Transforming the low voltage grid.

Managing the impact of low carbon technologies.

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Introduction

The transformation of the energy system to support the introduction and scaling up of low carbon technologies (LCTs) is putting pressure on the grid as never before. As we get ready for a future with far greater use of solar power, electric vehicles, electric heat pumps, and micro-combined heat and power systems as well as battery storage, we face a new reality. The more LCTs that are connected to our network, the greater the burden on the low voltage (LV) grid.

The increased demand and use of renewable energy resources have made monitoring a priority at all levels – not just high and medium voltage. Matching the ever-increasing demands on the LV network is not optional – but the vast scale of the LV grid means that the potential financial burden would be exponential without innovative, cost-effective approaches that can both minimise carbon emissions and disruption to consumers. We examine the progress to date, how we got here, and what we need to do next to keep our LV network working.

2050

UK MUST BRING ALL GREENHOUSE GASES TO NET ZERO

1.5°C

NET ZERO WILL LIMIT GLOBAL WARMING TEMPERATURE

The UK's decarbonisation journey

In 2008 under the Climate Change Act, the UK government set the 2050 target of cutting greenhouse gas emissions by 80% compared to 1990 levels, mindful of the growing evidence of climate change. But with concerns that this legislation didn't go far enough, in June 2019 the UK became the world's first major economy to pass laws to end its contribution to global warming by 2050 – referred to as Net Zero 2050.

This new target means that the UK must bring all greenhouse gas emissions to net zero by 2050, upping the ante considerably. The Net Zero target is to limit global warming to 1.5°C, as any further rise in temperature would represent a catastrophic disaster, according to the UN.

Decarbonising the energy sector and LV

Cleaning up the energy sector has meant that finding viable alternatives to fossil fuels became a priority. Huge leaps in the development of key clean energy technologies have been made in recent years, with the need for sustainable energy acting as an accelerant: solar energy, offshore wind, energy storage, EVs and distributed generation have all come to the forefront of the energy sector's combined efforts.

The ability of the LV network to support the decarbonisation of transport is a central concern, even more so since the UK government announced in February 2020 that, subject to consultation, it would ban the sale of new petrol, diesel and hybrid cars from 2035, five years earlier than the originally planned 2040 cut-off point.

Thanks to digital channel shift, energy networks are now using new tech to manage the network, and consumers are increasingly engaged as 'energy citizens,' reinforced by the roll-out of smart meters. As a result, LV monitoring has enjoyed a big boost: customers' smart meters are remotely readable, and smart measurement devices developed for secondary distribution substation can be used to improve LV network monitoring and management. However, the challenge of low voltage monitoring at scale has not yet reached the same level of attention as HV monitoring, having traditionally not been monitored at all.

A watershed in monitoring further down the hierarchy than HV and MV took place around 10 years ago, evidenced by a European initiative to extend monitoring: FP7 European project INTEGRIS (2010-12). Up to this point, distribution network monitoring was focused on primary substations operating at high and medium voltage levels. The rapid growth and penetration of distributed energy resources in LV grids triggered interest in extending the real-time monitoring to LV level. FP7 European Project INTEGRIS proposed an integrated real-time LV network monitoring solution and implemented it in a cost-efficient way.[1]

[1] *Lu, Shengye & Repo, Sami & Della Giustina, Davide & Figuerola, Felipe & Lof, Atte & Pikkarainen, Marko. (2014). Real-Time Low Voltage Network Monitoring-ICT Architecture and Field Test Experience. IEEE Transactions on Smart Grid. 6. 10.1109/TSG.2014.2371853*

Tackling the LV issue

Making the energy network smarter while accelerating the development of a low carbon energy sector and delivering savings to consumers was never going to happen without significant investment. In the UK, Ofgem funding facilitated a number of innovation projects to kickstart progress towards the UK's low-carbon future. The Low Carbon Network Fund (LCNF) started its work in 2010 and was initially intended to run till 2015, with some projects extending beyond that.

