Demand Response: A Way to Balance Production and Consumption of Energy for Turkey

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Abstract

Demand Response is an important component of Smart Grids and gaining popularity all over the world with the advancement of automation and communication system on the grid. But it is not widely known and implemented in Turkey yet. Balancing energy supply and demand is mostly done by controlling energy production. Inadequacy in energy production requires very expensive power plant construction. However, with the usage of Demand Response concept, the energy balancing can be also accomplished by the load reduction system which is not as expensive as the construction. In this article, the basics of Demand Response concept is reviewed and its effectiveness in power system is discussed with regard to the current state of the electricity market structure in Turkey.

Keywords: Demand Response, Smart Grid, Demand Response in Turkey, Advanced Metering Infrastructure

1. Introduction

In Turkey as well as all over the World, inadequacy of energy production, continuous price increase of electricity, difficulties in meeting the energy demand at peak hours, difficulties in integration of renewable energy power plants to grid causes serious troubles on energy supply reliability. For the effective utilization of energy production and the balancing of energy supply and demand, it appears that the transmission and distribution sides are in need of communication. This quest gives a great importance to the Smart Grid(SG) approach. SG is an "electricity network which intelligently integrates the actions of generators and consumers connected to it in order to efficiently deliver sustainable, economic and secure electricity supplies" [1].

In the SG architecture, communication between producers, consumers and regulators is very important. As shown in Fig-1., SG adds three key innovative components on physical energy grid. These are communications, computing and information, and smart applications. With these improvements, the control of energy supply and demand in real-time is made possible in SG.

Demand Side Management(DSM) is one of the most important concepts in SG. DSM basically consists of two components such as Energy Efficiency (EE) and Demand Response (DR). While EE focuses on the efficient and less use of energy in end-user side, DR concentrates on the balance of energy supply and demand considering all parties (supply-side, demand-side, transmission networks etc.) together.

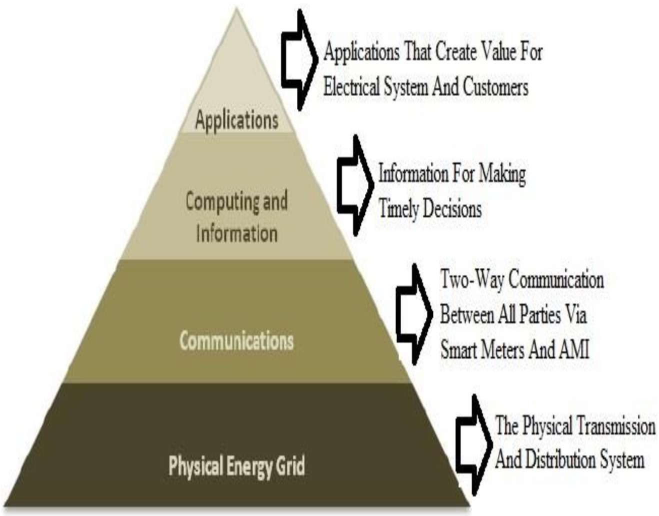

Fig-1. Smart Grid Infrastructure[2].

In this article, first the Smart Meters and Advanced Metering Infrastructure (AMI) which are backbones of DSM system are given. Then, the basics of DR concept are discussed. As of now, DR concept is not widely known and applied in Turkey. Finally, the applicability of DR in Turkey was examined in the light of the current state of the electricity market structure.

2. Smart Meters and Advanced Metering

Smart meters are measurement devices, which enables real-time pricing and duplex communication between utilities and consumers. Smart meters can make complex energy pricing easier for utilities. Thus utilities can make sensitive billings to instant price changes for their customers. Smart meters are used for about 15 years in Europe and U.S.A by using these features actively[2]. With smart meters, utilities can easily access customer data such as energy consumption, power quality, load baseline curve etc. Smart meters also help utilities to control customers' load remotely. Therefore, smart meters are the basic tools for DR applications.

Advanced Metering Infrastructure(AMI) consists of customer side devices and network, AMI interface and corporate side devices and network. Customer side contains smart meters, network systems, communicating control devices such as heating, ventilating, and air conditioning (HVAC) controls. AMI interface transfers data and signal in both directions. Meter Data Management Systems (MDMS) collect and analyze data from all customers. Through development of new software application platforms running on AMI, it is possible to form SG [3]. A major benefit of AMI is its facilitation of DR and innovative energy tariffs. Fig-2. below shows the AMI technologies and how they interface.

