represent a population of thermostatically controlled appliances. this demonstrates the usefulness of scalable population models for an aggregator controlling tcls [2].

an aggregation of a large number of dynamically controlled loads has the potential to provide significant added frequency stability to power networks, both at times of sudden increase in demand. it is possible that dynamically controlled loads could even be used to replace some of the spinning reserve [3]. a novel approach is proposed to the control of tcls that allows for accurate modulation of the aggregate power consumption of a large collection of appliances through stochastic control. by construction, the control scheme is well suited for decentralized implementation, and allows each appliance to enforce strict temperature limits. the control framework is able to accurately modulate aggregate power consumption across a range of time scales [4].

A new distributed control algorithm by randomizing smart appliances responses is introduced which provides a comprehensive analysis to characterize various impacts of the randomized demand response on the system frequency. the proposed algorithm is completely distributed in power grids, and thus does not require any centralized control or overlaid communication infrastructure [5]. a foundation for a practical method by which thermostatically controlled loads (tcls) can be utilized to provide regulation reserve to THE grid. an important tool that would be useful to the aggregator is provided i.e. a simple, compact battery model that characterizes the set of power profiles that the collection of tcls can accept while meeting their local constraints. the generalized battery model provided a succinct and powerful framework to characterize the aggregate flexibility of a population of tcls [6]. in this paper we discuss the following:

- The consumption by an end-use customer, such as a commercial building, is treated as an input from an external source.
- The current generation of emerging smart grid technologies present complex multi disciplinary problems.
- Emerging technologies such as dr requires simulations of not just the electric power system but also other disciplines such as building thermal models.

III. DEMAND RESPONSE

Regulating the use of energy has recently become critical for government and utility companies due to the concerns of the energy crisis with increasingly frequent power curtailment and scheduled blackouts during peak demand periods such as hot days of summer. While energy efficiency is the most prominent component of growing efforts to supply affordable, reliable, secure and clean electric power. Demand response is a key pillar of utility and regional resource plants, and its importance is growing. This enables customers to adjust their electricity usage to balance supply and demand. DR is a mechanism to enable customers to participate in the electricity market in order to improve power system efficiency and integrate renewable generation.

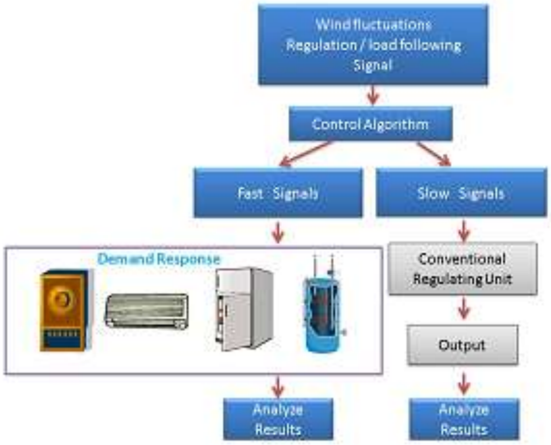


Fig. 1.Block diagram of demand response strategy.

IV. SIMULATION RESULTS

A.Thermal model of a building with heater load

Emerging technologies such as demand response in smart grid environment require simulations of not just the electric power system, but also other disciplines such as building thermal models, climate modeling etc.Temperature change in a building due to transmittive and ventilation heat losses,

$$\sum_i \rho_i c_{pi} A_i d_i \frac{dT_{in}(t)}{dt} = U \cdot A \cdot [T_{out} - T_{in}(t)] + \frac{n \cdot (\rho c_p)_a V}{3600} [T_{vent} - T_{in}(t)]$$

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

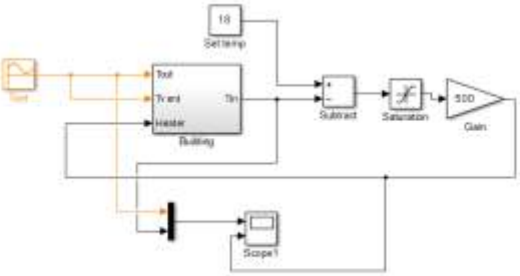
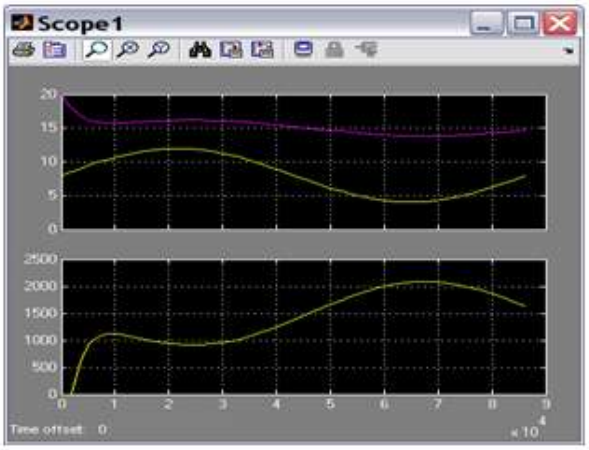


Fig. 2.Heater load in a building with p controller.

