LV Grid Monitoring and Visibility

New demands on the network from the way we heat/cool or power our homes to the cars we drive are changing the traditional power flows and role of the electricity network. Visibility and reliability of the Low Voltage (LV) network is now a key consideration for network operators. LV Monitoring is a key enabling technology for the transition to DSO and future networks.

Neil Davies - EA Technology Australia

The transformation of the energy system to support the introduction and scaling up of distributed energy resources (DERs) 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, battery storage and smart tech, we face a new reality.

The more DERs that are connected to our network, the greater the burden on the 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. As we continue our transition to Net Zero, data, particularly that from the low voltage network, will become increasingly important.

THE BENEFITS OF LV MONITORING

Installation of a flexible, intelligent monitoring solution provides multiple benefits not solely confined to visibility and understanding the impact and capacity for DER.

Drilling down into the data below the substation level can bring important insights into network performance, making management much easier and improve service and safety. With the right data at hand, it is possible to make informed operational decisions, address power quality issues and reduce the losses through improved network balance.

Companies installing the VisNet® monitoring solution are using it to:

- Lower costs
- Improve network resilience
- Drive efficiencies in operation
- Enhance utilisation
- Signal capacity to others

SYSTEM ARCHITECTURE

The VisNet® Hub is a substation monitor that samples voltage and current data on every LV circuit giving insight about load, faults and condition information across the network. It measures three phases, plus neutral for up to six LV circuits, busbar voltage and equipment temperature.

The VisNet Hub utilises EA Technology's Low Voltage Common Application Platform (LV-CAP®) operating system.

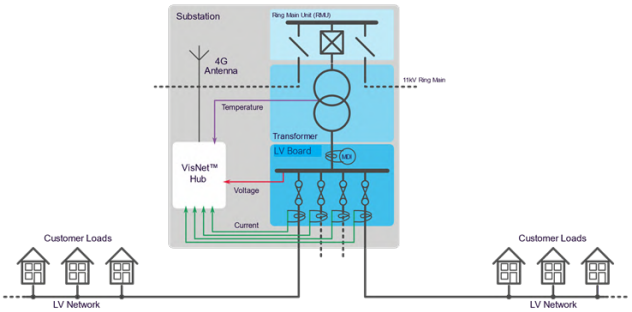
LV-CAP allows a network operator to deploy a single hardware unit per substation, incorporating a tailored suite of Apps, rather than deploying multiple devices in each substation, which implement functionality in different, incompatible ways, increasing both purchase and up-stream costs.

The Platform:

- Allows insights to be mined from data locally and consolidated centrally
- Can be combined with a tailored suite of relevant software Apps, allowing operators to distribute intelligence across the network and optimise the data transfer volumes in this data rich environment
- Provides local intelligence to allow credible decisions to be made

This rounded solution gives network operators the opportunity to have full visibility and control of their LV network, at the most economic price point.

An outline of a typical installation is shown below:



Typical VisNet Hub Installation

With the potential widespread requirement for monitoring LV networks, installation time can be another significant and often hidden cost. Using split core Rogowski coils and a commissioning App that streamlines the process, VisNet may be deployed in as little as 20 minutes.

APPS, ALARMS AND ALGORITHMS

The functionality of VisNet eco-system is based on the principle of using local Apps on the Hub to analyse data locally. This avoids having to back-haul lots of data to a central point for further analysis. Standard VisNet configuration provides outputs from the device every 30 minutes, plus a rapid channel for sending any 'events', such as Fuse blow whenever they occur within the 30min window. The hub can be configured to increase this rate to anything down to every 1 minute, although this will significantly increase the volume of data.

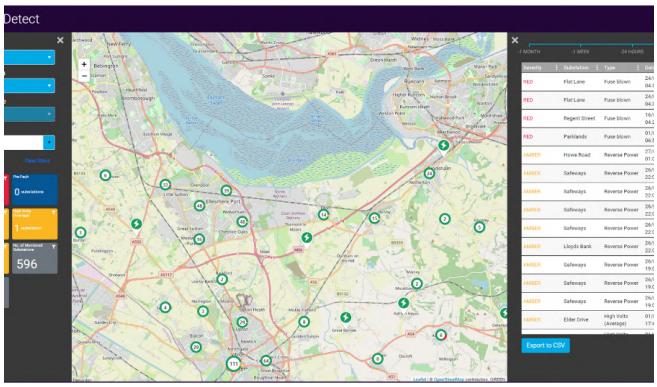
Core configurable alarms for events such Fuse Blow, HighV, LowV, HighI, HighKVA, RevPow, etc. are provided as standard. Additional functionality can be unlocked by configuring a 'Waveform trigger App' to take advantage of the hub's high sampling frequency and pull back the AC sinusoid following an interesting network event (e.g. event of over 1000A, etc).

VisNet being commissioned in a kiosk substation

Capture of the waveform information allows the detection of pre-faults, calculation of pre-fault impedance, fault location and additional apps e.g. for the detection of lost neutrals, harmonics and power quality. As new client requirements and algorithms are identified, additional apps can be securely rolled out to the installed fleet without the need for any site visits.

