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Modeling and prioritizing demand response programs in power markets

H.A. Aalami [1], M. Parsa Moghaddam *, G.R. Yousefi [2]

Tarbiat Modares University, Tehran, Iran

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ABSTRACT

One of the responsibilities of power market regulator is setting rules for selecting and prioritizing demand response (DR) programs. There are many different alternatives of DR programs for improving load profile characteristics and achieving customers' satisfaction. Regulator should find the optimal solution which reflects the perspectives of each DR stakeholder. Multi Attribute Decision Making (MADM) is a proper method for handling such optimization problems. In this paper, an extended responsive load economic model is developed. The model is based on price elasticity and customer benefit function. Prioritizing of DR programs can be realized by means of Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. Considerations of ISO/utility/customer regarding the weighting of attributes are encountered by entropy method. An Analytical Hierarchy Process (AHP) is used for selecting the most effective DR program. Numerical studies are conducted on the load curve of the Iranian power grid in 2007.

1. Introduction

As electricity markets are liberalized, consumers become exposed to more volatile electricity prices and may decide to modify the profile of their demand to reduce their electricity costs. Customers participating in Demand Response (DR) programs can expect savings in electricity bills if they reduce their electricity usage during peak periods. Benefits of DR programs are not limited to programs' participants only, nevertheless some of these benefits are market-wide ones. An overall electricity price reduction is expected eventually. Basically, demand response programs have been implemented with different goals, and had different priorities in the power markets. The most important DR implementation objectives are as follows [1]:

- More efficient utilization of the power market
- Reduction of demand from expensive electricity generating units
- Increase the short-term capacity
- Avoid or defer need for distribution and transmission infrastructure enforcements and upgrades
- Reduce the price of electricity for all electricity consumers
- Reduction of price volatility in the spot market
- Reduction of power interrupts and energy not supplied
- Reliability, power quality, security and stability improvement

As it can be seen, the above mentioned objectives are common goals and have some overlaps, and sometimes may conflict with each other. Independent System Operator (ISO) thus needs to determine which program best suits his needs. This evaluation should take into consideration not only the load profile characteristics, but also satisfaction of the customers through reduction of their electricity bills.

If ISO decides to optimize the aforementioned objectives, it will be faced with a very complex problem, because by satisfying some of the objectives, others may fall down. In the power systems, policy, demand growth, environmental, economical and social issues are faced with too many parameters, where traditional models are very weak to tackle them. The belief is finding a reasonable method using Multi Attribute Decision Making (MADM) formulation leading to a practical solution [2,3]. MADM methods have been applied to different power systems problems including expansion planning [4,5], load management, load estimation, congestion management, etc. [6,7].

In this paper first, a comprehensive load economic model is developed. This model is an extension of the model addressed in [8]. The developed model is based on the price elasticity of demand and it takes into account the effect of incentives and penalties of DR programs as well as customer benefit. This model makes it possible to evaluate the performance of different DR programs. Then by using MADM techniques the portfolio of DR programs is prioritized according to the attributes which are raised from concerns

* Corresponding author. Tel.: +98 21 82883369; fax: +98 21 82883369.
E-mail addresses: h_aalami@yahoo.com (H.A. Aalami), parsa@modares.ac.ir (M.P. Moghaddam), yousefi@cc.aut.ac.ir (G.R. Yousefi).
[1] Tel.: +98 21 82884334; fax: +98 21 82884334.
[2] Address: Isfehan University of Technology, Isfehan, Iran. Tel.: +98 311 3915467; fax: +98 311 3915467.

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