The future of low voltage operations

EY
Building a better working world

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Contents

Executive summary

Decarbonisation, decentralisation and digitalisation are three key drivers for the global energy transition phenomenon. In 2019, the UK became one of the first countries to pass laws to end its contribution to global warming by 2050. Since then, over 30 countries have committed to net-zero either in law or draft legislation. In the UK, the future energy scenarios (FES) estimate that, in all net-zero scenarios, net emissions from the power sector are negative by 2033.[1]

Rapidly emerging distributed energy resources (DERs), such as solar photovoltaic energy (PV), wind energy, electric vehicles (EVs), battery storage and heat pumps (HPs), are utilities' best levers to realise such ambitious decarbonisation and net-zero targets. These emerging DERs are also changing the centralised grid operations paradigm towards decentralised grid operations. As per the most likely FES, up to 42% of generation capacity in the UK will be decentralised by 2050.[2] The number of EVs and HPs will also grow from a few thousands to several millions in the coming decades. The analysis of the distribution FES in this paper further illustrates the region-wise growth patterns of these low-carbon technologies (LCTs).

The significant growth of DERs and LCTs, complemented by digital enablers, such as the internet of things (IoT), artificial intelligence (AI) and machine learning (ML), are shifting the new power model towards the edge of the grid and the consumers of electricity. The more LCTs are connected to the electricity network, the greater the stress is on the low voltage (LV) grid. The potential financial burden of reinforcing the network will be unmanageable without innovative and consumer-centric solutions (operational or commercial). Utilities will have to develop an LV and consumer-centric operating model that provides more sustainable, reliable and affordable electricity. This operating model, combined with a seamless consumer experience, will enable the shift in the perception of consumers from electricity consumers to trusted partners of grid activities.

Furthermore, utilities also need to maintain reliable and cost-efficient operations during times of excessive surge in electricity demands. How can distribution network operators (DNOs), and their distribution system operator (DSO) function responsible for the provision of flexibility and market coordination, increase network capacity without directly impacting costs for energy consumers? Certainly, network reinforcement is not the only solution that future DNOs are contemplating to meet the excessive demand. The network industry is discussing non-network solutions, such as active network management (ANM), localised and federated monitoring and control at LV network, and self-sustainable micro or community grids. These options, although economical in comparison to the option of overall network reinforcement, will require new capabilities and technology deployment at LV. These new capabilities will be based on a significant deployment of smart meters and intelligent electronic devices at the edge of the network. Hence, DNOs expect a significant data surge from the millions of intelligent devices and smart meter nodes connected at the LV network that will require a non-traditional big data management strategy.

[1] FES, National Grid, Jul 2021
[2] Ibid.

In the past decade, the technology landscape has changed dramatically. Ofgem's RIIO-ED2 position on data sets new challenges. It notes that "Data Assets" must be treated as "presumed open". This means that data must be made available for all people to use, unless the organisation responsible for handling the data provides evidence of a specific reason for needing to reduce its availability (e.g., to protect individuals' rights to privacy).[3]

Building on this context, this paper discusses the following burning questions for UK DNOs:

- What does the energy transition and transformation at LV mean for consumers of electricity?
- Why is increased rigour required for LV monitoring and data analytics?
- What are the various approaches for LV monitoring and control, and which is the most effective approach?
- What are some critical considerations in selecting and deploying LV monitoring devices?
- What is your data model, how to collect and process data, and where are you going to hold it? And, once you have the data, how do you make the most of it?
- What additions do DNOs need to make to their workforce to make big data work for them?
- What are the criteria to select appropriate LV data analytics platforms?

The paper concludes with a roadmap outlining important steps and recommendations DNOs can take to overcome key challenges, enable their DSO function and deliver an effective LV operations strategy fit for future needs.

[3] Data Best Practice, Supporting Information, Ofgem, May 2021

Introduction

Traditionally, the LV level of the network has not attracted investment in monitoring and control in comparison to higher levels of the network. This is because a significant reduction in customer interruptions has been achievable through investment in the HV network. But with imminent disruption at the edge of the grid, priority levels are redefined. Considering this disruption at the LV level in the future, the following changes are anticipated at the edge of the grid:

- An increasing number of DER assets will be integrated with the electrical grid at LV, many with IoT connectivity
- Increased two-way flows of electrical loads and control signals
- An increase in transaction volumes, and the number of parties participating in a single transaction as well as its complexity
- The decentralisation of control decision-making and the execution of control commands, done in near real-time using AI
- An increase in smart meters and intelligent devices connected to consumer premises

Figure 1 highlights the evolution of an electric network from a centralised to a decentralised world.

The utility value chain is increasingly augmented and interconnected by digital technologies, where both power and information flow in both directions across IT and OT systems.

