Thermal Load Modeling And Microgrid Scheduling With Smart Meters Data

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Abstract**—***One of the important points in optimal operation of micro-CHP based micro grids (e.g., a residential building) is to coordinate its thermal and electrical loads. Therefore, in this study, thermal load is analyzed more precisely in terms of the required hot water and desired building temperature. The micro grid is assumed to be equipped with smart meters and controllable electrical loads. The information provided by smart meters is utilized in implementing smart control of micro-CHP, storages, and demand response programs. This study is aimed at presenting an optimal scheduling model for a micro grid considering technical and economic constraints based on temperature dependent thermal load modeling. A sensitivity analysis is conducted to identify and rank the impact of several uncertainties such as variations in temperature, electrical and thermal demand*

Keywords—Thermal; Micro-CHP; smart meters

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1. INTRODUCTION

RAPID RISE IN fossil fuel prices along with extortionate capital cost of new central generating plants, highlights advantages in implementing alternate generating systems with higher energy efficiency. The microgrid concept assumes a cluster of loads and micro sources operating as a single controllable system that provides both power and heat to its local area. Microgrids, due to their major technological advantages, can help unleash the deployment of distributed energy resources (DERs) (e.g., micro-CHP); they can also help in replacing centralized power plants as well as benefiting high power quality and reliability (PQR) of supply to end-users.

In a micro-CHP system is defined as an energy conversion unit with an electric capacity below 15 kW that simultaneously generates heat and power. The important point in optimal operation of a micro-CHP-based microgrid (e.g., a residential building) is to coordinate its thermal and electrical loads. One of the most important characteristics of a micro-CHP unit, in contrast to wind turbines and photovoltaic systems, is that its output power can be easily controlled. Furthermore, micro-CHP units are commonly coupled to heat storage systems. These two characteristics together provide power generation flexibility. Normally, micro-CHP is controlled in such a way that satisfies thermal demand of a building, and its electricity generation follows thermal output power with an approximately constant ratio. This is due to the fact that micro-CHP unit's thermal efficiency is greater than its electrical efficiency; so, usually, thermal demand is the one which drives the output power of the unit, which is referred to as heat-led control.

Objective of the project:

The building's thermal load is modeled more precisely in the form of desired hot water and building temperature. Flexible thermal load's effect on micro-chip unit operation is investigated by considering acceptable intervals around the desired temperatures of the building and the water storage. Smart meter's data is used to segregate total electrical demand profile into suitable and nonshiftable loads and coordinate micro-chp's electrical and thermal output power. It is shown that this would lead to better micro grid's participation in implementing dr program.

2. THE TEMPERATURE – DEPENDENT THERMAL LOAD MODELLING DESIGN

Thermal loads of the building are modeled within the context of desired hot water temperature and building temperature. Inmodeling the hot water Storage, as this study is more concerned with energy management Concept, the energy equivalent of the hot water storage at each time step is taken into consideration and the dynamic of the water flow is not considered. It means that the storage is assumed to be always full, i.E., if some hot water is drawn from the storage, cold water with the same volume enters the storage and replaces the consumed hotwater and this changes the storage

Energy level. The water storage is heated through a micro-chp Unit. The thermal power required to maintain the building Temperature is drawn from the water storage as well. Accordingly, two processes change the water storage temperature. From its desired level: 1) substitution of the exiting hot Water with the entering cold water, and 2) the thermal power drawn/injected from/to the storage. Heat-led control is referred to as the most likely standard control strategy for a micro-CHP [6]. This kind of control is aimed at maintaining water storage and building temperatures at their desired levels. In this paper, the heat-led control is formulated based on with little changes focused on water storage temperature rather than its stored thermal energy. Reference has utilized an auxiliary burner along with the micro-CHP unit in order to supply thermal loads when micro-CHP unit has not started up yet, or when the micro-CHP maximum output power is not enough to supply the thermal loads.

Micro-CHP, based on technologies such as microturbines and reciprocating engines, can startup quickly (in the order of seconds) compared to conventional cogeneration units so it can be neglected compared to one hour scheduling time-step. Furthermore, in this study, the micro-CHP capacity is great enough to supply the peak thermal load; so the auxiliary burner is not considered.

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3. PROBLEM FORMULATION

The developed scheduling algorithm could be implemented through a digital computer controlled system using the advanced metering infrastructure (AMI) system data with different modules for data processing, electrical and thermal demand forecast for the next day, supervisory control system to set the new reference inputs for the micro-CHP unit, and controllable loads and local digital controllers to follow their set points with minimum delays.

It is important to mention that we have formulated the scheduling such that it leads to a mixed integer linear programming (MILP) problem (avoiding a nonlinear problem); thus, well known solution techniques such as branch and bound can be utilized to solve it. Therefore, the size of the residential building is not a binding factor here. As it was mentioned before, the main point of this paper is utilizing smart meter data and temperature dependent thermal load modeling. In so doing, we have used simple models of the microgrid’s components. Issues like the micro-CHP efficiency change at different load levels or battery charge and discharge with variant power level during an hour are not considered here which are consistent with the assumption used in Objective Function

The objective function is to minimize the operation cost including: the cost of the power purchased from the main grid ,during a day, and also the cost of gas consumed by the micro-CHP unit . In this study, as mentioned before in Section III, the micro-CHP’s startup time and consequent cost is neglected as it is assumed to be based on technologies such as microturbines and reciprocating engines with short startup times. Besides, as mentioned in Section II, the micro-CHP unit, in this study, should operate continuously in order to meet thermal demand thus maintaining the building temperature higher than a minimum level for the whole day; i.e., the unit would not be turned on/off with a high frequency

4. CONCLUSION

This paper presents an optimal scheduling model for a residential microgrid. In this model, temperature dependent thermal load modeling is formulated and smart meters data is used to achieve lower operation cost. It is shown that this kind of thermal load modeling together with implementing load shifting, based on smart meters data, can facilitate the micro-CHP smart control leading to more flexibility of microgrids. The scheduling is formulated such that it leads to an MILP problem (avoiding a nonlinear problem); thus, well-known solution techniques such as branch and bound can be utilized to solve it. This algorithm can be used in residential buildings energy management systems and help in realization of smart microgrids.

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