gridspertise

Advanced LV Management for Electrical Utilities

White Paper

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LV Grids Overview

Low Voltage networks typically involve the final stage of the electricity distribution chain, conveying power to end-users. They operate at voltages below 1kV and encompass the grid's most extensive and diverse segment. LV networks are characterized by their extensive coverage, spanning residential, commercial, and small industrial areas. These networks feature in most of the cases a radial structure, and they are subject to a bi-directional power flow in the case of distributed energy resources, requiring a robust infrastructure capable of handling fluctuations and varying demands. DSOs confront numerous challenges when managing LV networks.

Firstly, the rise of distributed energy resources such as solar panels and electric vehicles has led to a more decentralized power generation and fluctuating demand patterns, adding complexity to load management.

Additionally, aging infrastructure and the need for smart meters or advanced monitoring systems for effective real-time data collection and analysis pose significant challenges; this is crucial for maintaining grid stability, managing peak loads, and ensuring power quality.

Moreover, LV networks often face issues with voltage control and power losses due to the decentralized nature of consumption, resulting in fluctuations and power quality concerns.

Managing these fluctuations while maintaining grid stability demands sophisticated control mechanisms and grid automation. The impact of these challenges on DSOs worldwide is substantial. Asking for investments in modernization and grid digitization. This requires a comprehensive transformation in infrastructure and operational strategies, with a focus on flexibility and adaptability to changing energy landscapes.

Internationally, DSOs are working towards developing smarter grids, employing technologies such as predictive analytics, AI-based grid management, and integrated energy management systems. These initiatives aim to optimize operations, enhance reliability, and ensure cost-effectiveness in LV network management.

As the shift towards sustainable and distributed energy continues, addressing these challenges through technological advancements and adaptive strategies is crucial for the effective management of LV networks by DSOs globally.

Challenges and Impacts on SAIDI and SAIFI

LV grid management significantly influences System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI), which are critical metrics used in assessing the reliability and performance of power distribution systems. Please see below a list of potential threats impacting on SAIDI and SAIFI performances.

Challenges	Descriptions	Business Impacts
Lack of visibility	Most of the LV grids are not properly supported by any LV SCADA, so electrical Utilities have to manage the operations with manual and inefficient methods (impacting also Response Time to incidents).	• Longer Response Time • Manual update of topology • No power flow awareness
Ageing infrastructures	Ageing infrastructures lead to unexpected failures and longer restoration times. Due to the capillarity of LV grids, maintenance plans are often overwhelming for the most of Electrical Utilities.	• Unpredictable failures • Safety risks • Longer restoration time • Lack of digital capabilities
Equipment overload	Due to rising population and/or rising electricity demand Electrical utilities are forced to deal with undersized cables/transformers/breakers leading to frequent and unpredictable power cut-off.	• Increased wear-out • Frequent failures • Fire risk
Lack of FLISR automation	In absence of motorized switches and control systems LV grids are completely managed by in-field activities to identify and isolate permanent fault and restore power.	• Longer time-to-repair • Human error risk • Safety risks

Emerging Technologies

While most of the emerging technologies are being adopted to manage HV and MV grids, there is a strong need of enhancing LV grid management due to its impact on SAIDI/SAIFI and its associated complexities.

New emerging technologies paints a promising canvas for LV grid management, yet the road to integration and successful implementation is paved with challenges, including initial investment, system integration complexities and the need for skilled personnel. The key lies in judiciously selecting and tailoring these technological innovations to suit the specific needs and goals of each electrical utility.

The most promising technologies to enhance LV grid management are listed below:

Challenges	Benefits	Market availability
Virtualization Platforms	• Reduce installation footprint • Ensure interoperability • Single supplier support • No wiring errors/activities • Developer-friendly environment	• Rising
Edge Computing Platforms	• Strong latency reduction • Light IT infrastructure needed • Resiliency in case of communication loss • Cross data-domains analysis • Future-ready environment • Merging of Smart grid & Smart Meter Management domains	• Emerging
Remote Asset Management Platforms (RAMP)	• Reduced field effort for FW management • Bundle operations • Cybersecurity central management • Diagnostic information retrieval • Possibility of safe data storage on Cloud	• Emerging

Future Proofing Architecture

Having a clear picture of the LV distribution network will be one of the most interesting challenges for DSOs in these years. The possibility to have a digital twin of the LV grid will be relevant for reaching a cost-effective management of the network and for enhancing the reliability to the final customers.