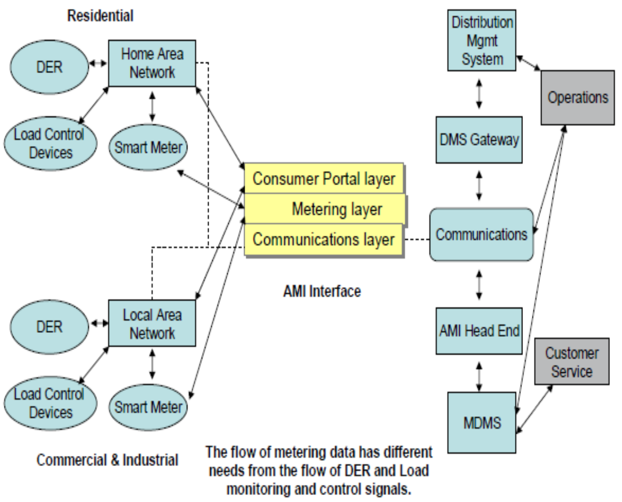

Fig-2. Overview of AMI[4]

3. What is Demand Response?

According to U.S. Department of Energy(DOE) "Demand response is a tariff or program established to motivate changes in electric use by end-use customers in response to changes in the price of electricity over time, or to give incentive payments designed to induce lower electricity use at times of high market prices or when grid reliability is jeopardized"[5].

2000-2001 California energy crisis that happened in the U.S., led to researchers forming of the energy demand with incentives, penalties and real-time pricing methods. From that time DR concept has become popular. The number of researches using various modeling algorithms to ensure market optimization are increasing day by day. In line with these researches, energy service providers and utilities have developed many load control strategies. Energy distribution and transmission companies has also shown considerable interest in this matter. European countries and the United States implemented various DR programs(DRP).

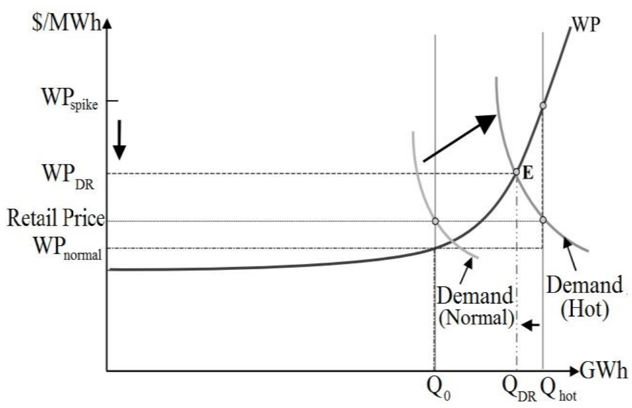

Fig-3. Impact of DR on wholesale electricity prices[6].

Impact of DR on wholesale electricity prices is shown in Fig-3. While the retail price per MWh is fixed, Independent System Operator(ISO) buys electricity from high Wholesale Price(WPspike) in the peak period. So, the ISO can not afford retail price and loses money. When DR is applied, the electricity consumption in peak period will be less and ISO will require less energy. Thus, ISO protects itself against losing money. And also, system reliability is protected in the peak periods.

DR concept, is the most important solution to reduce industrial and residential loads in peak periods. In DR concept, the price of electricity changes constantly, and customers sets their consumption according to this changes. Shifting load and reducing the demand with DR reshape customers load curve. Therefore, network reliability increases and operating costs decreases[7].

3.1. Types of Demand Response Programmes(DRP)

DRPs can be divided into two groups basically: Incentive-Based Programs (IBP) and Price-Based Programs (PBP)[5].

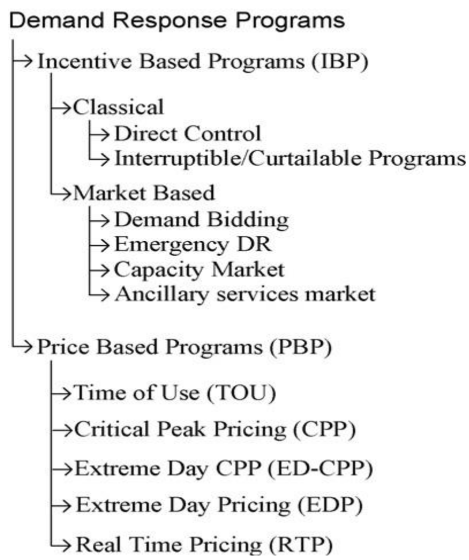

Fig-4. Types of DRPs[8].

