Demand Response - A Viable Alternative to Manage VRE

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Abstract— Demand Response (DR) programmes have been implemented in a number of countries around the world. In developed countries like USA and UK, demand aggregators provide DR services which are used by grid operators for balancing purposes. Utilities also design large scale I&C and Residential DR programmes to manage the distribution grid. In India, DR is still at a nascent stage of development and only a few pilots have been implemented. These pilot projects show that consumers in India are willing and able to alter their electricity consumption if adequate incentives are provided. With increasing penetration of renewable energy in the grid, DR can be a very useful tool with Utilities to enable smoother integration. In view of the potential benefits DR provides, it is imperative that an enabling policy and regulatory environment is created to enable DR to realize its full potential in India.

I. Demand response program

A. *Intrduction*

Demand Response refers to actions taken by end consumers of electricity to alter their electricity usage from their normal consumption pattern in response to directions from utilities, which could be in form of price signals or incentives provided by the distribution utilities. Whereas, a typical Demand Side Management program focuses on reducing the overall energy demand by improving energy efficiency, a Demand Response program encourages participants to reduce their demand during peak or shift demand to non-peak to ensure system reliability is not jeopardised. Whilst traditionally Demand Response programmes have has been used to reduce peak demand, such programmes can also be used to incentive increase in demand during required times (for instance during times of increased RE generation to reduce curtailment).

In a typical demand response programme, consumers willingly reduce their electricity consumption at a specific time in the day for a specified interval, when requested by the distribution utilities. Demand response programmes can be manual (as in the case of pilot carried out by ICF in Rajasthan and New Delhi) or automatic (as done by Tata Power in Mumbai and Delhi). Utilities may involve the services of demand aggregators[1] if the programme is large and manual in nature.

During times of mismatch between demand and supply, the utility may need to obtain either a quick supply response or demand response to maintain stability of the grid and to avoid deviating from the scheduled drawl of electricity. While supply response would mean injecting more/less power into the grid and may have its limitations, a demand response is considered to be more advantageous due to several factors:

(a) It smoothens the load curve and thus involves significantly lower capital expenditure compared to supply side reserve capacities

(b) It turns attention of the consumer towards possible areas for increasing energy efficiency

(c) It can help in mitigating transmission congestion

(d) Increasingly it can help in managing the intermittent supply from renewable energy based power plants especially rooftop solar.

B. *Demand respone program for managing VRE*

One of the major challenges faced by power system operators is managing the demand supply-balance in

[1] Demand aggregators are entities, which serve as the key interface between the distribution utility and consumers for implementing demand response program. Given the large number of consumers, and level of individual engagement required with each consumer, utilities often take services of demand aggregators.

electrical grids. A small variation in demand and supply could have huge implications on grid security. Increasing penetration of renewable energy power plants, especially wind and solar, poses higher degree of threat on grid security due to their inherent variability. Electricity generated from these sources, are subject to natural variability of the energy sources. In addition, forecasting wind resource and solar radiation accurately is still a developing science and not perfected. Such forecasting errors combined with inherent uncertainty in demand projection means higher reserve capacities and faster response rates are required to maintain system reliability. Add to this mix the rise of distributed generation and two-way flow of power (as against only one-way flow that system operators are traditionally used to managing) the complexity of system management at Distribution level is rapidly increasing. Some of the ways in which these challenges can be dealt with include:

- Increasing reserve capacities within the system with faster response rate: These reserve capacities can be utilized by grid operators whenever needed to balance demand and supply.
- Energy Storage: Large scale energy storage solutions like pumped hydro have been used for a long time for grid balancing. However, there are geographical and hydrological limitations to it. With the recent advancements in battery technologies and the rapidly declining costs, Batteries are very quickly becoming a viable alternative to provide a number of grid services.
- Demand response: Demand response has not received adequate attention so far in India, however as this paper explores, it can be a viable option for distribution utilities to manage their systems well. A well designed demand response program can be used very effectively wherein the demand may respond to available supply to some extent - i.e., the load follows the available supply.

A combination of all the solutions mentioned above will be required for large scale integration of renewable energy sources. Particularly demand response programs can be used effectively to manage integration of variable renewable electricity (VRE) with little or no investment.