Reaching a real-time oversight of the LV network requires a suite of hardware and software solutions that leverage on:

- Smart meter data for improved grid monitoring;
- A decentralized distribution network management structure;
- Open standards like IEC 61850 and IEC 60780-5-104;
- A centralized Low Voltage Supervisory Control and Data Acquisition (LV SCADA) platform.

In several electrical utilities, smart metering systems are already operational for billing purposes. However, these systems are generally unfit for real-time grid operation due to proprietary protocols and a vertical system restricting data access.

Merging smart meter data with grid measurements is indispensable for comprehensive LV network monitoring.

Yet, this integration's feasibility hinges on addressing two issues: scalability and interoperability.

The scalability challenge arises from the prevalent "centralized" distribution management architecture used by current DSOs. To overcome this, it is essential to adopt a decentralized distribution network management solution. This involves local data analysis and decision-making along the grid, reducing the burden on the central control center. This is possible thanks to the use of edge devices that integrate several use cases, allowing to monitor the status of LV feeders and any faults occurred, the temperature, current and voltage level of the transformer and environmental parameters (temperature, humidity, flooding etc.).

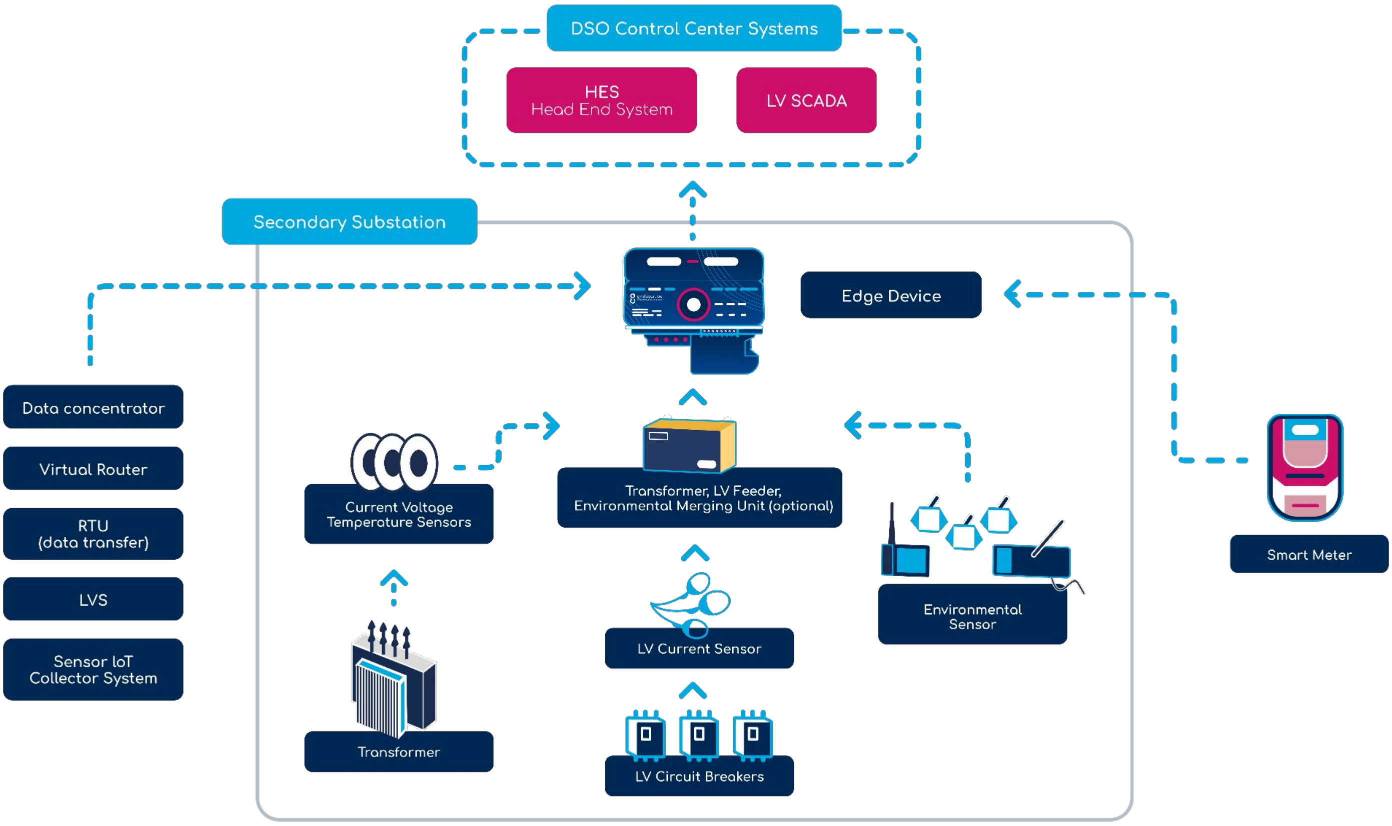
In this decentralized architecture, edge infrastructure (such as distribution transformer substations) becomes the location where metering data and LV grid measurements converge, leading to real-time database aggregation and local analysis.

