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Managing Demand Response for Smart Grids Based on Electricity Price and Demand

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Abstract

Demand side management to play important role in the electricity market for maintaining the balance between supply and demand. Demand relief from customers can solve a variety of problems. In future smart grid, Power generation sector facing important challenges both in quality and quantity to meet the increasing requirements of consumers. Energy efficiency, reliability, economics and integration of new energy resources are important issues to enhance the stability of power system infrastructure.

The main goal is to get load relief when needed, and to do so in a cost effective way. This paper mainly focuses on the real-time price .Forecasting Short Term Load/Price Forecasting(STL/PF) is performed for an electricity market that offers Demand mechanism which aims to maximize the social welfare. Comparing with existing price Response (DR) Program, Renewable Energy Source (REC) can be combined with Vickrey-Clarke-Groves (VCG) method to get better results in the power management. Though the RES Penetration to power systems is accompanied by some difficulties such as uncertainties associated with wind and solar power generations, it may be fruitful to manage the power generations. These uncertainties pose a challenge while computing optimal bids necessary for participating in the day-ahead unit commitment process. This problem can be solved by applying optimization techniques, with the aim of both maximizing benefits while minimizing risks considering forecast uncertainties. And since the combination of Renewable Energy Source (REC) with Vickrey-Clarke-Groves (VCG) in the power management is still under progress we may expect the Simulation resulting in the

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pricing method can benefit both users and utility companies

1)INTRODUCTION

Demand response (DR) has an important role to play in the electricity market for maintaining the balance between supply and demand by introducing load flexibility instead of only adjusting generation levels, at almost all operational time scales[1].demand side management was introduced by electric power research institute , 1980.DSM is a global term that includes a variety of activities such as :load management energy management, energy saving. Demand side management is one of the key components of the future smart grid to enable more efficient reliability and robustness in power system. The grid is usually designed for the peak demand rather than the average demand.

DSM program categories into direct load control(DLC) and price based control.DLC program can used effectively where there is a decentralized control over the operation of different loads, batteries and a alternative storage facilities. In price based program, the energy provider provides economic incentives to consumer by reflection the hourly change in the wholesale electricity price to the demand side.

Several time differentiating pricing methods have been proposed. That includes real time pricing (RTP),time of use(TOU)pricing, day head pricing(DAD).in time differentiating pricing traffic, the intended operation period is divided into several time slots and the pricing of electricity varies across time slot Various models for scheduling or dispatching DR which can be extended to either wholesale or retail markets are presented. Some papers also present measure of the effects of inclusion of DR into system operation. Reference [1] introduces the economics theory of the electricity industry.

To work properly, effective DR mechanisms are needed: consumers must be charged on an hourly basis and vary consumption with a certain level of responsiveness according to marginal prices (active demand side).in refer- ence [5] have carried out mathematical analysis of the side-effects of DR apart from the desirable result of reducing the local market price of electricity on a simple 3-bus power system. Reference [4] proposed a method of load control based on the price elasticity of consumers. Reference [8] proposed the modeling and integration of the Distribution system topology into the DR scheduling process. This allows calculation of DR available at the nodes of the transmission thus helping in better monitor and verification of requested DR. References [2],6] provide an introduction on the smart grid talking about the problems of the actual grid, the requirements for the future smart grid, the components, benefits, and the entities involved in the development process, framework to classify different types of Energy Management programs and a case

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against the smart grid. Reference [5]presents a set of guiding principles for DR, for each of the domains of utility, customer and energy management.

From this and given the importance of demand side management, in this paper The usefulness of DR in balancing the high penetration of renewable is presented. We propose a Vickrey-Clarke-Groves (VCG) mechanism which aims to maximize the *social welfare*, i.e., the aggregate utility functions of all users minus the total energy **cost.** Some of the main properties of the proposed mechanism such as truthfulness, efficiency, and nonnegative transfer were studied..

Simulation results showed that our proposed algorithm reduces the energy costs of the users. That is, competing users may sell their extra generation to local users at a price higher than the buying price of the utility company, and consuming users may buy the electricity from neighboring users at a price lower than the selling price of the utility company. Moreover, the possibility to trade facilitates the integration of RERs by encouraging the users to consume their excess generation locally which mitigates the reverse power flow problem.

The rest of this paper is organized as follows. dsm challenges and opportunities are presented in Section II. System Model are discussed in Section III. and conclusions are drawn in Section IV.

2) DSM CHALLENGES APPORTUNITIES:

DSM challenges such as load synchronization. Load synchronization is referred to as the contraction of the large .portion of energy consumption in low price hours. Therefore that each user is equipped with an energy consumption controller (ECC) as part of its smart meter. With the growing deployment of advanced metering infrastructure (AMI) and auto- mated energy consumption controller (ECC) devices TP is gradually be- coming a feasible DSM solution. In this regard, ECC de- vices can help by making such price-responsive decisions on behalf of users to achieve certain objectives, maximizing the social welfare, minimizing both the energy expenses and the waiting time , and maintaining system stability with minimum curtailment . How- ever, achieving social objectives (e.g., maximizing social welfare) is difficult because of its computational complexity. It also requires collecting various information about the energy consumption behavior of the users, the price elasticity of the users, and the benefit that each user obtains by consuming a certain amount of energy. However, in general, users are not willing to reveal such

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information, unless there is an incentive for them to do so. Therefore, elaborate design rules (mechanisms) are needed such that it is in each user's self interest to reveal its local information.

