TRANSMISSION AND DISTRIBUTION

Making connections

The number of renewable generators feeding power to the UK grid, at both transmission and distribution level, is growing all the time. Meanwhile, the number of electric vehicles on the road is rising rapidly. *Andrew Mourant* looks at how the network is adapting to a new normal.

The UK's power network is under stress. As well as the traditional movement of electricity from large power stations to users, the country increasingly relies on electricity for transport and heating, and renewable energy suppliers need to feed in the power produced by their solar panels and wind turbines. In recent years, the falling costs of renewables have accelerated the decentralisation of power supply, resulting in more complex flows of electricity.

The network is being asked to do things it was never built for. Simply extending or reinforcing it takes a long time and involves major investment. Adjusting to a world where much more energy is generated locally and connected directly to distribution networks requires creative thinking.

There are big demands on the UK's three *transmission* companies. These despatch electricity from power stations to 14 *distribution* network operators (DNOs), which then deliver power to users. A flavour of the challenges ahead for everyone is contained in the five-year business plans of companies such as National Grid Electricity Transmission (NGET) and Scottish and Southern Electricity Networks (SSEN).

Scottish approach

Few parts of the UK present more conundrums than the wild terrain of northern Scotland, where transmission company Scottish Hydro Electric Transmission – part of SSEN – is responsible for transporting power. The license area is made up of more than one quarter of the UK's land mass and must incorporate electricity generated by onshore windfarms and hydropower stations, as well as other conventional sources.

In its business plan for 2021–26, *A Network for Net Zero*, SSEN says that a minimum expenditure of £2.4bn is essential to maintain and grow northern Scotland's network. Delivering a clear pathway to ensure the country is on track to achieve carbon neutrality by mid-century will likely cost even more. Smart, flexible grid networks will be an essential part of the transition.

Among the looming capital outlays is a project that would see a 49 km-long overhead line rebuilt in Argyll. The existing line dates from 1960, and the condition of its towers, fittings and foundations is deteriorating. Addressing this will involve confronting a broader problem for SSEN – much of its infrastructure lies in a marine environment where salt causes materials to degrade more quickly.

At the end of 2018, around 15% of the UK's installed renewable generation capacity came from northern Scotland. By 2020, SSEN expects 8.1 GW to be connected to the transmission system. Just six years later, it anticipates an additional 3 GW will have come online – mostly offshore wind in the Moray Firth and near the Firth of Forth.

SSEN is also a distributor, operating in northern Scotland via Scottish Hydro Electric Power Distribution. There, as elsewhere, in the UK, the surge in output from renewables can put safe and secure operation of the network under strain. Problems include a decline in performance – either in the forms of reduced voltage or sudden large changes during periods of heavy loading. SSEN has responded by investing in specialist equipment that offers voltage support at key sites.

There are also power quality issues, such as flicker and harmonic distortion. SSEN uses equipment including filters to remedy this. According to the company, closing fossil fuel power stations has exacerbated the difficulties. Their loss reduces the system inertia and also weakens the response to a 'black start' situation (in which the network shuts down, in whole or in part, and needs rebooting). Historically, gas or coal power stations would have been used as part of restart operations.

Substations are designed to operate for a limited time without mains electricity, using batteries or diesel generation. These backup measures are essential to maintain security of supply during a black start or other interruption in the local network. During 2021–26, SSEN plans an upgrade to enable substations to run 120 hours without mains supply.

The company is preparing to support flexible network solutions that will allow low carbon technologies to grow. It plans a technical review of substations to see how suitable these are for energy efficiency measures and for adopting microgeneration.

Preparing for EVs

National Grid Electricity Transmission is braced for a £7bn expenditure for the five years from 2021 to 2026. It intends to renew or modernise up to 19% of its assets, as most of its network was installed in the 1960s and 1970s. Plans also include completing major electricity cable projects in London, Sheffield and north Wales; replacing 1,850 km of fibre optic cable; and improving the resilience of IT systems to cyberattack.

NGET sees the potential for a further 37 GW of offshore wind and interconnectors to be developed off the east coast of England in the next 10 to 15 years. This is good news, but it comes at a price – expansion could require a high number of cable route corridors, onshore substations, converter stations and reinforcements to the existing onshore network.

To address this, NGET says the onshore transmission network could be built around the east coast, reducing the number of circuits required. This could be achieved

Engineers carry out high-voltage transmission system maintenance in Wales

Photo: National Grid Group

Pandemic response

Six months ago, few would have predicted that lack of demand might become a headache for the power industry. Yet COVID-19 and lockdown left National Grid grappling with the conflicting needs of maintaining stability in the network while keeping suppliers on board.