II. DEMAND RESPONSE PROGRAM – GLOBAL LANDSCAPE

A. United States of America

Several developed power markets have adopted demand response programs and integrated them in their plans to transition to a smart grid. In USA, load management and interruptible/curtailable tariffs were first introduced in the early 1970s. Initially such tariffs were applicable mainly for large industrial customers but in many cases never used. However, since then Demand Response has come a long way and supportive Government policies have played a major role in establishing demand response as an important market tool both at wholesale markets and for Investor Owned Utilities. When The Energy Policy Act, 2005 (EPAct 2005) was enacted, it mentioned that one of the key objective of national energy policy was to eliminate unnecessary barriers for demand response participation in energy markets [1]. This accelerated development of demand response industry within the country. Today in US Demand Response programmes have moved much beyond I&C customers and there are large residential Demand Response programmes that the utilities run.

A basic concept of how energy efficiency programs or demand response programs can be integrated with energy markets is elaborated in Figure-1. It shows how different types of demand response programs can be used by grid operators for medium term (month ahead) and short term (day ahead, hour ahead and even 15 minutes time intervals) planning. Direct demand control which refers to smart system wherein utility or demand aggregator or system operator have the ability control end use of electricity can be even used for managing grid disturbance for short durations.

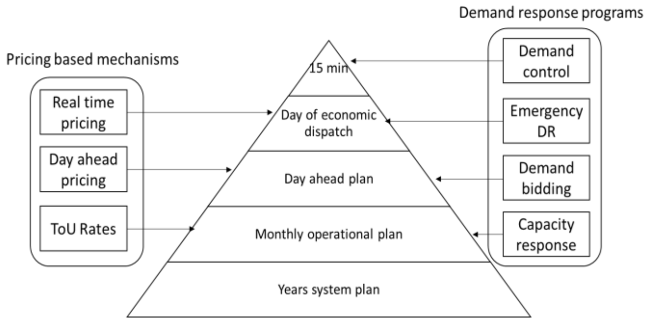

Figure 1: Types of DSM Bidding Programs

Demand response program can participate in all types of energy markets (capacity, energy and ancillary services market) as explained below:

Energy Markets: In energy markets, demand aggregators can offer (in advance) to reduce the amount of electricity expected to be drawn from the grid. These can be used by system operator as a resource for balancing demand and supply within the system. It can be done for day-ahead, week ahead and month ahead markets.

Ancillary Markets: In ancillary markets, demand aggregators have to make load available instantly at different times of notification i.e. standing-by to shed load as reserve capacity. This can help in easing transmission congestion, maintain quality, reliability and stability of power system.

Capacity markets: In capacity markets, both demand response and energy efficiency programs can participate. The demand aggregators can bid for demand reductions into the market. In this case the end consumer, will need to reduce load when required for the entire year.

In markets like PJM, in Pennsylvania, USA, which is the largest wholesale electricity market in USA, almost entire reserve capacity available with the grid operator is in terms of demand response program. Demand aggregators are allowed to participate in all type of markets– ancillary services, energy and capacity markets. In this market, apart from generating resources, demand side resources like demand response and energy efficiency programs are also available. The demand aggregators which are also known as curtailment service providers in PJM market, aggregate the demand reduction which can be provided by retail consumers. Prices for these demand reductions provided by various curtailment service providers are discovered in the market, based on which these services provider are paid by PJM. Part of these payments are shared by service providers with retails consumers depending on the agreement between them. In 2016, slightly more than 6% of total committed capacity in PJM market was through demand response program (10-11 GW) [2]. Similarly, demand response is being offered as a resource in other energy markets of USA also like NYISO, ISO-NE, MISO and CAISO.

B. United Kingdom

Other developed markets have also started showing a lot of interest in the DR programmes due to its inherent advantages discussed earlier. In United Kingdom (UK), demand response is used as resource for short term operating reserves (STOR) and frequency response. Demand aggregators enter into agreements with multiple consumers for providing temporary demand reduction by turndown/ turn-off of their electrical appliances. These cumulative demand reductions are then made available in energy markets. Many of the UK’s ancillary services are being wrapped into commercial products by a new wave of Smart Grid companies looking to deploy technologies such as energy storage and demand response. Particularly popular services include following [3]:

STOR: It has a minimum 3 MW entry capacity. Demand aggregator needs to provide relief of at least 3 MW for 2 hours and maximum response time of up to 240 minutes. However typically contracts for 20 minutes or less are required.

