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# DEMAND SIDE MANAGEMENT – AN INTEGRAL ASPECT OF SMART GRID TECHNOLOGY

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## ABSTRACT

*Smart grids are considered to be the next generation electric grids. Drivers for this development are among others: an increased electricity demand, an ageing network infrastructure and an increased share of renewable energy sources. One of the most important aspects of smart grid is that it allows two way communication between the provider and consumer and enable optimisation of electricity use. While there is plenty of experience in optimizing energy generation and distribution, it is the demand side that receives increasing attention by research and industry. Energy demand management, also known as Demand Side Management (DSM), is the modification of consumer demand for energy through various methods such as financial incentives and behavioural change through education. This paper gives an overview of DSM, analyses the various types of DSM and also gives an outlook on the latest demonstration projects in this domain.*

***Keywords: Demand Side Management, Generation, Network, Optimisation, Smart Grid.***

## I. INTRODUCTION

Smart grids are considered to be the next generation electric grids. Drivers for this development are among others: an increased electricity demand, an ageing network infrastructure and an increased share of renewable energy sources. A smart grid is an electrical grid which includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficiency resources [1]. Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid. A common element to most definitions is the application of digital processing and communications to the power grid, making data flow and information management central to the smart grid.

Various capabilities result from the deeply integrated use of digital technology with power grids. Integration of the new grid information is one of the key issues in the design of smart grids. Smart grid technologies emerged from earlier attempts at using electronic control, metering, and monitoring. In the 1980s, automatic meter reading was used for monitoring loads from large customers, and evolved into the Advanced Metering Infrastructure of the 1990s, whose meters could store how electricity was used at different times of the day.[9] Smart meters add continuous communications so that monitoring can be done in real time, and can be used as a gateway to demand response-aware devices and "smart sockets" in the home.

Early forms of such demand side management technologies were dynamic demand aware devices that passively sensed the load on the grid by monitoring changes in the power supply frequency. Devices such as industrial and domestic air conditioners, refrigerators and heaters adjusted their duty cycle to avoid activation during times the grid was suffering a peak condition.

## II. WHAT IS DEMAND SIDE MANAGEMENT?

To ensure stability on the electricity grid, electricity supply and demand must remain in balance in real time. Traditionally utilities have called upon peaking power plants to increase power generation to meet rising demand. Demand-side management (DSM), which includes energy efficiency and demand response (DR), works from the other side of the equation – instead of adding more generation to the system, it pays energy users to reduce consumption. Utilities pay for demand-side management capacity because it is typically cheaper and easier to procure than traditional generation[2].

Demand-side management allows energy users of all kinds to act as "virtual power plants." By voluntarily lowering their demand for electricity, these businesses and organizations help stabilize the grid, and they are paid for providing this important service. Utilities and grid operators treat demand response capacity as a dispatchable resource that is called upon only when needed.

## III. OPERATION

Electricity use can vary dramatically on short and medium time frames, largely dependent on weather patterns. Generally the wholesale electricity system adjusts to changing demand by dispatching additional or less generation. However, during peak periods, the additional generation is usually supplied by less efficient sources. Unfortunately, the instantaneous financial and environmental cost of using these "peaking" sources is not necessarily reflected in the retail pricing system. In addition, the ability or willingness of electricity consumers to adjust to price signals by altering demand may be low, particularly over short time frames. In many markets, consumers, particularly retail customers, do not face real-time pricing at all, but pay rates based on average annual costs or other constructed prices[3].

Energy demand management activities attempt to bring the electricity demand and supply closer to a perceived optimum, and helps give electricity end users more direct price signals to adjust their usage or automated signals to change load depending on system conditions. These system conditions could be peak times, or in areas with levels of variable renewable energy, during times when demand must be adjusted upward to avoid over-generation or downward to help with ramping needs.

Adjustments to demand can occur in following ways:-

- Through responses to price signals, such as permanent differential rates for evening and day times or occasional highly priced usage days.
- Behavioural changes achieved through home area networks.
- Automated controls such as with remotely controlled air-conditioners.
- With permanent load adjustments with energy efficient appliances.

## IV. TYPES OF DEMAND SIDE MANAGEMENT

There are basically four types of demand side management. They are:-

- Energy Efficiency
- Demand Response

- Variable Renewable Energy
- Dynamic Demand

The four types of demand side management named above are explained as under:-

### 4.1 Energy Efficiency

Energy efficiency is the goal to reduce the amount of energy required to provide products and services. For example, insulating a home allows a building to use less heating and cooling energy to achieve and maintain a comfortable temperature. Installing fluorescent lights, LED lights or natural skylights reduces the amount of energy required to attain the same level of illumination compared with using traditional incandescent light bulbs[4].

Improvements in energy efficiency are generally achieved by adopting a more efficient technology or production process[1] or by application of commonly accepted methods to reduce energy losses.

The 2 main motivations to improve energy efficiency are:-

- Reducing energy use reduces energy costs and may result in a financial cost saving to consumers if the energy savings offset any additional costs of implementing an energy efficient technology.
- Reducing energy use is also seen as a solution to the problem of reducing greenhouse gas emissions.