In Classical IBPs, customers get paid for participation according to the previously signed contracts. Participation payment can be in the form of bill credit or discount rate. In Market-based IBPs, payments are made to customers according to their load reductions in peak periods[8].

In PBP programs, the main aim is directing customer's electricity usage by changing electricity sale price in different time periods. The price of electricity in peak periods is significantly higher than off-peak periods. Thus, customer is obliged to adjust its electricity usage according to these price changes. Real Time Pricing (RTP), Time of Use (TOU), Extreme Day Pricing (EDP), Critical Peak Pricing (CPP), Extreme Day CPP (ED-CPP) are the programs in this category. In TOU, unit price of electricity changes during certain time periods. Calculation of the unit price is done based on average electricity consumption in different periods. EDP, CPP and ED-CPP extra pricing are done only for special conditions. In RTP, the electricity sale price is determined in real-time by even considering momentary changes in buying price. Customers are constantly informed about prices. Economists indicate that, RTP programs are the most effective DR programs for competitive electricity markets and ISOs should focus especially in such programs[8].

3.2. Demand Response Event

Fig-5. shows the periods of DR event. In Fig-6., we can see DR event on a sample Customer Baseline (CBL). DR event usually begins with a warning signal sent by the ISO in peak times. The consumer begins load reduction immediately after the signal is received. The complete load reduction must be achieved before due time in the ramp period. The amount of load reduction is, estimated or has been previously stated in the contract signed with the ISO. The load reduction period continues at the same level until the release signal is sent by the ISO and the release period starts. After this period, consumption returns to normal.

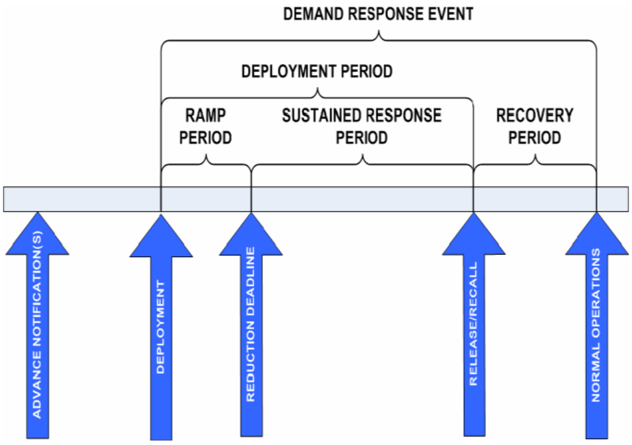

Fig-5. Demand Response Event Periods[9].

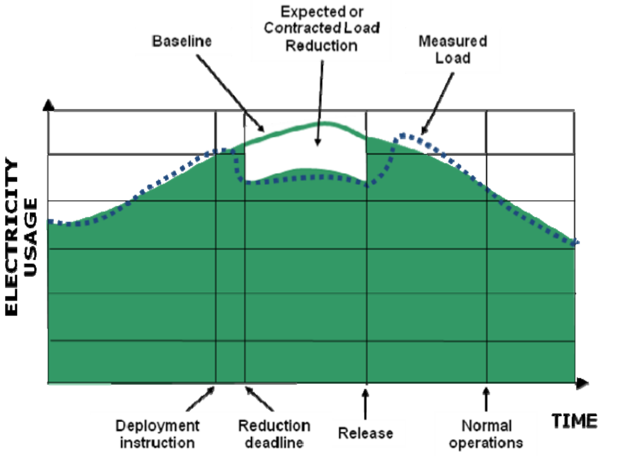

Fig-6. DR event shown on an example Customer Baseline [9].

Many DRPs are based on incentives and penalties that imposed during the DR period. Calculation of the CBL is made in various ways and is very critical for the DRPs. If CBL is calculated too high, ISO may be obliged to pay more to the consumer. If the CBL is calculated too low, lower load reduction is recorded. This case reduces consumer's willingness to participate into DR program. It is best to make an accurate estimate of the CBL for both the ISO and the consumer.