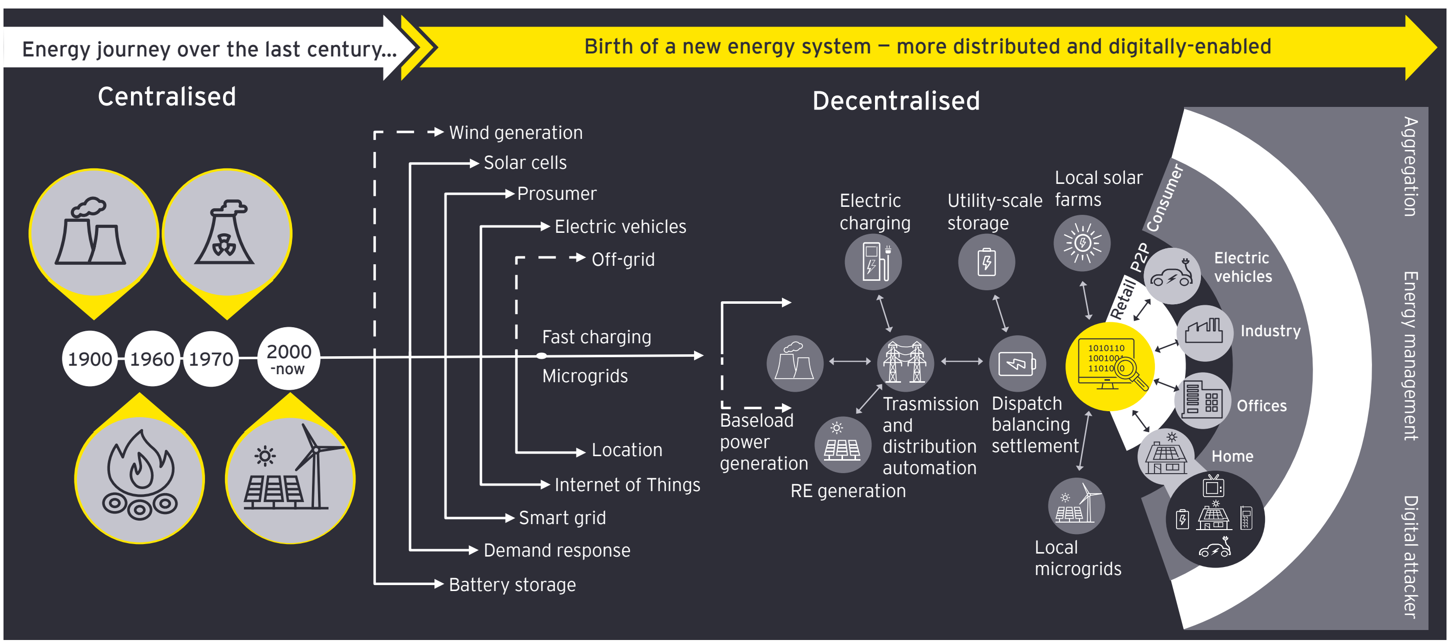

Figure 1

Source: EY Analysis of Distribution FES

In this context, EY and Kelvatek conducted an analysis of the distribution FES of six UK DNOs. It was found that a significant growth of new elements of LCTs, such as EVs, HPs and low carbon DER (solar and wind distributed generation), is predicted until 2050.

The following picture shows the future growth trends of these technologies on each distribution operators' regions in the UK. A large portion of these technologies will be embedded at LV level.

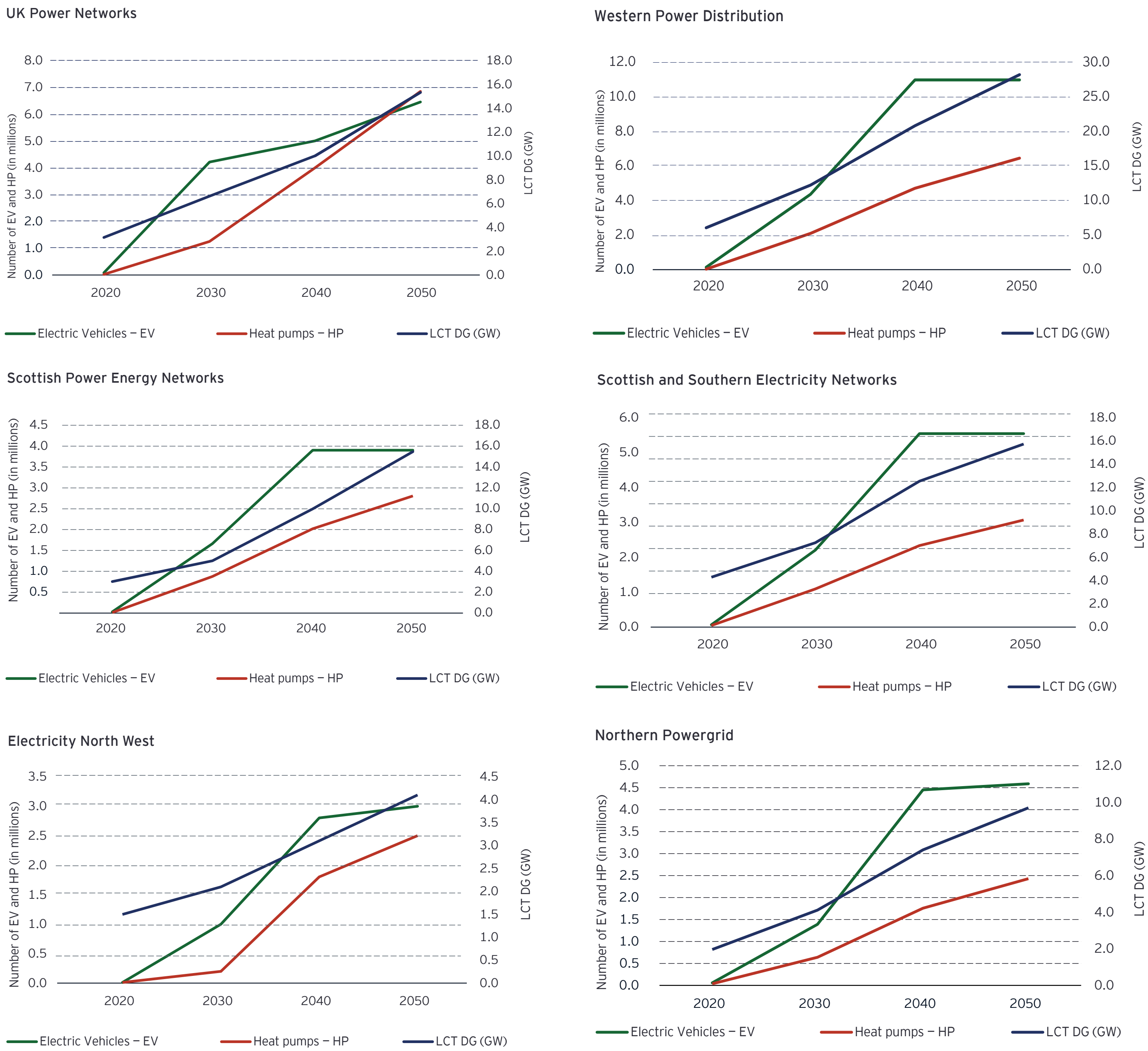

Figure 2

Source: EY Analysis of Distribution FES

These emerging LCTs, complemented by disruptive digital enablers, have enabled and introduced the need for a new consumer-centric operating model for utilities.

The upcoming section discusses the importance and the need for a consumer-centric operating model in the new LV operations and energy transition paradigm.

What does energy transition and transformation at LV mean for consumers of electricity?

Most new LV technologies (including PVs, EVs, batteries, smart meters, HPs and thermostats) will be implemented on consumer premises. Hence, consumer interest and priorities in the LV operations and energy transition journey cannot be underestimated. Utilities will only be able to generate an enthusiastic response from consumers as their trusted partners if their expectations are regarded with an impeccable consumer experience.

