Commentary for RE Focus Magazine:

Reducing Peak Load and Managing Risk with Demand Response and Demand Side Management

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In recent years, it seems like everything from weather to fuel prices has become more volatile, adding new stresses to electric systems which are already running at or near their peak capacity. What has received less attention is the opportunity and value of investments that both lower demand and help mitigate price volatility in the market. This article looks at approaches to balancing supply-side investments with appropriate demand-side investments, and argues that these investments are an important and necessary factor in any well-functioning electricity system.

Rising Demand and Uncertainty

Demand for electricity is rising all over the world, both in developing and developed countries. The IEA forecasts that world electricity demand in 2030 will be over 50% higher than current demand. Part of this rise is due to rapid industrialization in China and other developing countries, but demand is also projected to rise in the OECD countries. Meeting this demand is going to require tremendous infrastructure investment, and will make meeting Kyoto emissions targets very difficult.

The electricity system in the West is complex, involving generation with a mix of fuels, transmission and distribution over large areas, and interaction with millions of customers. Any increase in capacity requires investment in all these three areas, and so this rising demand is going to be costly for all involved - customers, governments, and utilities. Since deregulation, electricity trading has made management of the system more complex, and now in Europe emissions trading is increasing the complexity and cost of meeting demand even more.

Demand Side Management Programmes

At Summit Blue Consulting, we have designed and evaluated many different demand side management programmes in the USA, most of them run by electric utilities, and almost all of these programmes have proved to be an excellent investment. There is a wide variety of programme types – from helping homeowners to replace inefficient furnaces and air conditioners to promoting the use of more efficient motors in industry. The benefit-cost ratio, from the perspective of the utility, ratepayers, and others, typically ranges from 1 to 3, but can be as high as 20. And this is just on the financial side; reductions in pollution are an added bonus. Customers get non-energy benefits too, such as equipment that works better.

Investment in energy efficiency can help to eliminate or defer the need to build new generating units. Unfortunately, in the US new generation usually comes in the form of fossil fuel power plants, which cause both local and global pollution problems, and there are now moves towards a new nuclear plant building spree. If these can be avoided, it is a benefit to everyone.

So, how much demand can be avoided by energy efficiency alone? The European Union's recent energy green paper estimated that 40% of the EU's Kyoto Protocol obligations could be met through widespread energy efficiency implementation, and electricity demand could be reduced by up to 18%. However, some momentum is needed to make this potential a reality. One reason energy efficiency is often not seen as a priority is its requirement for long-term thinking. Homeowners and property managers will often go for the cheapest option in the short term, even though there are much better options available that are more efficient and cheaper in the long term. A compact fluorescent light bulb is guaranteed to save money over its lifetime, compared to a incandescent – they use less energy for the same lumen output and last much longer – but faced with a $5 price tag versus a $1 one, most people will chose the incandescent. Utilities are in the business of selling energy, not conserving it.

DSM programs can help overcome these barriers by offering incentives and educating the wider public on their energy options. It should be noted that most of the DSM programs being run by large public utilities in the USA have been implemented due to regulatory requirements (Strangely enough, smaller private utilities are much more likely to implement these programmes, as the owners have more say in the running of the utility and they are keen to mitigate costs and risk). Therefore, in order to increase these programs the regulation requiring them needs to be more widespread and more consistent.

Peak Demand Management

Demand side management reduces overall demand, but there is also the problem of peak demand management. Crises in which supply does not meet demand can arise for many reasons – extreme weather (i.e. very high demand), plant outages or transmission line failures (i.e. not enough supply) – but since deregulation, these crises have also been brought about because of electricity trading and fuel price spikes, as was seen in California in recent years. These crises can make emissions per kWh used rise because the units which are brought on line to meet the extra demand are the least efficient ones, which are not usually run to meet base load. In addition, starting up generation for a short period is much less efficient that keeping a unit going at a regular output rate. At these times the spot market will respond to the demand/supply ratio and then the utility will end up paying much higher prices for the traded electricity.

At critical times, ISOs (Independent System Operators), which manage the grid, can meet the extra demand by bringing more generation on line (if it is available), or by importing energy from another region, or by calling on customers to reduce demand – which is where demand response comes in. Demand response programmes allow a certain amount of load to be reduced for a limited number of hours, so avoiding the need to supply that load in an expensive and/or inefficient way. They have been run successfully in many areas of the world, and been have shown to be surprisingly reliable, so much so that utilities count the capacity of the most reliable programs as spinning reserve.

In recent years technology developments have made a new generation of demand response programs viable. While there have been few DR programs that have achieved a significant capacity in Europe (100 MW or greater), DR is being more aggressively pursued in North America, with a large number of DR programs being implemented by both public and private entities that exceed several hundred MWs each.

Demand response can be implemented through several mechanisms. Some are financially-based and load curtailment is voluntary, based on the current electricity price and the customer's response to it. Some are only called on in emergencies, and involve large customers such as aluminium plants. Some are based on direct load control, where power to equipment such as AC is controlled by the utility; these programs are not voluntary once the customer is signed up. The reduction in power to the equipment is guaranteed not to last more than a maximum time limit (usually eight to twelve hours).This type of program is the most reliable but the most costly to set up because of the equipment needed at the customer site.