3.3. CBL Calculation Methodologies

CBL calculation methods can be divided into two groups basically. These are day matching and regression analysis methods. In day matching method, CBL is calculated by taking the average of a few days that most resemble DR event day. In regression analysis, CBL calculation is based on the consumer's historical consumption statistics[9]. There are many other methods for CBL calculation based on consumer variables (type, amount of electricity consumption, previous consumption curve, load variability etc.) and the weather conditions. In this paper, Day Matching methods will be discussed below.

3.3.1. Day Matching

A subset of past days are selected and the average of them is taken as CBL. Subset selection is done according to the specific approach. For instance, hourly average of a few historical weekends can be used for the CBL calculation on weekends.

3.3.1.1. Previous Day Approach

These methods are based on hourly consumptions of consumers in similar days. Similar days are the past days which have the same characteristics with the day that DR event take place(weekday, weekend, season or month similarity etc.) .Thus, resulting average hourly values that belong to CBL are calculated from a customer's previous and actual consumption. In Fig-7. below, average of three past similar days to the DR event day is taken in order to calculate CBL.[9].

Hour	Days Averaged to Create Baseline			Hourly
	Day 1	Day 2	Day 3	Baseline
1	1.81	1.20	1.14	**1.38**
2	1.64	1.08	0.98	**1.23**
3	1.49	0.97	0.92	**1.13**
4	1.41	0.91	0.88	**1.07**
5	1.34	0.93	0.83	**1.03**
6	1.30	0.96	0.83	**1.03**
7	1.29	1.02	0.89	**1.07**
8	1.45	1.05	1.04	**1.18**
9	1.53	1.10	0.99	**1.21**
10	1.59	1.31	1.09	**1.33**
11	1.75	1.52	1.10	**1.46**
12	1.86	1.58	1.14	**1.52**
13	2.06	1.83	1.23	**1.71**
14	2.11	1.98	1.39	**1.83**
15	2.21	2.16	1.47	**1.95**
16	2.29	2.22	1.62	**2.04**
17	2.30	2.25	1.76	**2.11**
18	2.41	2.37	1.75	**2.17**
19	2.41	2.43	1.89	**2.24**
20	2.29	2.24	1.75	**2.09**
21	2.26	2.24	1.71	**2.07**
22	2.37	2.34	1.71	**2.14**
23	2.27	2.24	1.65	**2.05**
24	1.99	1.88	1.45	**1.77**

Fig-7. Previous Day Approach Example[9].

3.4. The Role Of Aggregators in DR

Aggregators are wholesale market players licensed by the ISO and provide intermediary services between the ISO and customers. Aggregator makes DR agreements with the ISO through the total demand of customer groups. As a result of DRP, aggregator gains profit and also pays a sum of this profit to customers. Aggregator can set up customers technical infrastructure for the implementation of the DRP, and it can intervene on the customer's system in case of need[10]. In Fig-8. Possible transactions between aggregator and customer depicted[11].

Aggregators are in service in Europe and USA wholesale markets. But they are too few. Because, the job description of aggregators is not clear. DRPs announced by ISOs are the most significant factors that makes Aggregators job attractive[11].

Aggregator's role is very important for the implementation of DR. ISO prefers to deal with aggregators instead of dealing with individual consumers. In this way it is easier to implement DR.

Fig-8. Possible transactions between aggregator and customer

4. DR in Turkey

4.1.Development of The Electricity Market In Turkey

Turkey's electricity market is growing at about 9% per year. These statistics show that Turkey's electricity market is among the fastest growing markets in the world. Beginning from the early 1980s, the privatization of the electricity market in Turkey began to discuss. However, major reform process began with the Electricity Market Law which was put into practice in 2001. With this law, Turkish Energy Market Regulatory Authority(EPDK) has been established. Electricity distribution service has been divided into 21 regions and was privatized in 2012. Day-Ahead Market, one of the important building blocks for a modern electricity market, is operated by Turkish Electricity Market Financial Settlement Center(PMUM) actively since the beginning of 2012. PMUM is a sub-unit of Turkish Electricity Transmission Entity(TEIAS).

Turkey put into practice the new Electricity Market Law in 2013. EPDK, aims to create an electricity stock market, which will be managed by a newly developed company, Energy Markets Joint-Stock Company(EPIAS). EPDK prepared articles of association of EPIAS. EPIAS is a joint venture company consisting of many public and private sector partnerships[12].

Intraday market, another important building block for a modern electricity market, has just become operational in July 2015. For operation of the Intraday market, a native produced robust software infrastructure has developed. With this step, infrastructure activities for the transition to a modern electricity market were considerably completed.