Power delivered to consumers must be sustainable, reliable and affordable. With the rise in DERs and LCTs at LV, future utilities will have to make this energy transition journey seamless for consumers without disrupting the fundamental power requirements of sustainability, reliability and affordability. Below are some critical ideas that DNOs can consider to improve consumer experience and participation in the LV operations and energy transition journey:

- Engage and educate consumers on the benefits of new LV technologies and energy efficiency measures by running digital or face-to-face campaigns and roadshows, formulating incentive plans, amongst other methods
- Minimise electricity disruptions for consumers whilst installing new LV technologies, e.g., installing smart meters or sensors at the LV substations with minimal customers minutes lost (CML), upgrading LV services/cut-outs or installing EV chargers without much disruption to other consumer services
- Improve the reliability of power supply during excessive demands
  - This can be done by implementing robust power quality and network monitoring solutions, and AI/ML-enabled big data analytics (or digital twin platforms) for situational awareness and informed decision-making
- Provide a seamless experience of sustainable DERs and EV connections by simplifying and automating customer journeys, e.g., provide a one-stop portal for new connections queries, applications and payments
- Bring cost efficiencies in CAPEX and OPEX by optimising network investments, prioritising non-network and flexible solutions, improving situational awareness of the control room, implementing locational and time-of-use tariff structure, automating business and back-office processes, and upskilling staff
- Develop consumer-centric business models and platforms to increase their participation in grid activities. Platforms to facilitate prosumer activities
  - Platforms to facilitate prosumer activities, such as LV demand and supply flexibilities market participation, Peer-to-Peer energy transactions and Vehicle-to-Grid (V2G) supply services, will provide an additional revenue incentive to consumers to become a trusted partner in LV operations and the energy transition journey
- Implement omnichannel consumer touchpoints and seamless communication mechanisms (chatbots on web portals, social media, SMSs, etc.) to assure consumers on their complaint resolutions, queries about outages or new connections, or other settlement disputes
  - Additionally, upskill contact centre staff and systems with pre-prepared scripts and workflows to answer queries on new DER/EV connections and settlements
- Finally, give significant importance to cybersecurity whilst managing network operations, consumer data and information

These are some salient points that DNOs and their DSO functions must consider whilst defining a consumer-centric LV operations and energy transition model. To enable this model, visibility into consumer grid activities and interpretations from consumption patterns/data will become important. Hence, the next sections of this paper focus on the fundamental capabilities, the LV monitoring and control, and the big data analytics that DNOs should develop to onboard themselves as well as consumers on this journey seamlessly.

Why is increased rigour in LV monitoring and data analytics required?

Despite the network operators' best efforts to find cheaper, more efficient and carbon-friendly alternatives to traditional reinforcement, this can be the only option left to take on certain parts of the network when demand becomes too high over sustained periods of time. The real challenge for network operators in ED2 is identifying these parts of the network and only reinforcing where necessary. To do this, a high degree of network visibility is required to allow for comprehensive modelling of the entire network, from HV to LV.

In their ED2 business plans, network operators have reserved a significant sum of money for network reinforcement beyond flexibility and market instruments to control load flows. Most plans indicate an increase in reinforcement on the secondary network, mainly due to the large uptick of LCTs forecast on this part of the network and the lack of short-term flexibility solutions at lower voltage levels over the ED2 period. In fact, two separate companies are forecasting a greater than a 200% increase in spending compared to the current funding period.[4,5] With increased loads flowing through network assets, there is also an inevitable impact on network reliability as already aging assets degrade faster as they come under increasing strain. Cable overlay programs that simultaneously upgrade the capacity of cables whilst renewing asset resilience will also be necessary over the funding period. Being able to collect data on these assets, model the progression of degradation, and then apply these standards to other parts of the network will be essential to target the correct areas of the network and optimise the spending in these budgets.

From the energy consumers' point of view, proactive responses on LV outages by leveraging smart meters, DER connections and operations, and inclusion in grid operations as prosumers are vital services. These will define the state-of-the-art customer experience.

It is widely accepted that LV monitoring and data analytics are essential first steps in enabling the aforementioned whole system energy transition and will play a significant role throughout RIIO-ED2. However, with the increasing complexity of the electricity network, how do DNOs ensure their investment in LV monitoring and analytics meets the needs of today's and tomorrow's network? The upcoming sections answer this critical question.

[4] Early draft business plan consultation 2023-2028, Electricity North West, Apr 2021

[5] Business Plan 2023-2028, Western Power Distribution, Dec 2021

What are the various approaches for LV monitoring and control?

Current practice

This transition is driving the need for LV monitoring. Currently, many DNOs are forced to infer views and forecasts about key factors, like LV load growth, from generalised sources, rather than using specifically targeted data collection. They also have been placed into a position of reactive LV fault management, with multiple fuse blows often taking place before installing reclosing equipment or homing in on fault locations. LV network management will become significantly more complex. This is because on a more integrated network, it is harder to disentangle load, fault and asset degradation issues from one another, and to understand the links between the three in order to form a clear view of the correct interventions required. A more rigorous LV monitoring approach would be required to address the challenge of LV resilience with increasing DERs and LCTs. What are the different approaches that can be contemplated?

Approach one: mass installation of basic load monitors

One way to resolve the current lack of LV visibility on the network is to install as many LV monitors as possible, at the lowest cost achievable, across swathes of the networks with the aim of building a clearer picture of load profiles. This approach means installing LV monitoring devices at a very high percentage of substations. It would also give widespread visibility of capacity issues, supporting more accurate and effective decisions around asset reinforcement or investment deferral.

This simplistic but operationally intensive approach to improving LV network visibility runs the risk of missing a bigger opportunity. It would bring important visibility of load issues and, in some cases, a limited ability to show that a fault has occurred. However, improving fault prediction, supporting highly accurate fault location, or informing an accurate running picture of LV cable health and load-carrying capabilities will be restricted. Furthermore, it is certainly operationally unproven and it will not provide much information relating to customer premises, outages and consumptions.

Moreover, this approach of installing a high percentage of LV monitoring devices will carry considerable capital and operational expense. Hence, it is not a promising solution for DNOs in the long-term.

Approach two: targeted installation of advanced LV monitors

To deliver LV monitoring's true added value, a more controlled and targeted deployment of monitoring is necessary. The deployment must include LV monitors that can simultaneously deliver load benefits whilst improving overall network reliability as required.

Supporting a combined view of LV management, maintenance and investment requires the solution to incorporate a range of advanced capabilities into a single LV monitoring solution at mission-critical substations. Any solution should combine high resolution and adaptable measurement triggers to give DNOs the insights required to manage both immediate pressures and the complex challenges that will hit in the future as decarbonisation gathers pace. This capability ensures that not only are DNOs in a position to mitigate load issues, but they can also ensure network reliability, as measured by Ofgem's Interruptions Incentive Scheme and cable asset health.

Furthermore, a targeted methodology should not only pick out those feeders and substations that are likely to experience high load or fault conditions, or that need potential long-term monitoring for overall cable asset health. It also should identify those feeders and substations that require a monitor for overall network health reasons only, such as potential overloading, voltage or phase imbalance issues. This will help DNOs to identify whether a substation requires an advanced LV monitor or a basic LV monitor to optimise the investment.

