Convergence: The Future of Digitally Enabled Microgrids
Transmission and Distribution Networks are heading towards a seismic transformation; where our future energy systems will be digitised, decentralised and decarbonised. This means that the future network operators are expected to support different types of customers from commercial aggregators, grid-scale renewable generation, storage operators and flexibility service providers, connecting them to market revenues and incentives.

The Future Microgrid, in its convergence with primary networks, will deliver a digitally enabled decentralised energy system harnessing localised demand management, renewable energy generation, storage and flexibility. To enable this market transformation, the structure and governance of our electricity networks must change to enable greater convergence between Microgrid operations with that of the local network. Once, networks played a simple, static role: taking power from the main electricity grid and delivering at an appropriate voltage level to consumers. Increasingly, the expectations of both the regulators and customers alike is that electricity distribution network operators need to be seen to be playing a more active role in not only helping to balance the UK energy system, but also in helping to shape the future market transition.

Renewable energy generators such as wind and solar farms, battery storage and biomass are now embedded, privately owned and operated assets within our electricity transmission and distribution systems. Many large industrial and commercial sites from factories and data centres, to healthcare, public buildings and university campuses, now incorporate their own power generation and battery storage systems. Consumers both large and small are fast becoming “Prosumers” by choosing to generate and store more of their own power through low carbon technologies.

These new “Prosumers” are starting to see the financial and environmental benefits in new digital automation hardware and software solutions which can manage energy consumption in real time, and in harmony with that of their own renewable energy generation and storage capabilities.

Convergence with the Microgrid

Small-scale power generation, and distribution systems that operate in isolation from the main electricity grid have existed for decades. Normally, they operate in areas where connection to the primary grid is technically or economically unfeasible, such as remote islander communities.

Today, however, there is a growing demand for the development of Microgrid solutions in both industrial and commercial, high energy user sectors. In these sites, a Microgrid could comprise various distributed energy resources within a local electricity power distribution network. Distributed Energy Resource (DER) assets such solar photovoltaic, wind, battery storage, combined head and power and bio diesel generator units, are monitored and controlled through a remote software platform which can automate the balancing of the different energy inputs and outputs with that of local loads and demand.

The future Microgrid is inextricably linked in its ability to control and automate local power flows in convergence with local network management. In this future, the Microgrid’s primary role, is still to reduce reliance on power delivered by the network operators, but now extends to the real-time balancing of connected, distributed energy resources with that of the local grid to deliver demand flexibility.
Earlier insights of the future Microgrid were centred on their seamless operation, whether connected to the grid or in isolation (island mode) from it. However, when considering the needs of our future energy system and market; the Microgrid system is one of the key technologies in the growth of regional and local flexibility services. This contrasts with the network companies and Ofgem, whose role it is to enable the connections of Microgrid and other low carbon solutions whilst maintaining reliable supplies, avoiding unacceptable price hikes and facilitating market participation in flexibility. This convergence between Microgrid technologies and that of network companies is in delivering seamless flexibility, where it is in the interests of both the network operators and customers alike to exploit opportunities in local balancing of demand, use, generation and storage.

Consequently, after what has been a quiet spell for proponents of Microgrids; industry, businesses and communities are once again becoming interested in the opportunities of a digitally enabled, decentralised energy system, which provides:

**Security of energy supplies.** In the event of a failure of supply from the primary network connection, Microgrids can switch to island mode to keep local loads maintained and vice versa.

**Tackling climate change.** The ability to optimise the use of low-carbon energy generation and storage, such as wind and batteries, to meet net zero targets.

**Reduced costs for customers.** Sites with renewable energy capacity, or which can generate power as a by-product of other processes (e.g. using methane produced from the anaerobic digestion of biomass in water treatment plants), will want to rely on their investments to deliver reliable energy for their use.

**Access to flexibility services.** Industry, businesses and communities, can have their energy use automated and controlled in a platform solution enabling their participation in emerging energy flexibility markets, helping to maintain network reliability, and access new forms of revenues.

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**Technical Challenges**

Microgrids require **control systems** not too dissimilar to those used in conventional power distribution systems, and ensuring the following is maintained:

- Demand is always balanced by the power supply.
- The voltage within the Microgrid is always kept within certain defined limits. This is especially critical when the Microgrid is operating in island mode.
- The frequency of the Microgrid is always kept within its limits. Again, this is critical when the Microgrid is operating in island mode.
- Control of the DERs to ensure flexibility, Demand Side Response (DSR) and ancillary services participation at peak requirement.
- Control of the loads, for example by implementing curtailment and or load shedding when demand cannot be met by the distributed generation within the microgrid.
- Maintaining frequency synchronisation of the microgrid with that of the electricity distribution network.
- Automating the balancing of loads between micro energy networks with that of the local grid, to maintain supplies and optimise market participation.

The challenges above call for a new level of intelligent system automation and control through the system integration of energy networks, loads and distributed energy resources. Where automated decision making simplifies control of the Microgrid to support the balancing of local loads, ensuring DER assets are fully utilised and that system management optimises energy market participation.

**Fig 1: Cross sector alignment**

Source: https://www.energynetworks.org/info/modernising-energy-data.html
The good news for both Transmission and Distribution Network Operators, who will become the TSO’s and DSO’s of the future, is that the technology needed to control and automate the convergence of Microgrid systems with the local electricity network is becoming much more accessible. In part, that’s thanks to the innovation in the conventional power distribution sector, which is adding additional digital intelligence and automation at the substation level to improve network visualisation and control. Innovation in the sector has contributed to the development of sophisticated, highly autonomous control hardware and software solutions for industrial users, renewable energy developers, investors and community-level groups, in delivering the technology to enable wide-scale participation in flexibility helping to balance the network.

The future vision for Microgrids is one where it plays a pivotal role in creating demand for local energy systems which are active participants in the operation of local networks energy market, delivering attractive returns on existing and new assets; such as back-up generation, renewable energy and storage whilst providing greater control over supplier costs.

With over 50 years of control and systems integration experience in the power generation, transmission and distribution sectors, Capula is the perfect technology partner in the implementation of digital control and automation systems to both enable Microgrids and participate in the new flexibility markets. We are experts in systems integration and in the design, implementation and support control and automation systems installations ranging from Nuclear facilities, Transmission and Distribution networks to industrial and commercial sites.

Our solutions start with energy and asset visualisation platforms and extend to encompass automation for the most demanding critical network infrastructure. We believe that innovating in digital solutions enables distributed energy resources both existing and new to provide services that balance, support and optimise the operation of the network. Our Microgrid control and automation technologies help our industrial and commercial customers access additional revenue streams through the ancillary markets and furthermore, as part of the EDF group, we have the benefit of being able to extend the services and innovation opportunities available to all our customers.

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