Firm Frequency Response (FFR): Under this programme, participants need to provide a minimum of 10MW to the grid within 30 seconds of a frequency event, such as a power station tripping out. Historically this was done by generating utilities, but now even demand aggregators are participating.

Frequency Control by Demand Management (FCDM): This helps prevent dramatic falls in frequency by automatically interrupting the demand of large consumers (more than 3MW), when frequency falls below a trigger point of 49.7Hz. This helps the system because as demand falls, frequency should increase. Once it has stabilized, the provider manually restores its demand connection. Demand aggregator or FCDM service providers needs to provide demand reduction or interrupt their electricity supply within two seconds notice for a period of up to 30 minutes.

Fast Reserve: This is used by the grid operator for controlling the grid frequency when sudden, often unpredictable, changes happen in generation or demand, for instances very low or high generation from renewable energy sources. Demand aggregators or fast reserve service providers need to start delivering the service within two minutes of instruction and reach a minimum of 50MW within four minutes. This market is dominated by pump storage businesses, which can quickly open a valve and generate the required MW extremely quickly.

C. Europe

Even in Europe, demand response is gaining in importance rapidly. With increased renewable addition to the energy portfolio of the EU market, demand response is being looked upon as an effective tool for grid management. A snapshot of the current status of demand response programme implementation in Europe and UK is provided in Figure 2 [4].

Whilst in some European Countries Demand Response is already an established commercial activity, other European countries are beginning to open it up. However, Demand Response has not received collective action from the European Countries to make it a universal and tool across the European electricity market. The European Parliament recently (September 2016) noted that the task of integrating a growing share of renewables and prosumers, and improving the mobilisation of demand response and storage, requires a combination of liquid short-term markets and long-term price signals. It calls for time-varying prices that reflect the scarcity or surplus of supply and provide incentives for storage and demand response.

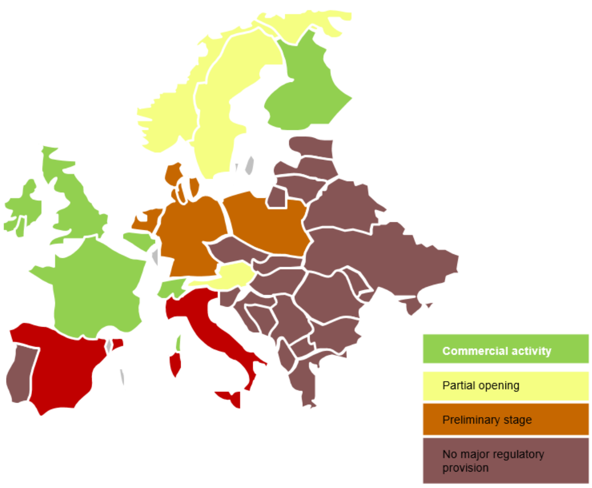

Figure 2: Status of demand response in Europe and United Kingdom

D. *India*

India has set a target of achieving 175 GW of installed capacity by 2022 from renewable energy sources, which includes 60 GW from wind power, 100 GW from solar power, 10 GW from biomass power and 5 GW from small hydro power. While this is a significant step towards achieving the country's Intended Nationally Determined Contributions (INDC) target, it also poses a serious threat on grid security if not managed properly. Grid operators will require huge amount of balancing resources to manage intermittent power from such a massive renewable energy base. Keeping in view the experience of developed countries, demand response program can be effectively used as one of the resources for managing VRE. The benefit of Demand Response is that it sits directly at consumer end and does not entail large investments.

Demand response programmes in India have so far been limited in number and impact. This is largely due to the lack of regulatory obligations on supply quality. However, Discoms, grid operators and regulators are beginning to realise the importance of Demand Response in managing the system particularly as more and more renewable energy both utility scale and distributed gets added into the system. A few Demand Response pilots have been carried out in India that have helped inform the stakeholders on the possibility of such programmes to benefit the system.

ICF Consulting India Private Limited with support from Shakti Sustainable Energy Foundation has assisted distribution utilities in the states of Rajasthan and Delhi to implement pilot demand response programmes. The main objective of these programmes was to assess consumer's responsiveness and ability to reduce electricity demand when required.

In Rajasthan the pilot project was implemented with a government owned utility – Jaipur Vidyut Vitaran Nigam Limited. During the pilot phase four demand response events were implemented in the peak summer months of April and May, 2014 through a demand aggregator. During these four events, 10 industrial consumers participated and demand reduction of 21-22 MW was achieved in each event.

