MODELING DEMAND-PRICE CURVE: A CLUSTERING APPROACH TO DERIVE DYNAMIC ELASTICITY FOR DEMAND RESPONSE PROGRAMS

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Overview

The ongoing adaptation of smart grid technologies results in several transformations in contemporary power systems operation and planning. A key factor for the transition to efficient smart power networks is Demand Response (DR). DR aims at significant demand savings by the combination of load management techniques, distributed generation and storage. The exploitation of the benefits of DR is held via numerous research studies in recent years. Also, various pilot programs have implemented in some European countries.Price-based DR programs aim to the modification of energy consumption patterns through a set of tariff schemes such as time-of-use rates, real time pricing and others. Based on contracts between the retailer and consumers, a special tariff is offered to the consumers that reflects more accurately the cost of generated electricity in the day-ahead market. The consumers response to the offered price is modeled via various demand-price curves. The consumers modify their consumption according to the offered price. This modification is expressed by the elasticity parameters. If the consumers are elastic, the modification of consumption is more evident and follows the price signals.

Methods

The elasticity is defined as the level of demand alternation with respect to the price signal send by the retailer. It is parameter that determine how flexible is the load during the 24-hour period. We consider an existing high voltage industrial consumer located in Greece. We regard that it is charged with the System Marginal Price (SMP) of the Greek pool market. Using the K-means clustering algorithm, for each hour the profiles of load-SMP patterns are extracted. By combining this profiles, the elasticity curve is extracted for each day. This approach leads to the formulation of dynamic elasticity curves for each day, leading to a more representative modeling of the flexibility of the demand.

Results

Fig.1 presents the flow-chart of the K-means algorithm. K-means is the most common algorithm with numerous application in various research areas. The algorithm is applied to the hourly load-SMP patterns of the complete year. The number if clusters for each hour varies from 2 to 30. Under a proper mathematical criterion, the optimal number of clusters is drawn. Fig. 2 shows the dynamic elasticity curve of the consumer under study. It can been noticed that the consumer presents various degrees of demand flexibility through the year as modelled by the volatility of the dynamic elasticity curve.

Conclusions

In the majority of the related literature, the value of elasticity is considered constant through the day period. However, this approach does not reflect always the actual behavior of the consumers. The demand is more elastic in various periods through the day and through the various seasons. In this paper, a novel method is proposed to extract dynamic elasticity curves. The clustering tool is utilized to extract the profiles of demand-price patterns through the day. The profiles are used to determine the hourly elasticity of a complete year. The proposed method leads to the extraction of a different elasticity value per hour, resulting in a more accurate modeling of the consumers responsiveness to the price signals. The proposed method is applied to a high voltage industrial consumer located in Greece. High voltage industries are energy intensive and therefore are suitable for price-based DR programs.

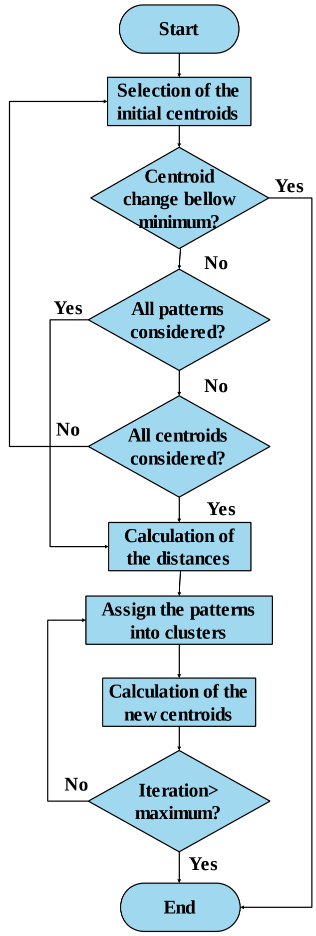

Fig.1. Flow-chart of the K-means algorithm.

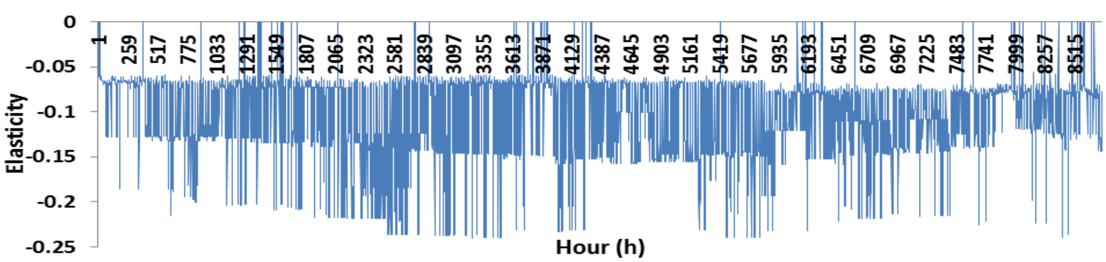

Fig.2. Yearly dynamic elasticity curve.

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