In isolation, this approach constrains LV visibility and control to limited areas. Thus, this is more suitable when the growth of DERs and LCTs are limited only to parts of the network. In the future, LCTs and EVs are expected to grow significantly across most network sections. Hence, it will become impractical to predict precise network conditions and available capacity with a limited and targeted LV monitoring option. In the case of more geographically diverse DER and EV growth scenarios, a holistic approach that covers most parts of the LV network may be required.

Approach three: leveraging smart metering data

Another option is to utilise only the data from smart meters to inform LV network status and reinforcement investments. Every SMETS2 smart meter collects load profiling and premise energisation information, which can be transformed into information on how much the network is being utilised on a particular feeder.

The increasing penetration of smart meter deployment will also provide a great opportunity for those DNOs with the capability to manage, analyse and utilise the data they provide. Smart meter data can improve the ability to detect power outages before customers call — customer interruptions at the LV level are detected automatically. At present, network operators are mostly reliant on customer contact. Last gasp notifications from smart meters or from LV monitors will allow a faster response to those faults that they cannot proactively repair and to manage the consumer relationship better. This will lead to an improvement in their Broad Measure of Customer Satisfaction rating.

In the area of load management, where smart metering penetration is high enough, smart meters will be able to provide strong indicators for the need for reinforcement intervention or for higher resolution monitoring.

The main challenge with smart metering in the short-term is the penetration of deployment and limited prediction ability. Some DNOs predict that, to make informed decisions around load investment, deferral or reinforcement, there would need to be around 80% smart meter penetration per feeder. This installation coverage is approximately 50%, as of September 2021, and the impacts of LCTs at the LV level are predicted to rise dramatically towards the end of ED2.[6]

Also, smart meters can predict network conditions with limited visibility. Smart meter data cannot predict asset health, available network capacities or precise fault locations. Hence, an LV monitoring approach based on smart meter data only is not sustainable for DSOs in the long run too.

Almost half of all domestic meters with large suppliers are now smart meters

Great Britain, domestic meters operated by large energy suppliers
Q3 2021, millions

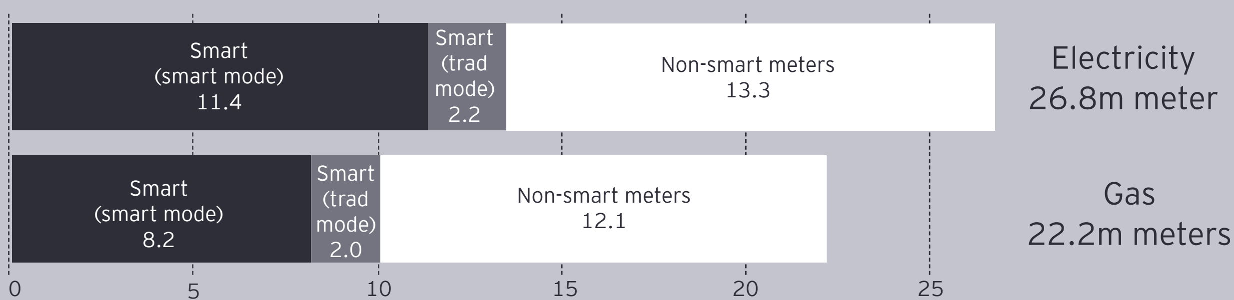

Figure 3

Source: Smart Meter Statistics in Great Britain: Quarterly Report to end September 2021, Energy suppliers reporting to BEIS, Nov 2021

In summary, the most promising solution to manage LV network operations would be a combination of approach one, basic monitors to compensate for the short-term unavailability of smart metering data; approach two, targeted installations of advanced monitoring devices to deliver benefits quickly from critical parts of the network; and approach three, leveraging smart meter data in the longer term once penetration levels hit a critical mass. This hybrid approach will help in optimising capital spend in LV substation automation and will also enhance the visibility of consumer premises through smart meter data.

With the expected penetration of smart meters set to increase across future funding periods this approach means that the most critical areas of the network are monitored as early as possible to stack potential benefits and ensure network resilience, while future areas of the network that could be impacted by EV and LCT will be monitored by smart metering, which fulfil many of the requirements of basic load monitoring.

Furthermore, by implementing the required data analytics capabilities, DNOs can correlate LV substation visibility and consumer premise data. This will help in establishing very useful insights related to consumption patterns, phase balancing and LV connectivity, and will also facilitate the calculation of available LV feeder capacities for more EV connections to enable informed decision-making by their DSO functions in terms of constraint management zones and provision of flexibility services.

By using smart meters' and LV monitors' data to detect outages, DNOs can become faster and more efficient at responding to faults and restoring supplies, avoiding costly CI/CML penalties.

In general, smart metering data, along with a myriad of other LV monitoring data sets, can be utilised to allow ANM interventions, enable LV flexibility support or even voltage regulations.

[6] Ibid.

What are some critical considerations in selecting and deploying LV monitoring devices?

Many areas that are set to experience the greatest amount of load growth will also experience higher levels of cable asset degradation and therefore, higher instances of faults that affect more customers across the network.

To maximise the business case for LV visibility, there is a real opportunity to stack the benefits that can be achieved. One of the largest lifetime costs for LV monitors is the actual site visit, assessment and installation. Any monitoring solution utilised needs to enable various distinct use cases that will develop over a decade or more during its installation on the LV network. Repeated visits for maintenance to install enhancements or additional capabilities add to the lifetime cost of the monitoring solution and the carbon footprint. Only deploying for load visibility essentially limits the scope of access to incentive schemes, asset health measurement, actionable operational savings, and other future benefits that DNOs could get from a future-proofed, multi-purpose, resilient LV monitoring solution.

There are many benefits of which the right monitoring solution can take advantage, as shown in figure 4.

Low voltage monitoring lifetime benefits

Network edge, AI-enabled device

Neutral condition assessment	Optimisation of connections	Highly accurate fault location	Identification of losses due to imbalance	Cable health indexing	Prediction and classification of faults

Entry-level load monitor

Load visibility	Optimisation of connections	Fault notification

Figure 4

Source: Kelvatek analysis, 2021

Hence, it becomes critical to consider lifetime costs and advanced capabilities before selecting the right LV monitoring device. Advanced monitors can only play their role if they are targeted effectively: not all feeders will experience fault conditions within the lifetime of a monitoring unit and not all feeders need to be monitored to infer a picture of overall cable asset health. Targeted LV monitoring on identified substations is an important step in any deployment. Many DNOs are currently only considering load-related data when it comes to the deployment of any solution. Some, however, have taken a more holistic view. Instead of just considering load, they have drawn in multiple sources of data and applied advanced statistical techniques to determine the optimal investment path. This means that advanced LV monitors only need to be deployed to the network where they provide most value in terms of protecting network reliability, informing network reinforcement, and helping inform the planning and configuration of any future network.