In May, UK electricity system operator National Grid ESO announced that it wanted power stations to reduce output. Among its measures was to strike a one-off fixed-term contract with EDF to cut production from its Sizewell B nuclear power station. This, says NG ESO Chief Engineer and Head of Control Roisin Quinn, is 'a cost-efficient and secure outcome for consumers'. It also gives extra options to ESO control room engineers to manage system stability, frequency and voltage.

For small-scale renewable generators (some connected locally rather than to the high voltage transmission network) NG ESO has devised what it calls 'optional downward flexibility management'. This voluntary service will see householders receive payments if asked to reduce or turn off their renewable supply.

Already, wind farms are paid to switch off when the grid cannot take their power. These constraint payments have been running since 2010 and have caused controversy as the amount charged by wind farms greatly exceeded the value of the subsidies they sacrificed, such as Renewable Obligation Certificates.

However, another use beckons for surplus power produced by renewables. Technology firm Ryse Hydrogen plans to build electrolysers that will produce hydrogen fuel on a large scale for buses, lorries and cars. The process will use excess wind energy not needed by the grid. Ryse has submitted a planning application to construct what it claims will be the UK's biggest electrolyser at Herne Bay, Kent, linking to the offshore Kentish Flats windfarm.

through expanding the existing network via a new loop of circuits to shore, as well as providing connection sites for current offshore wind, interconnectors and future projects. Costs would be minimised and there would be less need for disruptive onshore construction. The price, according to NGET, would be between £3bn and £5bn, and deliver considerable net benefits for consumers.

Undoubtedly there will be further pressure on the network should a market for electric vehicles take off. NGET thinks this this could be met largely through a network of ultra-rapid points at motorway service areas. Government says it wants to see six such charge points (150 kW–350 kW capable) at motorway service areas in England by 2023. This figure should rise rapidly to 2,500 by 2030 and 6,000 by 2035.

NGET believes the most economical solution is to plan for a future where there is no liquid fuel. The alternative is to deploy infrastructure after the number of EVs rises, with all the costly and disruptive work that would go along with it. Thus far, NGET has identified over 50 sites along the strategic road network, where an upgraded connection would put 95% of EV drivers in England and Wales within 50 miles of an ultra-rapid charging station.

Increased complexities require a collaborative approach with DNOs. NGET is preparing to spend £105mn from 2021–26 on low-voltage substation re-builds, due to the higher levels of fault associated with distributed generation. It is committed to replacing, rather than refurbishing, transformers, claiming this makes better long-term sense for consumers.

Smart and self-reliant

As an alternative to costly new infrastructure, with all the upheaval that brings, IT solutions – particularly smart grids – are evolving. The distribution arm of Scottish Power, Scottish Power Energy Networks, (SPEN) is well into the second year of a five-year trial which it hopes will yield new ways of smoothing out supply and demand. Backed by Ofgem, which has contributed £5mn, Project Fusion is being piloted in East Fife, an area with energy sources including onshore and offshore wind, and hydrogen storage.

East Fife can be seen as a microcosm of the problems that exist across the UK. The local distribution network is grappling with unforeseen increases in load growth and being pushed to its limits. As a rising number of customers struggled to connect their solar and wind- generated power to its network, SPEN faced a time-consuming and costly reinforcement.

Fusion is all about exploring the possibilities for flexibility within the local market. The carrot on offer is financial reward for those signing up to a scheme that seeks to devise a better balance of generation and demand. An online interactive platform will be created where SPEN will advertise local network requirements to the power-creating market. Groups of small-scale generators represented by aggregators, or larger operators, can respond to those needs by bidding to sell their available capacity.

By getting them to adjust to a variable neighbourhood demand, SPEN hopes stave off any need to build new grid networks that otherwise could be needed to support electric vehicles, local electricity generation and heat pumps. The aim is to create a new competitive marketplace where communities can take control of demand and supply of electricity. Partners include Fife Council and the University of St Andrews.

As the UK moves toward a future powered by renewables, a degree of decentralisation is inevitable, and even desirable. All stakeholders, from householders to network operators, must be prepared to embrace their evolving role in power transmission. These changes cannot solely be enacted from the top down.

National transmission, local distribution

The transmission network sends high-voltage electricity from sources of production to distribution network operators. These, in turn convey power to industrial, commercial and domestic users.

Three transmission operators run and maintain the system. These are National Grid Electricity Transmission (NGET) for England and Wales, Scottish Power Transmission for southern Scotland, and Scottish Hydro Electric Transmission for northern Scotland and the Scottish islands.

The system is made up of wires extending across Britain and offshore waters. National Grid Electricity System Operator (NGESO) has overall responsibility for ensuring the network remains stable and secure.

Most users taking power are connected to distribution networks. There are 14 licensed DNOs in Britain, each with regional responsibilities. These are owned by six groups: Electricity North West; Northern Powergrid; SSEN; SPEN; UK Power Networks (covering mainly London the south east and eastern England); and Western Power Distribution.