Issues related to demand supply management in smart metering information system for smart grid

[1]Nutan Y. Attarde, [2]Neelam S. Pinjari, [3]Ujwala. Tade,[4] Rekha Sonune
[1]Assistant Professor,LTCoE,Mumbai, [2]Assistant Professor, [3] Assistant Professor,[4]Assistant Professor
[1] nyattarde@gmail.com, , [2] neelam.pinjari@gmail.com,[3] ujvala.tade@gmail, [4] rekha_sonune@rediffmail.com

Abstract: **The most important features of the smart grid is the meter data management system (MDMS)which collects, exchanges, and processes the meter data with an objective of minimizing the power consumption and supply. Currently, the electricity consumption is not efficient .This results in the waste of a large amount of natural resources. This leads to arising different needs such as plug-in hybrid electric vehicles (PHEVs), which can potentially double the average load, It has increased the need of developing new methods for demand side management (DSM).We consider a smart power infrastructure, where several subscribers share a common energy source. Each subscriber is equipped with an energy consumption controller (ECC) unit as part of its smart meter. Each smart meter is connected to not only the power grid but also a communication infrastructure such as a local area network. This allows two-way communication among smart meters .Considering the importance of energy pricing as an essential tool to develop efficient demand side management strategies. We propose a novel real-time pricing algorithm for the future smart grid. We focus on the interactions between the smart meters and the energy provider through the exchange of control messages which contain subscribers' energy consumption and the real-time price information. We analytically model the subscribers' preferences and their energy consumption patterns in form of carefully selected utility functions based on concepts from microeconomics. Then we propose a distributed algorithm which automatically manages the interactions among the ECC units at the smart meters and the energy provider. The algorithm finds the optimal energy consumption levels for each subscriber to maximize the aggregate utility of all subscribers in the system in a fair and efficient fashion. After that we will show that the energy provider can encourage some desirable consumption patterns among the subscribers by means of the proposed real-time pricing interactions.**

Index Terms— **meter data management system (MDMS), hybrid electric vehicles (PHEVs), demand side management (DSM), energy consumption controller (ECC).**

I. INTRODUCTION

The major source of energy for human beings is electricity. Without electricity, no technology or science could have been possibly developed. But there are many problems associated with effective functioning of the electric grids which cause a serious loss of power and may even create severe scarcity in future. Also, the latest advancements in generation of electricity from renewable sources also require a means for effective utilization.[1]

So, keeping in view of these, for better performance of the grid, smart grids should be developed all over the world so that we have a more transparent, reliable system that allows consumers to save money and enable utility companies to utilize electricity more efficiently and accurately. The smart grid performs various functions such that it increases grid stability, reliability, efficiency and ultimately reduces line losses. Also the smart grids are designed to allow the two-way processing of electricity from consumers that have distributed generation systems. Various technologies like sensing and measurement, usage of advanced components are to be used for successful functioning of the grid A smarter electricity grid could fundamentally change the way people manage their electricity usage. In theory, the technology could help reduce demand, save money, and improve reliability and efficiency. The smart grid will incorporate new networking technology, including sensors and controls that make it possible to monitor electricity usage in real time and make automatic changes that reduce/minimize energy waste Procedure for Paper Submission

Smart power infrastructure enables several subscribers to share a common energy Source. Each subscriber is equipped with an energy consumption controller (ECC) unit as part of its smart meter. Each smart meters connected to not only the power grid but also a communication infrastructure such as a local area network. In this two-way communication among smart meters energy pricing is an essential tool to develop efficient demand side management. We propose a distributed algorithm which automatically manages the interactions among the ECC units at the smart meters and the energy provider. Since there are increased expectations of customers, both in quality and quantity, the limited energy resources, and the lengthy and expensive process of full use of new resources, the reliability of the grid has been put in danger and there is a need to develop new methods to increase the grid efficiency. So these factors leads to advancement in methods for demand side management (DSM) in Smart Metering.[2]

II. Advanced Metering Infrastructure (AMI) of interval meters and two-way communications systems serves as a gateway for customer interaction. Smart Metering has the potential to reduce both customer and utility costs. Today's current electricity meter, one will see that it is very mechanical, humming along blindly, waiting to be read by a technician, to determine the amount of electricity used in a given month, at the end of which you receive a bill. A smart meter utilizes what is known as real-time monitoring (RTM). RTM system enable the consumer to know how much electricity is used and even when it is less expensive to use it. When people are made aware of how much power they are using& timing of usage, then they optimize the usage and reduce their consumption in peak hours or when electricity is expensive. A smart grid also prevents the entire system from becoming overloaded, considerably reducing the chance of a power outage.[3]

We propose a real-time pricing algorithm for DSM programs to encourage desired energy consumption behaviors among users and to keep the total consumption level below the power generation capacity. In our system model, the subscribers and the energy provider automatically interact with each other through a limited number of message exchanges and by running a distributed algorithm to find the optimal energy consumption level for each subscriber, the optimal price values to be advertised by the energy provider, and also the optimal generating capacity for the energy provider. However, smart pricing is known as one of the most common tools that can encourage users to consume wisely and more efficiently. By charging users more in peak and less in off-peak hours, the provider can induce users to shift their consumption to off-peak periods, thus relieving stress on the power grid and the cost incurred from large peak loads.

We propose a dynamic demand scheduling (D2S) scheme an effort toward cost-effective energy consumption at customers' end. This proposes scheme is a novel real-time pricing Algorithm for the future smart grid. We focus on the interactions between the smart meters and the energy provider through the exchange of control messages which contain subscribers 'energy consumption and the real-time price information. We analytically model the subscribers' preferences and their energy consumption patterns in form of carefully selected utility functions based on concepts from microeconomics.