Targeted methodology combined with advanced statistical techniques

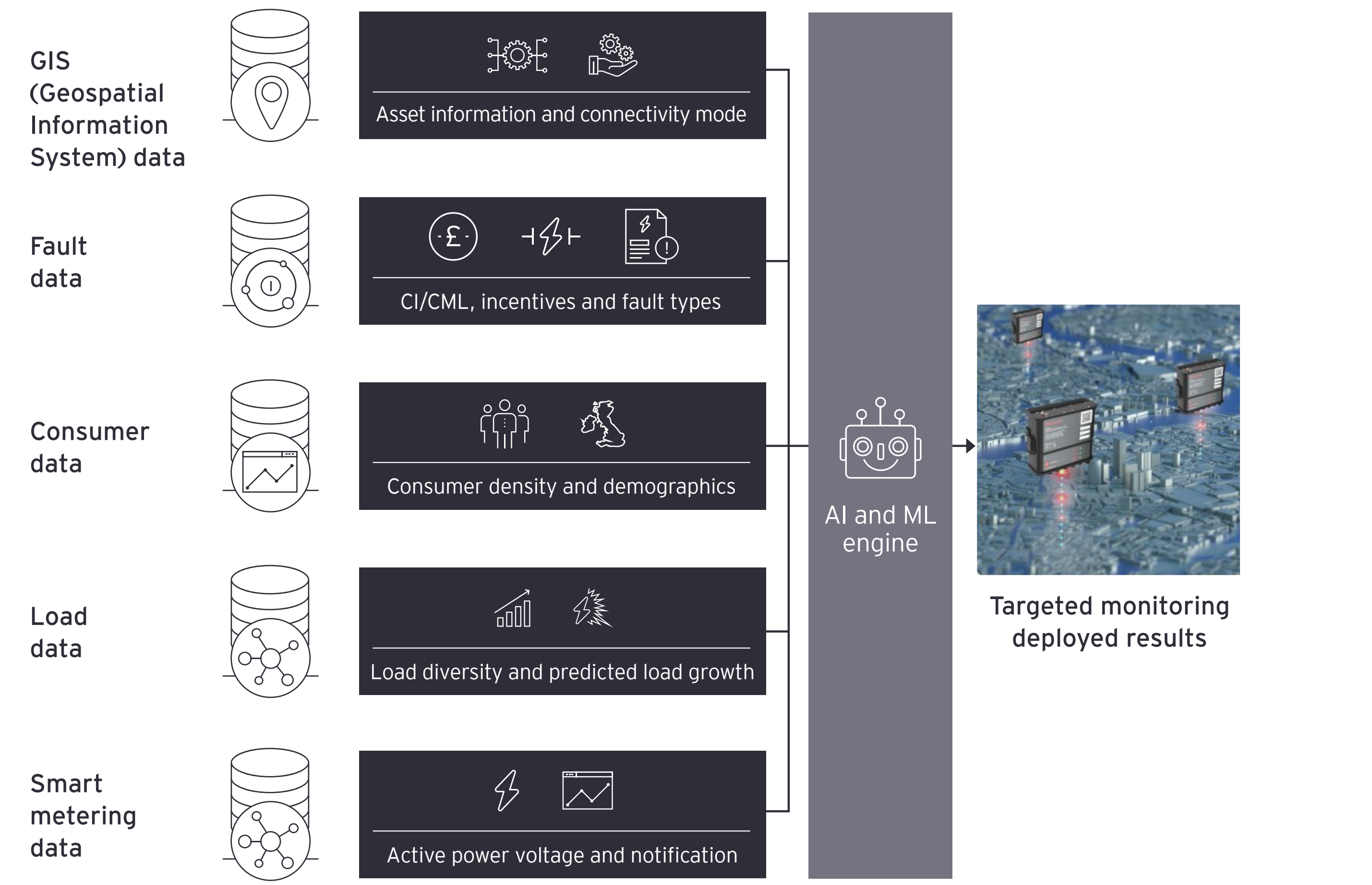

Figure 5

Source: Kelvatek analysis, 2021

The fact that many DNOs are contemplating targeted monitoring and advanced statistical techniques to predict the network state further substantiates the idea discussed in the previous section. More specifically, it confirms that the targeted installation of LV monitoring devices, combined with smart meter data and LV data analytics capabilities, is the most promising approach for managing LV operations.

What is your data model, how to collect and process data, and where are you going to hold it?

The data agenda for the energy sector was set when the Energy Data Taskforce (EDTF) shared its findings with the industry. Commissioned by the government, Ofgem and Innovate UK, the EDTF report about modernising the energy system through leveraging the huge amounts of data collected by network operators and other market operators had several key recommendations:

- Digitalisation of the energy system
- Maximising the value of data
- Visibility of data
- Coordination of asset registration
- Visibility of infrastructure and assets

Of course, these recommendations pose a significant challenge to the status quo within the energy sector. Following that, the network operators have responded with ambitious plans to digitalise the way they run their business and offer services to consumers. With this comes several foundational challenges for network operators to overcome and will require a standardised data model across the industry as the first step.

Ofgem have responded to this by broadening the scope of where the Common Information Model (CIM) will be applied to industry data exchanges to standardise communication methodologies across industry participants. All UK CIM implementations will use the Common Grid Exchange Specification with some additions from the Common Distribution Power Systems Model. These standards will form the basis of future industry data exchange architecture.

Collecting data to drive business efficiency and improve the customer experience

Business efficiency and data management are inevitably interconnected. Collecting, analysing and acting on real-time data can transform the way a business operates, and reduce environmental impact. Data provides the information and insight that enables improved capital allocation, enhanced operational performance, the achievement of performance incentives and increased return on investment. Every step towards operational excellence and efficiency is therefore a step towards greater sustainability.

Building these capabilities means introducing data from every level of the grid, bringing along with it the ability to capture, store, tag and normalise data to transform it into actionable information.

