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Optimal electrical and thermal energy management of a residential energy hub in the presence of solar PV systems

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Abstract

In order to reduce greenhouse gas emissions, transmission and distribution losses and the consumption of primary energy specific strategies are needed in all energy services. The energy hub is a new concept for future multi-carrier energy systems. An energy hub acts as an interface between different energy carriers such as electricity and natural gas distribution systems. From a maingrid point of view, an energy hub is a functional unit capable of receiving, converting and storing of various forms of energy [1, 2]. In fact, an energy hub plays an important role in connecting and interdependent operations of current various energy infrastructures. The energy hub can include different types of components such as combined heat and power systems (CHPs), boilers, electrical energy storages (EES), heat energy storages (HES), etc. The energy hub can range from an industrial plants or big building complex like hospital, airport or shopping mall to a region or city [3]. In addition, worldwide concerns over global warming and climate change have caused to a recent global push towards many forms of renewable generation technologies. The energy hub offers an opportunity to system operators by providing the flexibility to manipulate the effects of volatility and intermittency of renewable, in particular wind and solar, energy resources. Since, energy hub can connect to the upstream network or distribution network, and import /export electricity from/to the maingrid, proper operation of the energy hub is crucial from the maingrid point of view. In this paper, a stochastic model of energy hubs for solving the optimal scheduling problem is presented. Also, a linear two-stage model is presented for optimal scheduling of energy hub consisting of solar panels, boiler, CHP system and energy storage devices. The objective is to supply daily electrical and thermal demands of a residential energy hub for tackling penetration of renewable energies, providing reserve and reducing operation cost. Stochastic programming method is adopted to handle the uncertainties of solar power generation as well as energy demands. The Monte Carlo simulation approach is used to generate several scenarios. A proper scenario reduction method is also applied to reduce the volume of computations. At last, the results obtained from the studied cases indicate the appropriateness and usefulness of the proposed model. The main contributions of this paper can be summarized as follows:

- In addition to conventional resources of electrical energy, solar panels are used as renewable energy resources.
- A two-stage stochastic programming method is used to model uncertainty related to solar generations as well as electrical and thermal demands.
- EES and HES are considered to reduce the intermittent nature of solar generation and to provide reserve energy for more optimal scheduling of energy hub.
- The penalty cost is defined based on value of lost loads (VOLLs) for the energy hub and is utilized during optimization process.

Keywords: Energy hub; photovoltaic generation; energy storage system; stochastic programming.