The role of demand aggregator was to inform consumers about event time and obtained their consent and willingness. Consumption of each consumer was monitored using the meters installed by distribution utility and post event, an incentive of INR 2.5/kWh (20-30% of retail tariff) was provided to the participants. Figure 3 provides a snapshot of actual savings in MW achieved during one of the event as compared to baseline.

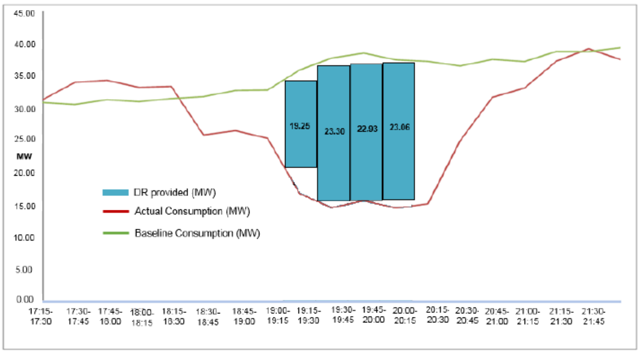

Figure 3: Rajasthan pilot project - Demand reduction achieved vis-à-vis baseline consumption

During all those four events, there was shortfall in wind generation in the state and distribution utility was drawing more than their allocated quota from national grid. As per Indian electricity grid code, this attracts penal charges to be paid by the distribution utility to grid operator. Hence the utility avoided those penal charge to the extent of demand reduction achieved.

The second pilot was recently implemented in the supply area of another distribution utility - BSES Yamuna Power Limited in Delhi, India. The objective of this pilot project was also to assess responsiveness and ability to reduce demand by mostly commercial consumers (malls hotels, offices etc.). During the pilot, eight demand response events were implemented in the peak summer months of April to June, 2017. During these events a total of nineteen consumers participated and demand reduction of 0.8-3.5 MW was achieved. Although the number of consumers were higher than previous pilot project in Jaipur, the total demand reduction achieved was lower. This was primarily because these nineteen consumers were commercial consumers and their overall electricity demand was also less as compared to industrial consumers.

Both these pilots have helped assess the potential for Demand Response in the Industrial and Commercial categories. Residential demand response still remains untested in India.

III. CONCLUSION AND OUTLOOK

There is no doubt that demand response can be used as a commercially viable tool to manage intermittent electricity supply form renewable energy sources. This has been successfully demonstrated in developed markets. With increasing penetration of renewable energy sources in developing countries also, need for such a cost effective resource for grid management cannot be overlooked. Further with increased accelerated deployment of smart grid infrastructure, demand response can also be used as ancillary resource which can be made available within minutes or seconds.

In India, it is still at a nascent stage of development and only a few pilots have been implemented. Pilot projects implemented in the country show that consumers in India are willing and able to manage their electricity consumption if adequate incentives are provided. This flexibility in demand can a very powerful tool in the hands of the utilities and system operators which can be used to provide ancillary services. This can also reduce the investments needed in generation to provide ancillary services to some extent.

Given the potential benefits it provides, it is imperative that an enabling policy and regulatory environment is created to enable demand response to realize its full potential in India. Some of these could be:

- Demand response may be included as provider of Ancillary services in addition to generating stations
- Regulatory commissions may create an enabling environment to facilitate wide-spread implementation of demand response programs
- Support for installing the required infrastructure to implement DR programs must be accelerated – support from central institutions on standardization, capacity building and finance can expedite this
- Demand response as a resource can eventually be introduced as a traded product on the exchange

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BIOGRAPHICAL INFORMATION

Gurpreet Chugh is currently Consulting Director, Energy at ICF Consulting. He has close to 15 years of experience in the global Energy sector in with a mix of consulting, M&A, business development and operations. He has structured private M&A deals in West Africa, Russia, Indonesia and India. In his professional career as a consultant, he has worked on consulting engagements for International energy majors and provided advisory services on issues across the gas value chain. He has worked in India, UK, Russia and West Africa. Gurpreet is a Chartered Financial Analyst (CFA®), has received an MBA in finance from Management Development Institute, Gurgaon and has a Bachelor's degree in Engineering from NSIT (formerly DIT), University of Delhi.

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