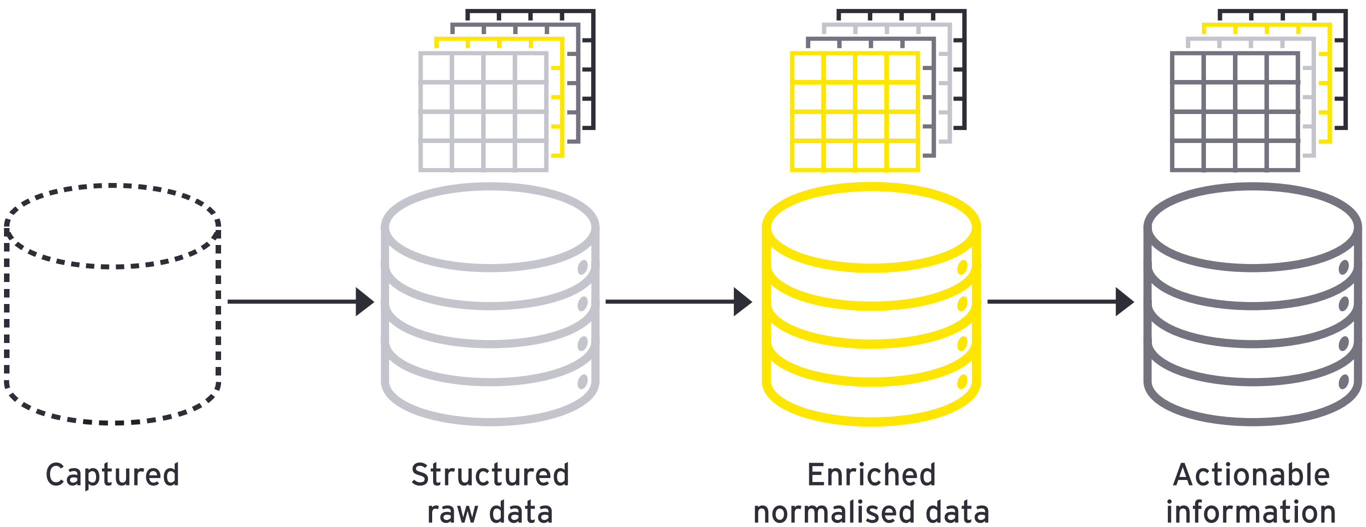

Figure 6

Source: Kelvatek analysis, 2021

For distribution networks, the opportunity to improve data collection and analysis is vast. Increasing numbers of intelligent devices are being installed on the network and these devices have the potential to provide the data foundation that will enable better ways to build, operate, and manage existing infrastructure.

Comprehensive data collection combined with the necessary controls and security management standards is making it possible to adopt Open Data principles. This will have the same far-reaching consequences in improving transparency and trust for DNOs and the consumers they serve that we have already seen in industries, such as banking.

Along with the necessary data controls, security, and data integrity management at LV, it is also important for utilities to periodically maintain and calibrate the source of the LV data. Most new network assets are inbuilt with smart sensors and intelligent processors. Hence, it is critical to maintain those assets and sensors to ensure that operational assets ratings/specifications and real-time data are accurate over the lifecycle of each asset.

Intelligent electronic devices, sensors and smart meter gateways to collect this vast network data are manufactured to support a myriad of communication protocols across the globe. Hence, it becomes very important for industry stakeholders to identify and standardise these protocols before implementing LV monitoring solutions. Some of the interoperable protocols and global technology standards that are being considered at global utility industry levels for network operations, data collection and exchange are:

- IEC 60870–101, 60870–104, DNP3, MODBUS for field device communications (e.g., RTUs, smart switches, etc.)
- IEC 61850/51 for substation automation
- IEEE 2030.5 for interconnecting DERs and aggregator devices
- IEC 61968 for DSO IT-OT system's interfaces for data exchanges
- Open Automated Demand Response (ADR) 2.0 to communicate demand response signals to customers
- Open Charge Point Protocol (OCPP) 2.0 for V2G communications
- ISO/IEC 15118 standards for V2G communications
- IEEE 1547 standard for distributed generation interconnections
- Secure Inter-Control Centre Communication (ICCP) to interface with Transmission System Operator and other utilities for real-time data and control command exchanges
- IEC 62351 standard for cybersecurity

The aforementioned list, which is non-exhaustive, is indicative of standard protocols for the utilities industry followed in different geographies by various product vendors. There is an ongoing discussion to adopt some of these protocols globally as a common standard. Hence, it is imperative for DNOs to ensure that whichever product or operational technology platform they implement should support relevant interoperable protocols and standards for their local ecosystem. It should also give them the ability to flex over time.

For intensive operational data, DNOs traditionally preferred on-premise storage because of sensitivity and criticality considerations. However, in the future, with millions of new data nodes at LV, the amount of operational data received will increase significantly. Hence, it will be imperative for DNOs to segregate critical and non-critical data from this data ocean, and to consider a more flexible on-premise and private cloud-based hosting of data. The improved security standards have made the cloud-based hosting of data a very promising option.

This approach will not only reduce overall data management cost, by utilising on-demand and economical subscription-based cloud storage spaces, but also enable easy accessibility of relevant data to external stakeholders as per EDTF and Ofgem recommendations.

So, once you have the data how do you make the most of it?

Integrating the whole network (from HV to LV) is a mammoth task, but the first step along that journey is ensuring that data is defined using common standards and that the host analytics platform is interoperable. Once this is established, then DNOs can implement various data analytics use cases by combining real-time data and historical operational data.

Combining near real-time data with historic information provides the ability to analyse trends, forecast investment and predict equipment lifecycles based on actual usage. Many devices, such as automatic reclosers, have been acting as network monitors for many years, enabling DNOs to build a detailed picture of performance and reliability over time. However, collecting comprehensive LV network data and deducing actionable insights is a multi-step process for a network operator. By connecting network histories with current data, the data analytics landscape can become foundational for progress towards net-zero. Additionally, it can help meet other key objectives, such as reducing capital spend by making more efficient use of the existing network. Simultaneously, the utility can also optimise operational spend by gaining a full picture on the demand and supply on the network for informed real-time decision-making.

With improved LV monitoring, some LV data analytics use cases that network operators can prioritise are LV connectivity improvement, fault prediction, asset health prediction, load forecasting, network congestion hotspot analysis, available network capacity forecasts, optimisation of network switching or curtailment, etc.

There are potentially two options that DNOs can contemplate for implementing these LV monitoring and data analytics use cases:

1. Scale current SCADA, Advanced Distribution Management Systems (ADMS), Distributed Energy Resource Management System (DERMS), GIS and historian for ANM at the LV network
2. Manage an integrated combination of two different sets of systems at HV and LV network (e.g., SCADA, ADMS, DERMS, GIS, historian at HV, and a bespoke integrated LV analytics platform for LV)

Based on the analysis, current SCADA/ADMS/historian/GIS and DERMS products have not yet proven the ability to scale to the millions of LV nodes that are required in the future. Also, the existence of diverse technologies, and protocols and bespoke LV analytics requirements make standardising existing products challenging at the LV level. Hence, many DNOs are contemplating the second option above to ensure that LV networks are embedded timely and seamlessly in the whole system optimisation approach.

The implementation of managing an integrated combination of HV and LV networks will require digitalising LV network data and LV analytics use cases. DNOs have already published digital strategies which broadly seek to align to the principles of Open Data and interoperability, and the building of LV data analytics capabilities. Both have been further reinforced as part of their ED2 business plans.

