A Review of Customer Management Tools: The Energy Industry

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Abstract. In a deregulated electricity market, as the one formed by the current developments in the regulatory framework, where the electricity customers are able to choose their supplier freely, energy companies are expected to be more and more competitive, while changing the focal point of their activities from the traditional production-centered to a customer-centered. As part of this customer-centric evolution, energy companies are focusing their attention on software platforms that support closer customer relationships, enhance customer service, and reduce costs. Customer Relationship Management (CRM) constitutes a very attractive solution for addressing their customer management requirements. The present paper describes the tools incorporated in such a system and additional tools necessary for tackling future challenges.

Keywords: Electricity retail companies, customer management, Customer Relationship Management (CRM) systems.

1 Introduction

Current developments in the regulatory framework of the electricity market driven by Directive 72/2009/EC, lead to the creation of a new energy trading environment, in which electricity customers are able to choose their supplier freely. As a result, energy companies begin to realize that their most valuable “asset” is the consumer, while knowledge (not just merely data) is their only sustainable advantage, leading to a change in their focal point of their activities from the traditional production-centered to a customer-centered.

Especially with the recent developments in the field of smart metering, energy providers/companies will be expected to cope with a vast amount of data (such as hourly consumption per meter), which can be considered more of a problem – the company is data rich but information poor – than bless, if properly employed. The need for efficiently managing massive amounts of customer data along with the ever increasing competition in the retail market combined with the need to retain and attract customers inescapably results in investing in systems that support closer customer relationships, enhance customer service, and reduce costs through effective knowledge mining from vast amounts of data, providing effective support for decision making – summarized under the label Customer Relationship Management (CRM) systems.

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At the heart of any CRM system lies a central database containing information about each customer (contractual data, energy consumption etc.). Moreover a CRM system is comprised by a number of tools such as:

- Risk management
- Load modeling/Customer profiling
- Billing/Tariff design
- Meter data management

These tools facilitate the handling of a large volume of data, the extraction of useful information regarding the electricity consumer behavior as well as the operation of the company in general.

The rest of the paper is organized as follows: in paragraph 2 the current situation regarding the above mentioned tools is described. In paragraph 3 the developments in the same tools as well as additional tools necessary for the retail company of the future are described. Paragraph 4 concludes the paper.

2 Current Situation

2.1 Risk Management

Energy companies in general and electricity retailers in particular, who buy electricity in bulk from the wholesale market at constantly changing prices only to sell it to retail customers at a fixed price, are inevitably exposed to price and volume risks. In order to reduce their exposure to price risks, retailers hedge their positions using a combination of various contracts such as: forwards, options and contracts for differences [1].

Forward contract for physical delivery is an agreement to buy/sell a specified volume of electricity at a specified future time at a price agreed today [2]. This is in contrast to a spot contract, which is an agreement to buy or sell an asset today. The price agreed upon is called the delivery price, which is equal to the forward price at the time the contract is entered into.

Options are contracts with a conditional delivery, which means that they are exercised only if the holder of the contract decides that it is in its interest to do so. They come in two varieties: calls and puts. A call option gives its holder the right to buy a given amount of a commodity at a price called the exercise price. A put option gives its holder the right to sell a given amount of a commodity at the exercise price.

In case the market participants are not allowed to enter into bilateral agreements (such as forwards or options), they resort to *contracts for differences*. In a contract for difference, the parties agree on a ‘strike price’ and an amount of the commodity. Once trading on the centralized market is complete, the contract for difference is settled as follows: In case the strike price is higher than the wholesale electricity market price (spot price), the retailer pays the generator the difference between these two prices times the amount agreed in the contract. If the strike price is lower than the market price, the generator pays the retailer the difference between these two prices times the amount agreed in the contract.

2.2 Billing/Tariff Design

As the electricity systems become more and more stressed by high volumes of energy during peak load hours that occur only a few hours per year leading to price spikes, it becomes clear that grid reinforcements and expansions and new peak generation capacity cannot be the most efficient answer [3].

The answer lies on the other side of the scale. Load is today seen as a resource for achieving better utilization of the existing power production and transfer capacity. The flat rates however at which the electricity consumers pay their consumption – it being the norm for many years in the electricity market – begin now gradually to be considered old-fashioned and obsolete. In contrast, multiple tariffs or time-of-day tariffs are in the order of the day. By this way price-responsive demand is achieved, while providing an –up to now missing– link between wholesale and retail power markets.

