NETWORK OPERATION

Flexibility for the future

Members of the Power Potential team at a solar farm
Photo: UK Power Networks

As renewable energy expands across the UK, greater coordination is needed between the electricity system operator and distribution networks. *Dr Rita Shaw*, CEng MEI explains how a new reactive power market could help.

In November 2019, a solar plant in the UK managed what seems like an unlikely feat – it generated and supplied electricity at night. This was an achievement of the Power Potential project, a trial between electricity distribution network UK Power Networks and the National Grid Electricity System Operator (ESO), which aims to design a new market for reactive power.

Distributed dilemma

The last decade has seen a huge rise in the volume of distributed energy resources connected to the electricity network. Gone are the days when power generated by large, carbon intensive resources was carried long distances into people's homes. UK Power Networks now has more than 7 GW of distributed energy resources connected to its networks in London, the South East and East of England. That's almost as much as the UK's entire nuclear power output – the majority of this energy is renewable and it was connected at a fraction of the time and cost.

However, this huge rise in renewable energy presents new challenges for electricity networks to overcome. Capacity on the network for new generation is finite, but the demand for more renewable generation to help the UK meet its net zero targets isn't going away. We need to cut the cost of getting more renewable generation connected to the network, optimise the capacity of our existing infrastructure and help generators establish new income streams by providing us with products and services to manage the network.

UK Power Networks was the first electricity network to establish a standalone Smart Grid Development Team to facilitate our move from distribution network operator to distribution system operator – a transition that requires that we optimise power flows across an increasingly complex network.

The topology of South East England's transmission system, and its generation mix, make this area of the network extremely challenging to operate, particularly when it comes to voltage management. As a result, there are constraints on capacity for new generation. The reasons for these restrictions are twofold.

First, as electricity usage become more efficient, underlying demand falls, particularly at times when local generation increases. This means the net power demand reduces at the interface between the transmission and distribution networks at certain times, particularly overnight or at the weekend. Combined with the electrical properties of the electricity networks, this has led to a change in reactive power flows and high voltage conditions on the transmission network.

Second, if a fault occurs on the transmission system, a rapid reactive response is required to boost the voltage to maintain network security on the transmission system.

The general shift in balance of generation from transmission to distribution means the national system operator has fewer levers to manage voltage and system stability. By using generators on the distribution network to deliver voltage control, co-ordination between the generators and network operators can change local generation to actively contribute to network operation.

Once proven, this new source of voltage control from local generation could supplement the current system of voltage control from larger generators operating under the Grid Code, as well as from asset-based solutions such as shunt controllers, which traditionally have long lead times.

This is why we established Power Potential, a world-first project that could save energy consumers over £400mn by 2050 and enable connection of up to an additional 4 GW of low carbon generation in the South East of the UK. The four-and-a-half year project, which commenced in 2017, aims to test a new reactive power market for distributed energy resources (DER) and generate additional capacity on the network. It will increase system flexibility by using DER capabilities to support the transmission network without compromising distribution.

Complex networks

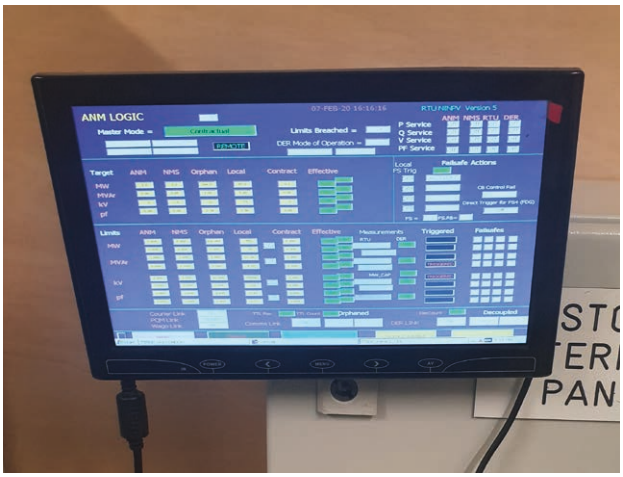
The project is based in the South East region of the UK, where the connection of distributed energy resources has grown rapidly, and interconnectors contribute to significant and complex power flows on the transmission system. Power Potential is setting out to give the system operator a control tool to manage system voltages in the region by working in collaboration with a DNO.