Understanding the impact of LCTs on the LV network and considering possible solutions was an objective for several initiatives. One LCNF project which EA Technology partnered on the Customer-Led Network Revolution (CLNR), led by Northern Powergrid which put LV monitoring in the spotlight. Its **Enhanced Network Monitoring Report** stated the endemic LV knowledge gap at the time (2014):

Secondary Transformer

Most secondary transformers are not closely monitored. It is typical for ground-mounted substations to include a basic, low accuracy but low cost maximum demand indicator (MDI - mechanical, analogue dial with a manually reset high-set needle), which records the peak current, usually averaged over a 30-minute period, on each of the transformer's LV phases. These readings are not taken back to the electricity companies control room in real-time. Readings will typically be taken when the substation undergoes its annual inspection, at which time the MDI is reset. It is not typical for pole-mounted substations to be monitored.

LV Feeder

Not typically permanently monitored. Temporary monitoring may be installed to provide designers with data on LV overloaded feeders.

LV cut-out

No monitoring from the electricity company, meter readings taken (or estimated) quarterly by Supplier. Increasingly half hourly (HH) settled, where it is HH settled data should be available to the electricity company.

Clearly, there was a way to go before sufficient data could be gathered to support the transition to anything approaching a smart grid.

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Installing LV monitoring without disrupting supply

One potential cause of concern for LV monitoring was the disruption that its installation might entail. Scottish & Southern Energy set out to solve that problem by proving that it was possible to install LV monitoring equipment without taking customers offline. Its project to "assess the impact of the PV panels and EV charging point on the LV network by utilising a first installation of retro-fit 11kV/LV substation monitoring solution."

The objective of this LCNF project was to install sensors at distribution substations with zero, or minimal, Customer Minutes Lost (CML) impact and monitor a range of measurements (V, A, kW, kVAr) on LV feeders, demonstrating that appropriate substation monitoring could both be installed retrospectively and provide meaningful electrical information. At the same time, it would assess the network impacts on the LV network of PV and EV uptake at a development of ten low carbon homes. According to the 2013 **close-down report**, the project "showed sufficiently detailed and accurate data can be obtained for an electricity company to assess the impacts of LCTs and develop a rigorous business case for modification of the LV network."

The impact of EV

Central to the need for better LV monitoring is the impact of EVs. A quarter of the UK's carbon emissions come from domestic transport, making the widespread adoption of EVs an essential component of achieving Net Zero. Another LCNF project – **My Electric Avenue,** delivered by EA Technology for Scottish & Southern Energy in 2014 – highlighted the challenges...

"The forecast growth in EVs is expected to cause an increase in peak-time demand for electricity; this effect will be seen both locally and nationally. At the local level there is a risk that low voltage cables could become overloaded if multiple EVs are connected for charging at the same time and during the normal daily peaks in electricity demand, e.g. the early evening peak at home when people return from work, or working during the day at work. The local substation could become overloaded, resulting in problems with the electricity supply to people's properties. This situation may result in costly and disruptive cable reinforcement (i.e. digging up the roads)."

Creating a comprehensive network of EV charging points to facilitate low-carbon transport is not so much an issue of capacity – there's enough power to keep EVs running. The problem is more that the demands of charging are concentrated in confined urban areas, and at peak demand the likelihood of overloading local feeders is high. Even with faster charging times, there is still an issue. Perhaps the most unpredictable aspect of this is that the impact of EV clusters will not be obvious until the point when they are actually on the network, requiring considerable reactive investment – and quickly.

Market barriers to the adoption of LV monitoring

The **UPGRID project**, funded by the European Union to identify real-world solutions to enable the flexible integration demand and distributed generation through a fully controllable low and medium voltage grid, looked at the market barriers in 2017, posing the questions:

Can Distributed Energy Resources (DER) technologies participate in stable markets for flexibility (if such markets exist)? Are Distribution System Operators (DSOs') prevented from investing in specific technologies by regulations?