Figure 1 [4] illustrates the effect of price sensitive demand on the market prices. Retail customers, who modify their usage in response to price volatility, help lower the size of price spikes. For this case, consumer response to price induces demand by 5% and cuts the price by 55%.

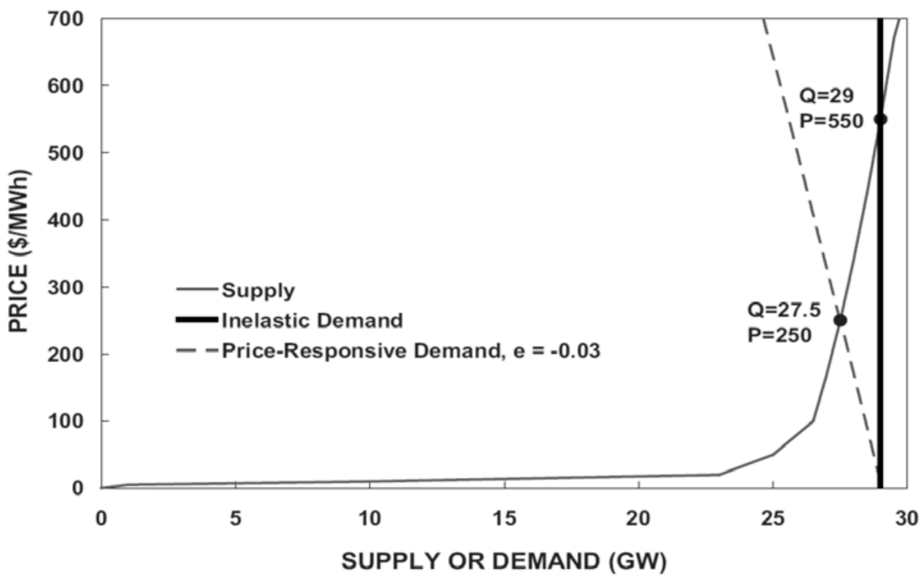

Fig. 1. Hypothetical wholesale supply and demand curves. The solid vertical line represents demand that is insensitive to price; the dashed line represents demand that varies with price.

Two mechanisms for achieving load flexibility can be identified [5]:

1. Sending price signals in the form of demand response programs, in which consumers bid load reductions at specified prices and receive payments for reducing load relative to a calculated baseline level of consumption if the bid is accepted or in the form of time-sensitive pricing (time-of-use or TOU rates) [3].
2. Sending volume signals through traditional direct load control or interruptible service program.

Sending price signals is, of course, advantageous for the electricity consumers, since they are provided with the opportunity to choose whether or not they will reduce their consumption during periods of high prices, thus saving money. Volume signals on the other hand provide power system operators with the advantage of greater control over the load but would be more difficult to be adopted from the consumers.

Today price signals are considered the most appropriate lever in order to induce the desirable consumer behavior. As a result, the traditional flat rate has been gradually replaced by two-part tariffs especially for domestic consumers. However, its economic justification has frequently been disputed [6].

3 Future Developments

Future developments that the electricity retailers will be called upon to act are mainly driven by the new metering technology. Smart metering and smart grid solutions will bring about radical changes in the interaction between the electricity retailer and the consumers. Loads will no longer be considered as passive entities, while real time pricing programs will create price-responsive consumers. What is more, retail companies will be expected to be able to cope with a vast amount of data acquired by the new real time meters.

Furthermore, changes in the regulatory framework with the introduction of competition in the retail electricity markets appear as new challenges for companies that participate in such markets. As more and more retail companies strive to gain more customers, they are expected to become more competitive. In order for them to be able to retain their customers, a number of tools are expected to be used: load modeling, consumer profiling, and behavior prediction.

3.1 Risk Management

Up to this date the electricity load has been considered more or less as constant with only minor changes over the years directly driven by changes in population, weather or living conditions. Consequently, load posed no risk to the electricity retailers.

Electricity prices, on the other hand, posed no risk for the electricity consumers, since consumers were price-insulated through the flat rates. However, as new metering concepts, such as real-time pricing, gain day-by-day in popularity, and with the application of real-time pricing, part of the price risk previously faced only by the retailers will be transferred to the price-sensitive consumer. This risk reduction, however, comes with a price for the electricity retailer, who is exposed to a volume risk due to the uncertainly over the load. Management of that risk is achieved by load modeling and consumer behavior prediction as described in the following paragraphs.

