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Energy procurement of large industrial consumer via interval optimization approach considering peak demand management

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ABSTRACT

Large energy consumers demanding large quantity of energy resources to be supplied are one of essential types of energy demands that need a lot of attention to be paid. Large consumers usually procures some of their energy demand from pool market and the price through which pool market injects power to this consumer is set to be uncertain. Uncertainty modeling is done through interval optimization method in which a bi-objective optimization problem is generated to be minimized instead of single objective problem. Mentioned bi-objective model including deviation and average costs as disagreeing objective functions is solved utilizing popular ε-constraint method. Moreover, trade-off optimal solution between mentioned objective functions is determined by fuzzy decision making approach. In addition to mentioned techniques, time-of-use (TOU) model of demand response program (DRP) is enabled for large consumer to reduce its average and deviation costs through modifying its energy consumption trend. It should be noted that large consumer is not just limited to pool market and in addition mentioned market, it can procure energy from bilateral contracts and local units like distributed generation system, photovoltaic system (PV) and wind turbine (WT). A sample large consumer is simulated and results of simulations are presented for comparison.

1. Introduction

Restructuring in the electrical industry has started since the 1980s to create competition at all levels, from generation to consumer which is shown in Fig. 1. A large consumer can be vehicle-assembling facilities, petrochemical industries or aluminum production complexes. Energy procurement at the minimum cost has more importance for large consumers due to their high-required demand (Aalami & Nojavan, 2016).

As shown in Fig. 1, in spite of other small consumers, the large consumers have multiple sources to meet their demand. A large consumer can consider pool market or wholesale electricity market (Fanelli, Maddalena, & Musti, 2016), bilateral contracts with GenCo (Aalami & Nojavan, 2016), and self-generating units (Grande, Yahyaoui, & Gómez, 2018) as the power procurement sources.

Pool market price has uncertainty, which may result in high procurement cost which is a big challenge for the large consumer. To reduce related risk to power price in the pool market, the consumer can sign bilateral contracts. Bilateral contracts are arrangements between a consumer and supplier, which allow the large consumer to buy electrical energy before its physical delivery. Beside the pool market and bilateral contracts, to reduce risk and cost the consumer can use self-generating units to meet some part of its demand. Different types of distributed energy resources (DERs) can be considered as self-generating units. Distributed generation units and renewable energy sources as DERs can be taken into account (Feilat, Azzam, & Al-Salaymeh, 2018) which large consumer owns them. To overcome volatile output of renewable energy sources, electrical storage systems (ESS) (Nojavan & allah Aalami, 2015) can be utilized in which store electrical energy when power generation is high and use the stored energy when the renewable energy source is not available.

By using demand response programs, a large consumer can manage its load during peak and off-peak times, which will result in reducing energy procurement cost. Demand response programs transfer some part of the load from peak time to off-peak periods. Among demand response programs, time-of-use pricing (TOU) program is more suitable for the considered problem. In the TOU, by assigning higher prices during peak periods, power procurement is changed over the hours of the day.

As mentioned above, one of available options for large consumer to supply its large scale energy demand is power market (Kirschen, 2003). Effectiveness of load management options like demand response on the performance of large consumer participating in power market has been discussed in (Albadi & El-Saadany, 2008). Each energy consumer

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