The trial is much more than just a concept. The philosophy of this project is to create an automated solution, which technically and commercially enables our network to dispatch active and reactive power services to the national transmission system without compromising safe network limits.

It meant integration of a unique Distributed Energy Resources Management System (DERMS) with our operational network management system, PowerOn, which keeps power flowing for our more than 18mn customers. Power Potential is not just a theoretical proof-of-concept to be transferred to our business-as-usual systems later, but a project which proves that integration is possible now. As part of the foundation for a potential future roll-out, this is so much more valuable and challenging to deliver.

For the trial, we have also temporarily altered all the customers' connection agreements and implemented business processes for oversight by the transmission and distribution control room engineers.

Overall the project achieves seamless integration of 20 systems and interfaces from multiple technology suppliers. It goes beyond the PowerOn system in our control room, both upstream to National Grid's Platform for Ancillary Services (which selects required service), and downstream to generators. The generators declare their service availability via the DERMS web interface, which the system then delivers in real-time via UK Power Networks' upgraded remote terminal unit at site and the customer's generator controller.



Energy is moving towards a digitalised future – customer interface panels will become the norm

Photo: UK Power Networks

The crucial thing about reactive power is that it acts on voltage on a localised basis, unlike active power, which affects system frequency, whether it's being generated in Dundee or Dartford. It means the distribution networks are key to enabling reactive power services, putting the onus on the national and regional systems to work together to coordinate the service delivery and optimise capacity in the whole system.

Commercially, the project will offer tangible benefits to customers, who will generate income based on participation in the trials. Solar developer Lightsource bp is among our early adopters. In November 2019, the firm's solar plant in East Sussex delivered reactive power at night, generating national headlines.

Lightsource bp implemented the functionality in the solar power plant controller and inverters to operate in voltage droop control rather than at a specific power factor. The plant can thus automatically respond to the local voltage and to voltage set-points issued by DERMS, to modulate reactive power output in response to these. This paves the way for solar farms to deliver a useful reactive power service even when there is no sun to produce active power.

Live integration was proven with Lightsource's solar plant in the commissioning test in March 2020, just before COVID-19 lockdown. We are now preparing to restart commissioning work with other customers. In the initial trial with each customer, we will show a simulated voltage requirement at transmission, which will translate into instructions at the generator. Subject to commissioning completing over the summer, the revenue opportunities from our full trials are due to begin in September.

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So, apart from generators providing these services to get a new stackable revenue stream, who else stands to benefit from this new market for renewable energy? A new and more efficient tool for managing transmission voltage control benefits every bill payer. And if you have a plant in development that isn't yet on the network, you could get a cheaper and quicker connection.

Changing network operation

Power Potential has already delivered a template to help network operators integrate more distributed energy resources via the DER Interface Schedule we have developed. The team has undertaken extensive lab and on-site testing with generation customers to work out how to integrate their hardware and software with both the distribution and national system control rooms.

The work to integrate Power Potential into our control room is shared and co-ordinated with development of our Active Network Management system (ANM). That means it's far more than an isolated trial, it's part of a series of long-term changes to the way our network operates.

Power Potential provides a template for a day-ahead procurement approach, and it maximises available reactive service based on the status of the distribution network. A fully-fledged reactive power market is closer, but we're not quite there yet. The industry needs to work together to resolve outstanding issues as we continue our journey towards net zero. What will the commercial terms be and how will these new activities be regulated in the next transmission and distribution price controls?

The trial has a requirement for DER to respond within a certain timeframe. Is there anything we can do for those who cannot meet the response speed requirement? Can we learn from other services or ways of procurement to make it easier for distributed energy resources to participate?

At UK Power Networks, we want to be as transparent as we can about the products and services we offer to enable as many generators as possible to offer as many services as possible. Power Potential is one of the brightest sparks helping turn that vision into a reality. ●

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