The control logic behind the heater load shown in Fig.2 is as follows: The set point temperature is taken as here as 18 degree Celsius. When the indoor temperature is less than the set point value heater starts pumping hot air to maintain the required temperature, i.e. heater is in the 'ON' state. Otherwise it is in the 'OFF' state

Fig. 3.Building temperature variations and heat output with heater load.



B.Building model with time scheduled ventilation

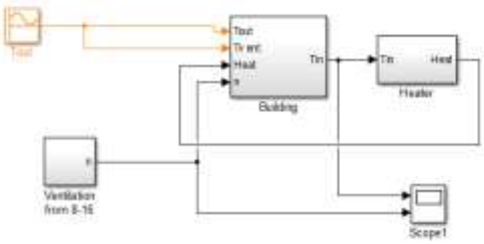


Fig. 4.Building model with time scheduled ventilation

Fig 4.shows the simulation model of a building with heater as well as time scheduled ventilation which is provided from 8 to 16 hours.

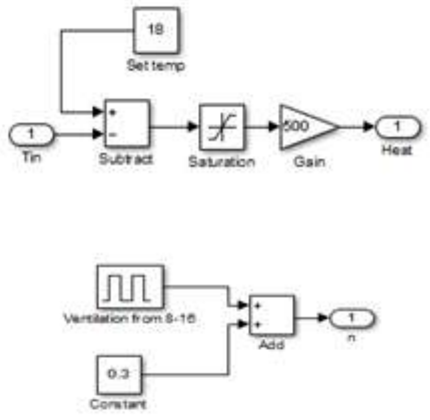


Fig.5.Heater with P Controller and time scheduled ventilation

In the case of heater load as shown in fig.5 the differential temperature drives the heater operation according to the variation in the indoor temperature. Time scheduled ventilation can be varied according to the number of air shifts per seconds (n).

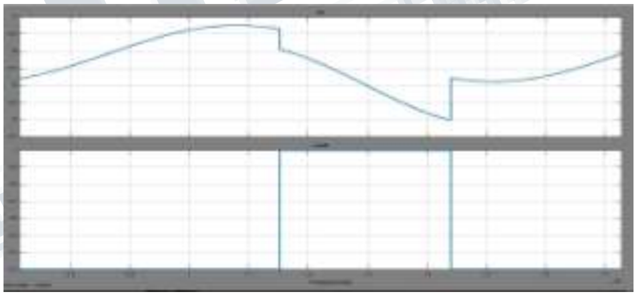


Fig.6.Indoor temperature variation and number of air shifts per second.

B.Building model with internal gains

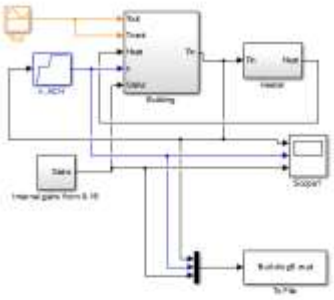


Fig.7. Building model with internal gains.

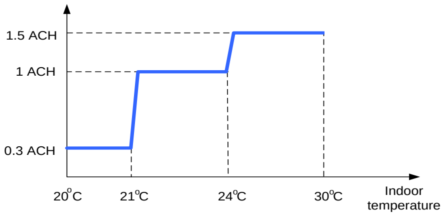


Fig.8.Ventilation system is governed by Tin.

Ventilation system governed by inside air temperature is shown in fig.8. Here, ach represents air changes per hour. The gain variations with heater and ventilation scheduling are shown below.

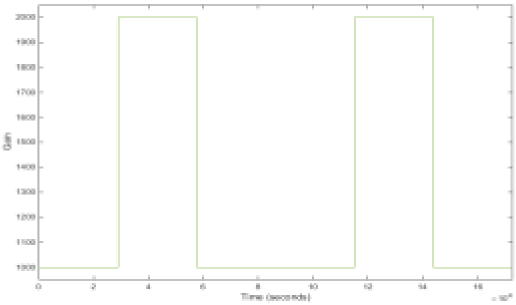


Fig.9.Internal Gains With The Load Scheduling

$$\text{Gains}= \begin{cases} \text{2000W from 0-8 and 16-24 hrs} \\ \text{1000W from 8-16 hrs} \end{cases}$$

During 0-8 and 16-24hrs heater is in operation, whereas from 8-16 hrs ventilation is provided. The resulting gain characteristic is shown in Fig.9.

V.CONCLUSION

The demand response concept is a fast evolving topic of crucial importance for the planning and operation of future electricity markets and of power systems in general. Presently, dr is evolving towards more flexible approaches, able to benefit from the participation of the involved players. Flexible and grid-friendly buildings would improve grid management and are an important contribution to the integration of renewable energy sources. The opportunities for demand response controls vary tremendously with building type and location.

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