What additions do network operators need to make to their workforce to make data work for them?

To have a truly data-driven business, you need several specialist roles within your organisation. Addressing complex data science tasks, such as building and maintaining machine learning models, constructing data models and a host of other use cases, requires a dedicated department within your organisation that can supplement different business units and operate within their specific fields of analytical interest. This allows your business to experiment with the data you collect to find new and innovative solutions to business challenges. It enables the democratisation of data, revealing insights to your entire organisation; and allows any business to measure the impact of changes implemented within your organisation or on your network.

Examples of skills that your workforce will need are:

- Analytics – R/SAS
- Coding – R, Python, Java, C/C++
- Databases – SQL, NoSQL
- Big data processing – Spark
- Algorithms and Modelling – decision trees, clustering, time warp analysis, regression models
- Frameworks and libraries – Spark MLlib
- Domain knowledge – electrical engineering, data science

The types of roles that would normally fulfil these skill sets are data engineers, data scientists, machine learning engineers and software developers, all with experience of working within the utilities industry or capable of working in partnership with subject matter experts.

What are the criteria to select appropriate LV data analytics platforms?

Mastering LV data in the world of future DNOs is not a choice but a necessity. Furthermore, it alone will not solve the problem: data needs to be validated, curated and stored within a state-of-the-art LV analytics platform. Future LV analytics platforms will need to meet the following properties as a minimum:

Scalability and resilience in data integration and computing

The recommended solution is very likely to be centralised and orchestrated in the cloud, creating a central repository of the current state of the network and its ‘memory’. The integration framework will need to be highly flexible to cope with diverse technologies from diverse sources. The ability to deal with real-time streaming data from IoT systems as well as asynchronous data loading will be required. Those systems are likely to handle periodic batches of daily data, and highly scalable timeseries technologies should underpin these types of platforms. From a computing perspective, the technology available should support real-time enrichment and transformation as well as the ability to compute very large volumes of data at scale and in a distributed fashion.

Adaptable and responsive

Whichever technology these platforms are built on, they should have the ability to react, change and adapt at all levels. One of the key architectural considerations should be to react to specific event triggers from IoT or other external data sources (coupled with a microservice layer, this offers the greatest level of flexibility to develop new use-cases, categories of insights, etc.)

The second consideration is the AI/ML capabilities of the platform, which should enable the rapid testing, implementation and deployment of new predictive models.

Standards support and flexibility

As the industry matures its thinking, approaches, and technologies, there will inevitably be a divergence in strategy. The chosen platform will be required to be capable of flexing to support a range of standards for integration and for exchange data formats to support the evolving data landscape. DNOs are making significant progress in this area with common data definitions being constructed that conform to a standard of the CIM and industry standard Open Protocols.

Productisation

If not mandated, sharing data and insights will be a requirement to champion innovation and improved value proposition for the consumer. The platform at the heart of LV network visibility should have the capabilities to not only bring data to life for its primary users through advanced visualisation and experiences, but also allow ease of integration for others in different ways. Some examples are to develop Software as a Service (SaaS) solutions for external consumers of that data or develop data products layers that can be served, sold and leveraged by others in the energy market ecosystem.

The following diagram depicts a possible high-level modular and conceptual micro-services (MS) -based architecture of future LV analytics platforms.

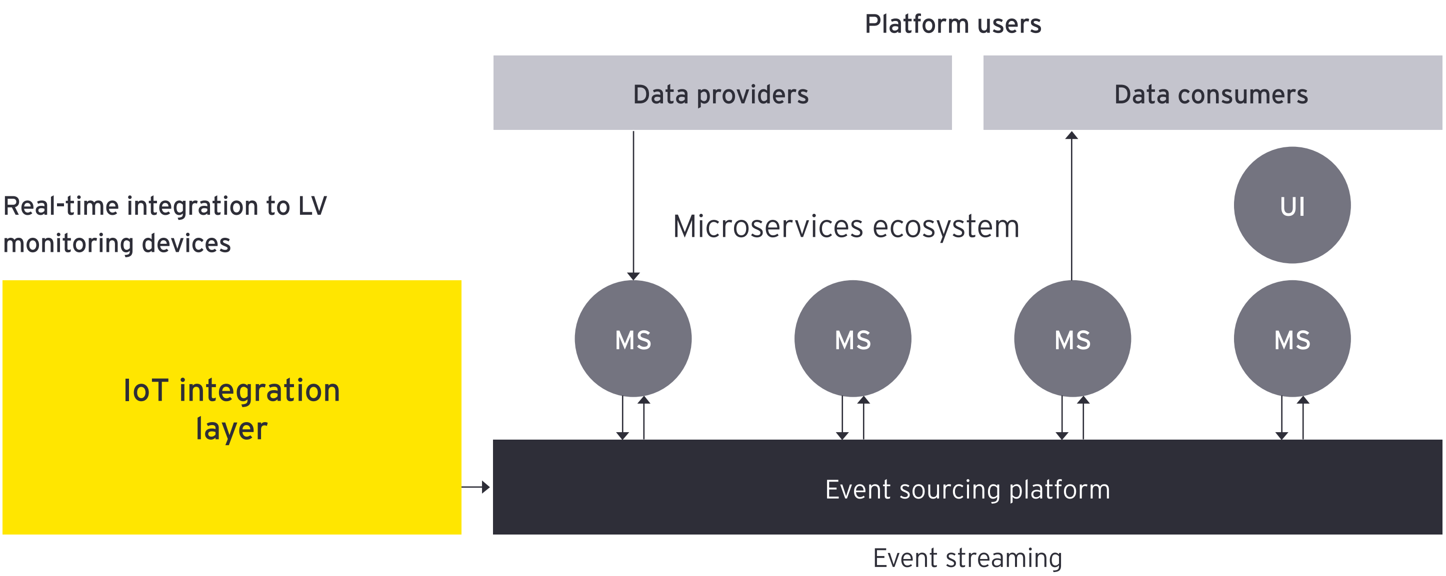

Figure 7

Source: EY analysis

Conclusion

With the disruption at the LV level, the network operations landscape is being redefined. New roles, policies, processes and technologies are evolving. The FES and government-mandated decarbonisation targets clearly show that the LV network disruption is inevitable within the next few decades.