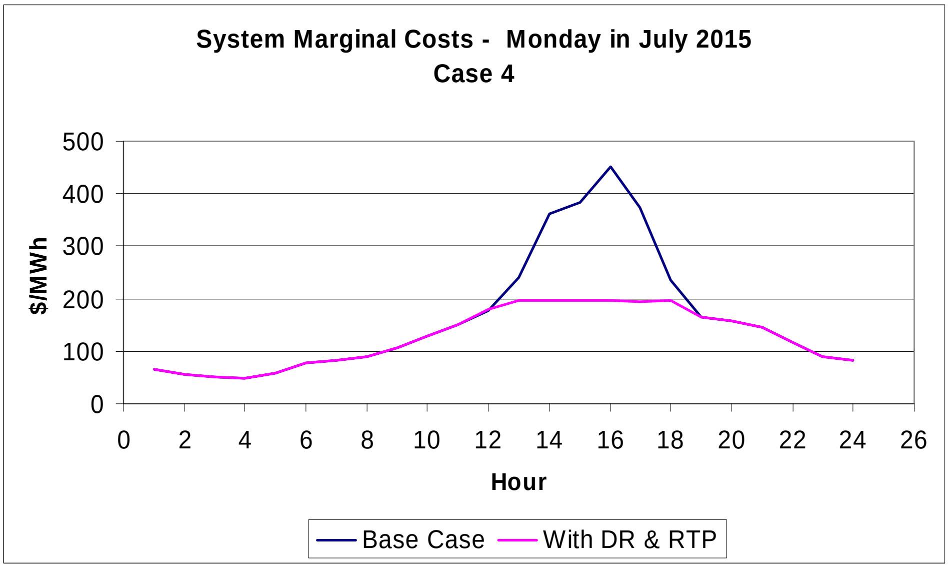
Another type of demand response program is real-time pricing, which helps to reduce peak demand by changing customer energy-use habits. Customers who are signed up for this program are charged a variable rate (it usually changes hourly) for their electricity, and this price is linked directly to the market spot price. Those who manage their energy use well, by switching as much as possible to non-peak (i.e. cheaper) times will benefit from the scheme, and if a high enough percentage of customers do this, it can change the load shape for the whole region. It also helps to reduce total energy usage, but by a much smaller percentage.

Estimating the Benefits of Demand Response

Summit Blue recently participated in a modelling effort to develop new ways of valuing the benefits of demand response. This was done as part of the International Energy Agency's Demand Side Management Programme, Task XIII, established to evaluate demand response practices from around the world and develop recommendations on best practices for integrating demand response into regular market activities. The results of the modelling, although preliminary, were encouraging.

The Strategist® (from New Energy Associates) planning model was used, which was used to model a sample electric system, including four different demand response programs. First runs of the model, over a 20-year time frame, showed that among other benefits, the addition of demand response programs to the system meant that the demand could be met without building new generating capacity. This turned out to be somewhat of a detriment as older units were not replaced with newer, more efficient units, but the model can be adjusted to take care of this problem. The growth in overall system costs over the 20-year period was reduced by approximately 5% due to the demand response.

In addition, the presence of demand response in the system reduced the "peakiness" of hourly system marginal prices, as can be seen in the graph below. This graph shows a peak day from a month in which a stress was created in the model by scheduling outages at several major generating units at the same time. The demand response mitigated the effect of the outages and would have saved approximately $M 24.5 on that day alone through the whole system.



Finally, the demand response increased system reliability. It reduced loss of load hours by at least 80% in all of the years, and greatly reduced the need for emergency energy (energy imported from other regions). These reliability benefits were not quantified in terms of dollars, but it is estimated that their value could be much greater than the savings in system costs.

Evaluations of demand response programs have shown them to be very cost effective. However, their benefits tend to come mostly during low-probability, high-consequence events, such as the 2003 blackouts in the Eastern US. In countries with a high share of renewables in the electricity mix, especially wind and solar which are not controllable, DR can be extremely valuable on days where there is either not enough or too much wind (when turbines have to be shut down), or there is low solar irradiance. If a system cannot meet demand, the resulting loss of load can be extremely expensive for both customers and utilities, but these situations are difficult to predict. In general they have happened every five to ten years, but when they do happen having the demand response in place can save millions of dollars and justify the program's existence.

New Possibilities

With electricity systems under stress around the world, and more stress predicted for the future, I believe that DSM and DR programs are going to play an ever-more critical role in electricity system management. They could also be combined with renewable energy and/or distributed generation programs to increase their effectiveness. At Summit Blue we have extensive experience in working with utility DSM and DR programmes and they have proved to be a very effective way to increase efficiency in all sectors of the market – residential and commercial. They can also be used to help low-income customers have a safer and more comfortable home environment without increasing their energy bills.

Reducing our energy use is not usually a high priority for most of us living in the West - our electricity bills are not a significant part of our monthly budget - but as the prices of fossil fuels are predicted to continue to rise, this could change in the future. As emissions trading starts to have more of an effect on the market, these types of programmes could help to tip the balance in favour of conservation. And then the benefits of any new renewables capacity which is added to the system will be greatly increased as the power which is generated will go a lot further.