The algorithm finds the optimal energy consumption levels for each subscriber to maximize the aggregate utility of all subscribers in the system in a fair and efficient fashion. Finally, we will show that the energy provider can encourage some desirable consumption patterns among the subscribers by means of the proposed real-time pricing interactions.[4]

For gaining higher reliability and continuity it is necessary that the smart grid system would automatically detect distribution line failures, identify the specific failed equipment, and help to determine the optimal plans for proposing crew requirement to restore service. The smart grid would automatically attempt to isolate failures to prevent local blackouts to spread over that area.

III. DYNAMIC MODELS OF SUPPLY-DEMAND UNDER INFORMATION ASYMMETRY

We develop dynamical system models for the interaction of wholesale supply and retail demand in electricity markets with information asymmetry. In this context, "asymmetry of information" refers to the architecture of the information layer of the market, in which, the market operator has full information about the cost of supplying the resource (e.g., through the offers of the producers), but has no information about valuation of the resource by the demand side. The real-time market is cleared at discrete time intervals and the prices are calculated and announced for each interval1. The practice of defining the clearing price corresponding to each pricing interval based on the predicted demand at the beginning of the interval is called extant´e pricing. As opposed to this, expost pricing refers to the practice of defining the clearing price for each pricing interval based on the materialized consumption at the end of the interval. In ex-post pricing the demand is subject to some price uncertainty as the actual price will be revealed after consumption has materialized. In exant´e pricing without ex-post adjustments, the entity in charge of real-time pricing faces the price uncertainty,as it will have to reimburse the generators based on the actual marginal cost of production, while it can charge the demand only based on the extant price. We will present dynamic market models for both pricing schemes. These models are consistent with the current practice of marginal cost pricing in wholesale electricity markets, with the additional feature that the retail consumers adjust their usage based on the real-time wholesale market price.[5]

We have investigated the problem of volatility of power markets in a dynamic general equilibrium framework. These are full-information model in which the system operator has full information about the cost and value functions of the producers and consumers. Market clearing is instantaneous and supply and demand are matched with no time lag. The producer's problem is, however, subject to supply friction or a ramp constraint, i.e., a finite bound on the rate of change of supply capacity. It is concluded that efficient equilibrium are volatile and volatility is attributed to the supply friction. In the formulation of the consumer's problem is not subject to ramp constraints[6].In our formulation, neither the consumer's problem nor the producer's is explicitly subject to ramp constraints, yet other factors are shown to contribute to volatility, namely, information asymmetry and high price elasticity of demand. Interestingly, if we included ramp constraints in the consumer's problem it would have a stabilizing effect, as it would limit the consumer's responsiveness to price signals and reduce her elasticity. This effect is implicitly and qualitatively captured in our framework through the introduction of an inelastic component in the demand, which certainly limits the rate of change in the demand, and was shown to have a stabilizing effect. However, uncertainty in the supply side, either in the available capacity or in the cost, works in the reverse direction: when supply is sufficiently volatile, a trade-off might exist and responsiveness and increased elasticity of demand might be desirable, though this needs to be quantified rigorously. The models developed in the paper do not include uncertainty in generation, and this would be an interesting direction for future research. The above discussion leads to another interesting question: "quantifying the value of information in closed-loop electricity markets". Given the heterogeneous nature of consumers and time-varying uncertainty in their preferences, needs, and valuations for electricity, learning their value functions and predicting their response to a price signal in real-time appears to be a difficult problem. Suppose that the consumers provide a real-time estimate of their inelastic and elastic consumption to the ISO. [7]

How valuable will this real-time information be and what would be its impact on volatility and reliability of the system? Given the potentially significant costs and barriers associated with obtaining such information in real-time, quantifying the value of information in this context seems an extremely important and timely question with potentially significant impact the architecture of future power grids. We address the interaction among multiple utility companies and multiple customers in smart grid by modelling the Demand Response (DR) problem as two non-cooperative games: the supplier and customer side games[8]. In the first game, supply function bidding mechanism is employed to model the utility companies' profit maximization problem. In the proposed mechanism, the utility companies submit their bids to the data center, where the electricity price is computed and is sent to the customers. In the second game, the price anticipating customers determine optimal shiftable load profile to maximize their daily payoff. DR method increases the utility companies' profit and customers' payoff, as well as in reducing the peak-to-average ratio in the aggregate load demand .A novel 'Model predictive control' (MPC) based algorithm uses updated real-time forecasts to minimize errors and ensure realistic benefits. We show that the MPC-based algorithm is robust and more effective at consistently reducing consumer electricity costs and peak to average demand ratio (PAR) than a 'day-ahead scheme' in the typical case of mean absolute forecasting errors greater than 10% [9].

For analysing the impact of the reliability of the smart grid, data communications infrastructure needs the power consumption optimization. The deferrable load scheduling requires price information from the meter data management system (MDMS) server. If the connection of home area network (HAN) and neighborhood area network (NAN) gateways from deferrable load to the MDMS server is unavailable, then the scheduling policy will be suboptimal and it will result in a higher power consumption cost. This leads to analyse the demand response performance degradation due to unreliable communication[10] .

CONCLUSION

Energy pricing is an essential tool to develop efficient demand side management (DSM). Energy provider can encourage some desirable consumption patterns among the subscribers by means of the proposed real-time pricing interactions. Using demand response (DR) method can increase the utility companies' profit and customers' payoff, as well as reduce the peak-to-average ratio in the aggregate load demand. Using novel game theoretic model, distributed energy generation and storage widely investigated for achieving greater electricity cost savings and peak to average demand ratio reducing.

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