Depending upon the level of DERs, LCTs and flexibility components penetration, there is a different level of investment expected from the DNOs in the build-up of LV capabilities. The following picture, in conclusion, shows a roadmap for investments for different capability developments based on the DER penetration and adoption rates at LV. Low adoption can be considered as 10–20% (of whole generation capacity) of grid-connected DER generation, medium range is 20–40% of grid-connected DER generation and anything above 40% is high DER penetration:

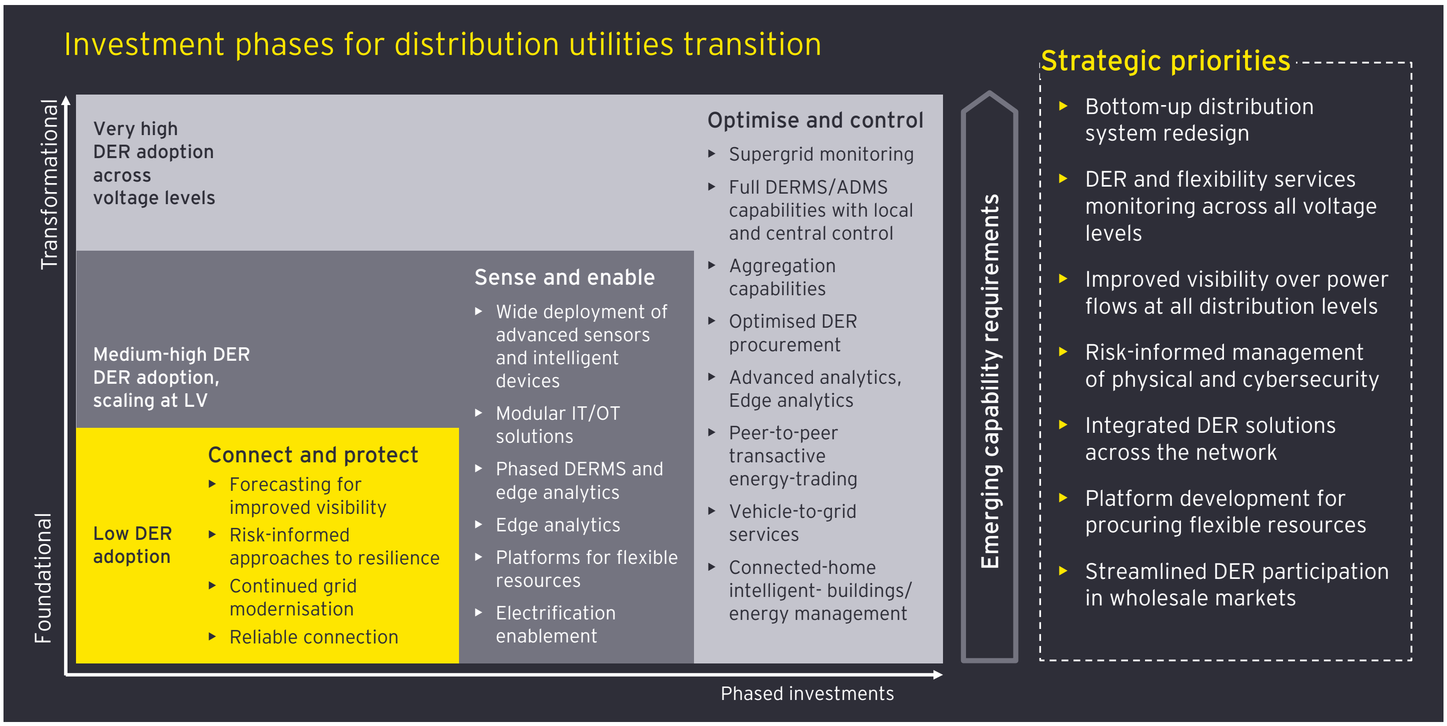

Figure 8

Source: Distribution systems in a high distributed energy resources future, Future Electric, and EY analysis

Having a strategy and approach to integrate DERs and demand variabilities at LV is a critical decision for the DSO function of a DNO. The first step is to ensure adequate LV network visibility. Based on the proliferation of DERs at LV, there are different LV monitoring approaches for which network operators can adopt and plan, such as mass LV monitoring implementation, targeted implementation or hybrid with smart meter implementation. The most recommended and sustainable LV monitoring approach is hybrid LV monitoring, with smart meter data and targeted LV monitor data leveraged selectively based on the business case.

Whichever approach is adopted, a DNO should follow the industry standards for LV data collection, processing, sharing and security. Also, scalable and interoperable data analytics platforms are a critical element for its success. They should be carefully selected to future-proof implementations of LV use cases and the sharing of insights with stakeholders. Seamless integration of HV and LV systems for whole system optimisation is a must requirement for network operators.

Some of the immediate key steps that DNOs need to take in this context are:

- Improving on LV network visibility and control for loads and DERs by adopting a smart meter and targeted LV monitors-based hybrid approach
- Developing Business as Usual processes to populate and maintain LV network data
- Defining common, secure and interoperable technology standards
- Scaling LV data capturing, processing and sharing interfaces with stakeholders
- Prioritising LV optimisation use cases and data requirements
- Selecting LV data analytics platforms to implement prioritised use cases
- Scaling and integrating existing HV (SCADA, ADMS, DERMS, historian and GIS), and LV analytics systems to meet the future growth at LV
- Developing the right ecosystem of data engineers, data scientists and partners

LV operations optimisation requires organisation-wide transformation. Some aspects that we could not discuss in detail due to the limitation of the paper's scope are:

- By introducing digital communities between control rooms and field operations to assist each other in real-time, operational staff can reach a greater effectiveness. Real-time insights will not be able to provide much value if the lead time to execute field actions is not reduced proportionately.
- Control room event management and the alarms filtering process are other areas that will require optimisation. Imagine millions of field devices and smart meters at LV start sending events during a storm — the control room event management process might become a bottleneck in such scenarios. Hence, an automated triaging, grouping and investigation of events will become critical before generating work orders.
- Spare parts and supply chain efficiencies will also require reassessment to keep up with LV network requirements (for example, new spare parts for DERs, EVs etc., new local hubs)

Optimising LV operations requires holistic thinking around the LV value chain. On that basis, it is critical for DNOs to adopt a fundamentally correct approach that is agile, adaptable and sustainable in the long-term. And there is no doubt that an effective LV monitoring and control approach, in combination with big data management, is the first step towards implementing a sustainable consumer-centric LV operating model.

Accelerating network performance for a sustainable future

EY delivered this paper in collaboration with Kelvatek. Kelvatek has been working collaboratively across the UK and Irish energy industry to help build a smarter and more sustainable future by targeting interventions and investment, whilst minimising unplanned interruptions. Underpinning this is their industry-leading solutions and services for fault and load management, asset monitoring, and biogas and gas monitoring.

Kelvatek is part of Camlin, which has a worldwide presence with facilities in 21 cities across 17 countries. Camlin's goal is to optimise the critical infrastructures that people, cities and communities around the world depend on, all day and every day.

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