Only relevant information, such as aggregated values and alarms, is transmitted to the control center in order to transfer data only where necessary, enhancing scalability by reducing communication overhead.

This allows DSOs to have less latency and less expensive bandwidth infrastructure.

Thanks to the adoption of standard protocols (interoperability between different devices) all these outputs can converge to a low voltage SCADA that allows to collect, integrate, and visualize real-time data and measurements from several smart components installed across the low-voltage network (smart boxes, switches, sensors and smart meters).

Thanks to the interconnection with external GIS (Geographic Information System), medium voltage and low voltage networks are shown on a cartographic map, enabling a sort of grid digital twin, tracking how network configuration changes in real time.



Use-cases Addressed by LV Edge Devices

- **Data Concentrator**: the edge device can collect, process and manage data from multiple smart meters. It acts as an intermediary between the smart meters in the field and the central data management system. The data concentrator gathers information such as energy consumption, voltage levels, and other relevant data, consolidating it for efficient transmission to the utility company's backend.

- **LV Supervisor for transformer monitoring**: this use case involves the use of sensors and technology to observe and collect data on the operating conditions of transformers. This data typically includes parameters such as temperature, voltage and current. The goal is to ensure that transformers operate within specified limits and to detect any anomalies or potential issues early on. This function helps to prevent failures, optimize maintenance schedules, and enhance overall reliability.

- **Environment Monitoring of temperature, humidity, flooding**: by implementing environment monitoring in distribution substations, operators can optimize performance, enhance safety, and reduce the risk of equipment failures or environmental incidents.

- **LV Feeders Monitoring**: LV feeders are components that distribute electrical power from a substation to various consumers or loads at lower voltage levels. Tracking voltage, current, power factor, and other electrical characteristics of the LV feeders helps utility companies and operators assess the health and performance of the distribution network, identify potential issues, and optimize the operation of the electrical grid.

LV network digital twin in real-time

Gridspertise

Gridspertise offers grid intelligent devices, end-to-end cloud-edge platform solutions, and services to accelerate the digital transformation of electricity distribution grids across three main areas: metering and grid edge digitalization, network infrastructure digitalization, field operation digitalization.

The Company's portfolio is designed as an open ecosystem, easy to integrate with Distribution System Operators' existing infrastructure, combining intelligent and automated grid devices with ready-to-use modular applications, running at central level as well as on the edge.

The company was set-up in 2021 as a carve-out of Enel's twenty-year-long experience in developing, testing, and scaling up digital technologies to transform legacy distribution networks into smart grids.

Gridspertise is today jointly controlled by the Enel Group and the leading global alternative investment manager CVC Capital Partners.

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