Energy efficiency has proved to be a cost-effective strategy for building economies without necessarily increasing energy consumption.

### 4.2 Demand Response

Demand response (DR) is defined as "Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."

Demand Response includes all intentional modifications to consumption patterns of electricity of induce customers that are intended to alter the timing, level of instantaneous demand, or the total electricity consumption.

In electricity grids, Demand Response is similar to dynamic demand mechanisms to manage customer consumption of electricity in response to supply conditions, for example, having electricity customers reduce their consumption at critical times or in response to market prices.

This is a quite different concept from energy efficiency, which means using less power to perform the same tasks, on a continuous basis or whenever that task is performed. At the same time, demand response is a component of smart energy demand, which also includes energy efficiency, home and building energy management, distributed renewable resources, and electric vehicle charging[5].

There are three types of Demand Response:-

- Emergency demand response
- Economic demand response
- Ancillary services demand response.

#### 4.2.1 Emergency Demand Response

It is employed to avoid involuntary service interruptions during times of supply scarcity.

#### 4.2.2 Economic Demand Response

It is employed to allow electricity customers to curtail their consumption when the productive or convenience of consuming that electricity is worth less to them than paying for the electricity.

#### 4.2.3 Ancillary Services Demand Response

It consists of a number of specialty services that are needed to ensure the secure operation of the transmission grid and which have traditionally been provided by generators.

### 4.3 Variable Renewable Energy

Variable renewable energy (VRE) is a renewable energy source that is non-dispatchable due to its fluctuating nature, like wind power and solar power, as opposed to a controllable renewable energy source such as hydroelectricity, or biomass, or a relatively constant source such as geothermal power or run-of-the-river hydroelectricity.

Its significance depends on a range of factors which include the market penetration of the renewables concerned, the balance of plant and the wider connectivity of the system, as well as the demand side flexibility. Variability will rarely be a barrier to increased renewable energy deployment. But at high levels of market penetration it requires careful analysis and management, and additional costs may be required for backup or system modification[6].

### 4.4 Dynamic Demand

Dynamic Demand is the name of a semi-passive technology for adjusting load demands on an electrical power grid. The concept is that by monitoring the frequency of the power grid, as well as their own control parameters, individual, intermittent loads would switch on or off at optimal moments to balance the overall system load with generation, reducing critical power mismatches. As this switching would only advance or delay the appliance operating cycle by a few seconds, it would be unnoticeable to the end user. This is the foundation of dynamic demand control[7].

## V. TYPES OF DEMAND SIDE MANAGEMENT PROGRAMS

Broadly, there are three Demand Side Management programs:

- Financial Incentive
- Load Scheduling
- Energy Conservation

### 5.1 Financial Incentive

In financial incentive DSM Program, Consumer's should charge at different tariff depending upon the energy use time. Utility companies should provide the inspiring prices to consumer's i.e. high unit rate during peak load time, average rate per unit during base load time and discounted rate per unit if consuming energy during low demand period. In addition to that also provide discounted rates at week end, holidays etc.[8].

### 5.2 Load Scheduling

The electrical load schedule is an estimate of the instantaneous electrical loads operating in a facility, in terms of active, reactive and apparent power (measured in kW, kVAR and kVA respectively). The load schedule is usually categorised by switchboard or occasionally by sub-facility / area.

Preparing the load schedule is one of the earliest tasks that needs to be done as it is essentially a pre-requisite for some of the key electrical design activities (such as equipment sizing and power system studies).

The electrical load schedule can typically be started with a preliminary key single line diagram (or at least an idea of the main voltage levels in the system) and any preliminary details of process / building / facility loads. It is recommended that the load schedule is started as soon as practically possible[9].

## VI. ADVANTAGES OF DEMAND SIDE MANAGEMENT

The various advantages of Demand Side Management are:-

- Low cost of generation per unit.
- Network reliability is improved.
- Power plants demand less maintenance.
- Reduction in consumer's electricity bill.
- Enhances the national energy security by reducing the dependency on expensive import of fuel.
- Creation of long term jobs due to new innovation and technology.
- Deferring high investment to setup transmission and distribution networks.
- Mitigating electrical system emergencies.
- Reduces the number of blackouts.
- Less stress on power plant that reduces local air pollution.
- Less stress on plant results in reduction of harmful green gas emissions.

## VII. CONCLUSION

Demand Side Management is experiencing a renaissance, driven by the approaching smart power grids, micro-grids and super-grids. While micro-grids obviously need a flexible demand side to ease system operation, super-grids import this need from offshore wind farms. DSM is a strategy to save energy, reduce consumption and environment improvement. DSM is an important tool for enabling a more efficient use of available energy resources. DSM applied to electricity systems can mitigate electrical system emergencies, minimize blackouts and increase system reliability, reduce dependency on expensive imports, reduce energy prices, provide relief to the power grid and generation plants, reduce investments in generation, transmission and distribution networks and contribute to lower environmental emissions.

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