3.2 Load Modeling/Customer Profiling

Load modeling is expected to be greatly facilitated by the utilization of the real time consumption readings provided by the new metering equipment. The discovery of common consumption patterns between different customers will contribute to a better understanding of the consumer behavior and will serve as a tool for a personalized and, thus, more effective interaction with the customers.

Several modeling algorithms can be used based on real time load curves. The wide variety of clustering and segmentation algorithms, as well as, the fact that they fall into the category of unsupervised learning renders them the most appropriate tool for the task at hand. Figure 2 presents a general division of classical clustering algorithms.

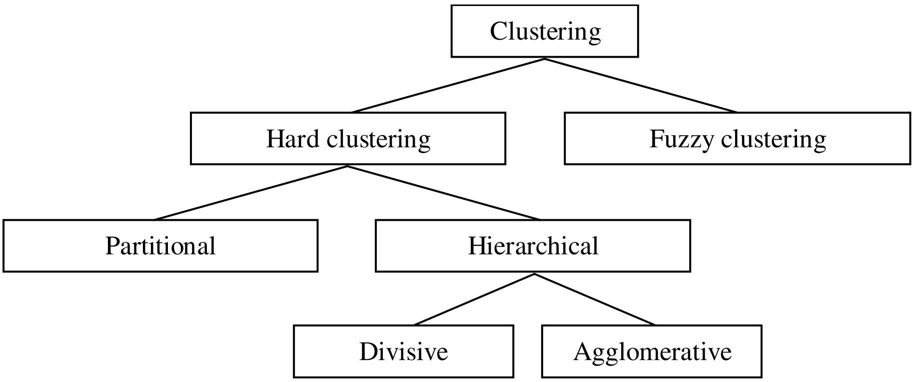

Fig. 2. Categorization of classical classification methods

Partitional algorithms (e.g. k-means) divide the data set into a single partition while the number of desired output clusters is predefined. On the other hand, *hierarchical algorithms* (e.g. single link, complete link) divide the data set into a sequence of nested partitions. Hierarchical algorithms are further subdivided into divisive and agglomerative. Divisive hierarchical clustering starts with all objects in one cluster and repeats splitting large clusters into smaller pieces, while agglomerative hierarchical clustering starts with every single object in a single cluster. Then it repeats merging the closest pair of clusters according to some similarity criteria until all of the data are in one cluster [7]. Partitional and hierarchical algorithms generate partitions; in a partition each pattern belongs *to one and only one* cluster (*hard clustering*). By contrast, *fuzzy clustering* associates each pattern with *every* cluster using a membership function. The output of such algorithms is a clustering but not a partition.

Apart from the classical methods developed solely for the purpose of clustering, as those mentioned previously, during the last decades several other methods are used for classification and clustering. *Artificial Neural Networks* (e.g. Kohonen's learning vector quantization (LVQ), self-organizing map (SOM), adaptive resonance theory models) are often used to cluster input data by representing each pattern by a single unit (neuron) [8], [9], while evolutionary approaches (e.g. genetic algorithms (GAs), evolution strategies (ESs), and evolutionary programming (EP)) solve the clustering problem by viewing it as a minimization of the squared error criterion of the clustering [8]. Finally, during the last years *Support Vector Clustering* (SVC) is used as a complementary method to the aforementioned for detection of the outliers exhibiting anomalous behavior [10].

Additionally, data reduction algorithms such as *Principal Component Analysis* (PCA) work in synergy with the previously mentioned classification and clustering algorithms [11]. PCA is a widely used statistical technique for unsupervised dimension reduction and is closely related to k-means clustering.

3.3 Billing/Tariff Design and Consumer Behavior Prediction

Flat rates and two-part tariffs can be considered today outdated. Instead, time-of-use (TOU) rates, in which electricity prices vary across time periods within a day and even seasonally are a significant improvement. TOU rates provide consumers with an economic incentive to reduce usage during high-priced periods and to shift load from high-priced to lower-priced periods. However, they do not give consumers the opportunity to mitigate price risk on the customer side of the meter, or to avoid potentially higher costs of traditional risk mitigation methods. Only dynamic pricing creates this opportunity for consumers [12].