EPIAS have just involved in activities actively(in September 2015). Operation of all organized wholesale electricity markets (Day Ahead Market, Balancing Power Market, and İntra-Day Market) that operated by PMUM, transferred to EPIAS.

4.2. DR Necessity for Turkey

As shown in the Fig-9. below, it is estimated that, between the years of 2013-2022 Turkey's energy demand will reach from 255 510 GWh to 418 590 GWh and peak load demand will rise from 40 600 MW to 64 490 MW[13]. So, in next 10 years period it is estimated that, the energy demand and peak load demand will increase by around 60%. In contrast, domestic generation only meets 28.5% of consumption. A great majority of the electricity is imported(70%)[14].

It is clear that, new power plant investments could not meet by this large difference. Consequently, Turkey needs to use the DSM methods to manage and reduce its energy demand. Energy Efficiency applications are in operation for many years in Turkey. In order to meet growing peak load demand, DR is the most significant alternative. Indeed, Turkey has been working seriously in DR methods to put into practice.

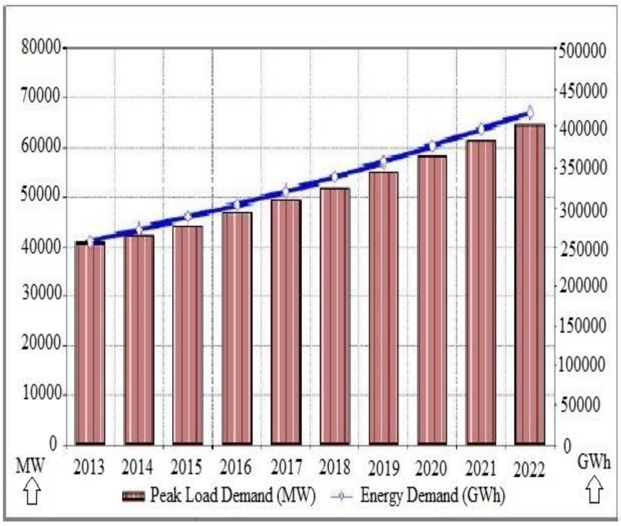

Fig-9. Turkey's Energy and Peak Load Demand Prediction (2013-2022) [13].

In recent years, Turkey is restructuring its Electricity Market at an unprecedented pace. Taken steps to the intraday market is a very important building block in the development of DR. Starting to run the intra-day market has provided the stage for the implementation of DR. Aggregators, which are one of the most important actors for DR application, began to be heard in recent times.

However, in order to enhance aggregators, and ensure they become major market actors, various precautions should be taken. These precautions are, to make their job definitions exact, to take DRP's to forefront by ISO's, to encourage customers to participate in DRP's by them. Turkey is at the bottom of the ladder in the AMI installation yet. AMI investments should be accelerated for the implementation of DR in a widespread manner.

The exposure draft of "Electricity Market Ancillary Services Directive" has been published by EPDK in July 2015. This directive shall enter into force in the coming months. The directive limits the total amount of the DR contracts to 2 GW in the first one year period. It is stated that TEIAS could draw up DR contracts with aggregators or directly with consumers. Thus, the terms of DR and aggregator will be officialized. If necessary investments will continue without slowing down, DR will find a wide span in Turkey.

5. Conclusions

In today's world, where energy consumption gradually increases, appropriate and effective use of energy has become an important issue. This situation has increased large-scale SG investments. In the last decade, application of DR, which is one of the most important components of the SG concept, is concentrated in the US and Europe. In the forthcoming years, this issue will gain an increasing popularity.

Turkey has not begun the DR applications except TOU program with an electronic meter by reason of the fact that the reform of its electricity market could not completed yet. In the new "Electricity Market Ancillary Services Directive", which will enter into force in the upcoming months, the terms of the infrastructure of DR application have been defined inclusively. In addition, relevant utility companies are increasing their SG investments regularly. All these developments show that the DR concept would find a wide application area in Turkey over the next decade.

To gain wide acceptance to DR applications in Turkey, SG investments should be accelerated, AMI should be established through pilot regions, the expansion of aggregators should be ensured, and consumers should be encouraged to participate into DRPs. But firstly, the transition to a fully competitive energy market should be completed as soon as possible. Turkey is determined to make this transition in a short time. It can be said that DR will find a large application area in coming years.

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