The technologies used in UPGRID enhanced the LV network's visibility and improved its controllability, with the practical impact of reducing LV feeder capacity uncertainty to increase hosting capacity. In short, better and more detailed information was available, showing that system operators and network operators could be less conservative in respect of how much demand generation they can integrate without impacting quality of supply.

Other issues identified by UPGRID across the four participating countries (Sweden, Spain, Portugal and Poland) included:

- **Whether or not the regulatory framework is conducive to innovation – are there specific mechanisms to incentivise the cost of R&D projects, and is there any reward for the risk?**

- **Are technologies recognised as investment opportunities?** [2]

[2] *D7.1 Market and Business Framework for Rolling Out Of UPGRID Innovative Concepts: Report on Market Barriers for Deployment of UPGRID Innovative Concepts, pp 42-43*

"The technologies used in UPGRID enhanced the LV network's visibility and improved its controllability"

LV monitoring progress in the UK

With the last of the numerous LCNF projects incorporating LV monitoring having come to a close by 2017, countless specifications and strategies are now being explored and adopted by the UK electricity companies based on the outcomes of trials and tests. So what's the key to unlocking low-cost, real-time insights?

Thankfully, after all the work put into research, off-the-shelf monitoring solutions are available. Smart LV monitoring systems looking at currents, voltage and frequency, energy and its direction of flow, power and power factor, total harmonic distortion can provide all the information needed for successful network operation and planning.

Now that the tech is finally available to provide all the necessary data on tap, how quick has progress been in installing widespread LV monitoring, and is anything getting in the way?

It seems that the timing is the critical issue at this point – but there is an element of 'chicken and egg' in terms of whether electricity companies should wait for LCTs to reach a tipping point before installing smart LV monitoring on a large scale. Doing more to future proof the network now can only encourage progress towards Net Zero, while it can be argued that holding back will cap the more widespread adoption of LCTs due to lack of confidence in the grid's ability to support them.

It's worth remembering that LV network visibility is needed for Active Network Management (ANM), an approach which is being more widely implemented worldwide. Globally, the ANM market is expected to shoot up from USD 728.3 million in 2019 to USD 1,583.4 million by 2024 at a compound annual growth rate of 16.8% from 2019 to 2024. Driving factors are, unsurprisingly, the increasing demand for management of power supply from distributed renewable energy sources and the need to avoid the overloading of power grids while making maximum use of available energy.[3]

Transitioning substations to become smart-grid ready is no small task and it is no surprise that there is a degree of hedging in whether to go 'all out.' For electricity companies, the pressure to reduce capital expenditure means that a balancing act comes into play. While leveraging the data from smart meters might appear to be enough to optimise the network, pre-engineered self-healing systems offer a ready-made solution and there is plenty of evidence to make the case for an outlay that will deliver return on investment.

[3]Global Active Network Management Market Research Report: By Component (Software and Services), Organization Size, and Application (Power Generation, Power Grid and Transmission, Oil and Gas, and Water Treatment and Distribution)--Forecast till 2024

Conclusion

Safer stronger smarter networks are needed for our ongoing transition to the energy systems of the future, where visibility of energy flows via digitalisation supports the move towards a failsafe, operationally sustainable supply to be guaranteed. There is no escaping the fact that the major impact of international regulatory changes makes LV monitoring crucial as we move towards Net Zero.

Networks need a robust and future proof data infrastructure that can adapt to a rapid reshaping of the energy sector. There are numerous ways to move the LV network forward, whether making progress by degrees with information gathered from sensors and specialised measuring devices or opting for widespread monitoring on a standard and open software platform which can flex to accommodate new ideas without incurring the burden of the installation of costly equipment. There is a clear business case for putting LV monitoring high up the agenda after decades of 'fit and forget' at secondary substations.

technology

Safer, Stronger, Smarter Networks

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