Traditional time-sensitive pricing varies rates across time periods within a day and even seasonally and comes in three forms:

1. Prices are set ahead of time, but the timing when these prices are in effect is unknown e.g. critical peak pricing
2. Both price levels and timing are unknown, but the time blocks within a day when prices change from one level to another are known
3. Price levels, time periods, and timing are all variable: real-time pricing

Flexibility in pricing is facilitated by the advancements in the metering systems. New technology in metering systems summarized under the term Advanced Metering Infrastructure (AMI) offers new capabilities for two way communication between the energy provider and the consumer that can be exploited for implementing demand response programs or, in more advanced environments, for real time pricing.

By this way the consumers respond to incentives specifically designed for encouraging a certain behavior (e.g. load shift during peak hours in order to relieve the electricity system) or to real time electricity prices. More specifically, in case the energy prices are announced in advance, the usage and operation of various household appliances are properly adjusted – when feasible (for example refrigerators consist a type of load that is difficult if not impossible to control, while water heating loads or the use of the oven are much more easily controlled) – by the homeowner. In case real-time prices are available, the adjustments take place in real-time. In the first case the consumer chooses a certain scheduling for the usage of the appliances beforehand, while the procedure in the second case is fully automated by means of the appropriate software embedded in the intelligent meter.

The real-time market price and control system turns home electricity customers into active participants in managing the power grid (use of load for congestion management or for achieving a higher accommodation ceiling of distributed generation through the right price incentives) and their monthly utility bills [13].

The aforementioned developments create a new environment, in which the electricity consumer behavior is no longer determined only by weather conditions and the personal preferences that aim at maximizing the comfort level. The –previously price-insulated– electricity consumers will be constantly informed about price fluctuations. As a result, price signals will play a far more decisive role in the choices made by electricity consumers that determine the load curve, making load forecasting not only difficult to perform but also imprecise. Thus, the old-fashioned forecasting will be replaced by more complex methods appropriate for behavior modeling. Methods such as game theory will undoubtedly prove to be a valuable ally in the effort of simulating the expected load response to price signals taking into account a new parameter as independent variable – electricity prices.

3.4 Meter Data Management

Automatic Meter Reading (AMR) provides a much higher frequency of data as meter reading moves from monthly to daily or even hourly. As a result future electricity retailers will be expected to cope with a vast amount of data, while problems regarding volume, scalability, and processing power of existing systems will arise [14].

Meter data management (MDM) solutions provide data storage and management and act as an intermediate between the metering system and various business applications such as the company billing platform, executive forecasting, customer service, customer relations, operation and support.

The definition of a meter data management solution can vary widely. At a minimum, MDM provides a database repository and utility-specific business logic to:

- Automate and streamline the complex process of collecting meter data from multiple meter data collection technologies
- Evaluate the quality of that data and generate estimates where errors and gaps exist
- Deliver that data in the appropriate format to utility billing systems

Some of the validation and estimation functions that the MDM system should enable are the following:

- Estimate interval data based on meter readings
- Replace all values with a constant
- Multiply or divide by a constant
- Add or subtract a constant
- Slide a range of interval data ahead or back in time
- Perform linear interpolation
- Split or combine intervals
- Restore a previous version

Additionally, utilities should be able to edit values using a host of standard editing functions:

- Add or replace values manually
- Modify read status
- Display or edit multiple reads
- Copy or cut/paste a string of values from one meter to another
- Copy or cut/paste values from a spreadsheet

The most important service that a MDM system provides is the pre-processing of interval meter data at large volumes very quickly, while in the future an MDM system should be able to:

- Accommodate two-way communications between Customer Information Systems (responsible for commercial integration of data acquired by the metering system) and AMI systems and
- Provide a platform to enable other AMI applications and business processes thus simplifying the integration of new AMI technologies.

Furthermore, MDM systems simplify the billing processes of a utility by supporting complex load calculations and aggregations that are essential for time-of-use and critical peak pricing programs [15].

4 Conclusion

As the retail industry gradually shapes into the form of a competitive market, electricity retail companies will face a number of challenges in order to retain and even increase their customer base. Their previous activities (such as risk management and tariff design) will need to be adjusted to the new challenges as well as enriched with new ones while the consumer will be at the center of their strategies. These activities will include – amongst others – load modeling, consumer behavior prediction and meter data management.

In this consumer-centric environment software platforms summarized under the label Customer Relationship Management (CRM) systems provide multi-dimensional support for decision making, thus constituting a very attractive solution for addressing customer management requirements and developing business strategies in a highly competitive environment.

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