VISEA DETECT USER INTERFACE

The Visea Detect interface is a cloud-based interface that allows users to make sense of LV network data for your fleet. The system combines dashboarding with actionable intelligence allowing users to drill down to access real time and historic data from the monitors.



Visea Detect UI

TYPICAL USE CASES

Users are deploying VisNet monitoring for a variety of reasons depending upon local drivers.

Managing network capacity

The information gleaned from monitoring can be used to accurately estimate what capacity exists to connect DER to the network, as

well as helping to manage any resulting power-quality problems as DER penetration increases. The quickest way to unlock additional capacity is to rebalance network loads and VisNet Hub can provide the information required to achieve this.

Accurate measurement of LV circuits increases confidence for investment plans and better serves customer needs when applying for connections. It allows identification of strategic investment for heavily loaded substations and for reinforcement to be deferred when appropriate and safe to do so.

Supporting connections and flexibility signalling

Increased network visibility will accelerate the rate of connections in areas with capacity and reduce wasted effort by both the network operator and applicants. In addition, it will allow the network to be operated closer to its limits and help inform when flexibility contracts are required and beneficial.

Improving network reliability and managing the customer experience

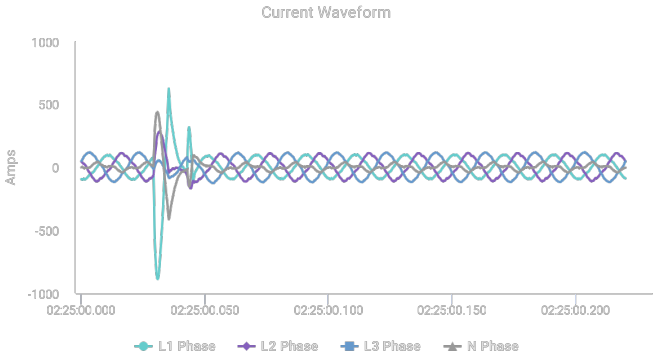
The LV network can contribute a sizeable portion of SAIDI / SAIFI, to which penalties and incentives are attached. Installation of monitoring allows data to be gathered in poor performing areas and track worst served customer information relevant to that area. High resolution monitoring allows utilities to intervene on potential faults in a proactive way, preventing an actual outage and improving the overall customer experience. Common sources of customer complaints such as flickering lights, high/low volts, neutral faults can be identified and resolved before they become a nuisance or safety issue.

LV MONITORING CASE STUDY – IMPROVING NETWORK PERFORMANCE

Back in 1974 when EA Technology was the UK Electricity Distribution Research Centre, some work was conducted on the recognition of "transitory faults" on the Low Voltage network. One of the collaborating electricity companies was Yorkshire Electricity. These events were observed to occur as dips or notches in the voltage waveforms measured by, at the time, expensive equipment at substations. They were found to be due to degradation of the cable insulation at a particular location which, following a short passage of current, self-healed before fuses blew and therefore before customers lost supplies. In 2017 the same companies, now called EA Technology and Northern Powergrid (NPg), collaborated again to further research these phenomena.

At the start of the Foresight Project in 2017, the project team considered whether these events (now named pre-fault events) could be used to enable a brand-new way of managing LV underground cable faults. At the end of the project in 2021, we had proven that they could.

Since LV monitoring equipment was deployed on the Foresight project, over 35,000 events have been recorded relating to pre-fault activity and quality of supply issues. This newfound visibility of the network has given NPg the opportunity to proactively find and fix impending faults and gain insights into quality of supply issues including flicker, off suppliers and illegal extraction to name but a few.



Pre-fault activity on a feeder

Prior to permanent damage (a fault) occurring, multiple pre-fault events typically occur over an extended period of time. Analysis of the waveforms and calculation of the pre-fault impedance allows estimation of the likelihood of failure and the location of the fault, assuming good cable records are available.

Over a four-year period, the Foresight project has disrupted the industry status-quo of locating and repairing LV cable faults only after they have caused an outage. It was found that the detection of pre-fault activity provided an opportunity for new ways of tackling faults by intervening earlier in their life cycle and before the impact of the developing fault becomes unacceptable and, in some cases, before they cause any customer interruptions. "Find and Fix before fault" is becoming a practical reality.

Faulty LV joint taken from service prior to failure

The same cable condition data set has also been used to provide previously unavailable LV circuit condition data. This has been populated into an LV Cable Asset Management Model (EA Technology's CNAIM model) capable of providing strategic insight into movements on the asset health indices of this significant class of assets and informing replacement programs of works and regulatory submissions worth millions of dollars.

SUMMARY

LV networks, to which the majority of customers are connected and which form a majority of the network asset base by dollar value, are becoming more critical and front of centre to electricity networks as we transition towards a more decentralised energy system. In many cases, the LV network is also approaching end of service life, which brings its challenges in terms of reliability, safety and long term works planning and resourcing. Monitoring and visibility of LV networks is becoming a necessity for prudent management and allocation of capital.

Experience demonstrates that selection and installation of appropriate monitoring equipment on the LV substation can have multiple benefits, improving the network of today as well as being an enabler for the networks of the future. T&D

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