3. SYSTEM MODEL

we consider a smart power system with a single energy provider and several load subscribers or users as part of the general wholesale electricity market as shown in Fig. 3. For each user, we assume that there is an ECC unit which is embedded in the user's smart meter. The role of the ECC is to control the user's power consumption, and to coordinate each user with the energy provider. All ECC units are connected to the energy provider through a communication infrastructure such as a local area network.

The intended time cycle for the system's operation is divided into U time slots, where U ⍭ |U|, and U is the set of all time slots. This division can be based on the behavior of the users and their power demand pattern: on-peak time slots, off-peak time slots, andFigure 3.1: An illustration of the regional energy providers, several users, and multiple power generators as parts of the general wholesale energy market.

Mid-peak time slots. Let N denote the set of all users and N ⍭ |N|. In each time slot, we classify the load demand into two types, must-run loads and controllable loads [40]. Must-run loads are price-inelastic. For example, a refrigerator always needs to be on during the day. On the other hand, controllable loads can be stopped, adjusted, or shifted to othertime slots and include the demand for services such as charging PHEVs. In of the maximum and minimum power levels of user n in all time slots respectively M ⍭ $(M_1, \ldots, M_N)$ and m ⍭ $(m_1, \ldots, m_N)$. We denote the minimum total energy requirements of user n as E_n and the vector of the minimum total energy requirements of all users as U ⍭ $(U_1, \ldots, U_N)$, where for each user n, we have $U_n \geq \sum_{k \in k} m^k$. For the users,

it is difficult to determine their required demand information, i.e., the minimum and the maximum power requirement in each time slot, the minimum total energy requirement, and the benefit obtained by consuming a certain amount of energy.

power consumption throughout the operation period .

For all the users, we define ω ⍭ $(\omega_1, \ldots, \omega_N)$. We assume that the utility functionsU (x, ω) satisfy the following properties:

Property .1 Utility functions are non-

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decreasing. This implies that the marginal benefit

Property .2 When the consumption level is zero, $U(0, \omega) = 0, \forall \omega > 0$.

Property 3 The marginal benefit of users $\partial^2 U(x, \omega) \partial x^2 \leq 0$ While the class of utility functions that satisfy(1) and (2) is very large, it is convenient to have a linear marginal benefit.

We note that the operation of each individual appliance is meant to achieve a goal or to finish a task. For example, the air conditioning system is used to keep the temperature in a predetermined range. Thus, the total power consumption of each user can be considered as the aggregate power consumption required to complete different tasks. In this chapter, since we define the utility functions for the aggregate load of different tasks, rather than for the power consumption of each individual appliance, the utility functions do not decrease.

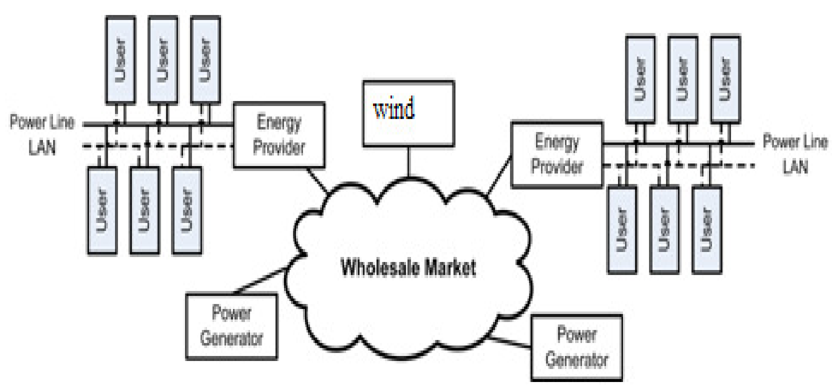

Figure 3.1: An illustration of the regional energy providers, several users, and multiple power generators as parts of the general wholesale energy market.

REVERS POWER FLOW

Minimum amount of their customers' load with RERs Integrating more environmentally friendly RERs into the power grid is one of the main features

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of the smart grid. The renewable portfolio standard requires the utility companies and energy providers . RERs such as solar and wind are non-dispatchable, since they are random in nature. In systems with high penetration of RERs, the power may flow from the distributed generators (DGs) to the substation, which negatively impacts the stability of the system. If the reverse power flow exceeds a certain threshold, it causes the voltage rise problem, which is a major challenge in integrating a large number of DGs in the distribution network

To tackle the reverse power flow problem, it is desirable that users consume their generating power locally rather than injecting the excess power back into the grid. Storage facilities and DSM techniques can be adopted to shape the load pattern of the users to better match supply and demand That is, DSM techniques can be adopted to encourage users to shift their load to time slots with high generation from RERs. To mitigate the problem of reverse power flow, we assume that users are able to sell their excess power.

4) Conclusions and Future Work

W e proposed a VCG mechanism for DSM. The proposed algorithm encourages efficient energy consumption among users aiming at maximizing the aggregate utility of all users while minimizing the total cost of power generation. Some of the main properties of the proposed mechanism such as truthfulness, efficiency, and nonnegative transfer were studied. We also compared our proposed VCG mechanism with the case where users are price taker. And since the combination of Renewable Energy Source (REC) with Vickrey-Clarke-Groves (VCG) in the power management is still under progress we may expect the Simulation resulting in the pricing method can benefit both users and utility companies.

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