Low-voltage grid management report

Life Is On | Schneider Electric

The European context

The energy transition is driven by the electrification of the supply and of the demand. As a result, there is a significant increase of Distributed Energy Resources (DERs) and Low Carbon Technologies (LCT) Loads connected or waiting to be connected to the Low-voltage (LV) grids of the European Distributed System Operators ("DSOs"). In Europe, the rooftop Photo Voltaic ("PV") represented 66% of the 209 GW installed across the EU at the end of 2022[1]. One of the DSOs interviewed to write this white paper reported a 100% growth year over year of PV sites installed base in residential and small agricultural farms.

The LV grid was designed decades ago to dispatch the power centrally generated down to consumers with predictable consumption patterns. As a consequence, the flow of power was unidirectional and easily forecastable implying well known and proven sizing rules — same for the voltage profile along the LV feeders. Today the energy transition can imply bidirectional, increased, and higher dynamics flows which are more complex to predict and to manage.

There is an increasing need for LV Grid Management (LVGMgt). After medium-voltage grids, the LV grids are indeed the next era of European DSOs' focus, calling for new use cases supporting LV grid planning and operations.

To better understand trends and DSO strategies in Europe, Schneider Electric interviewed nine DSOs and reviewed public reports from over ten DSOs. The following topics were discussed:

1. LV Grid challenges and DSOs' strategies
2. Overview of key use cases
3. Regulations to support LVGMgt and first inputs for business case
4. Available data and solutions within DSOs to support LVGMgt
5. Examples of LVGMgt solutions already implemented in Europe and Australia
6. Conclusion and next steps

Primary conclusions

- 100% of DSOs interviewed are currently working a plan for Low Voltage Management to be deployed in next 3 to 5 years.
- Risks of Customers dissatisfaction is seen as the top #1 challenge by 100% of DSOs.
- Real-time monitoring is listed as the foundation of LVGMgt by 90% of DSOs already facing issues on their LV Grids.

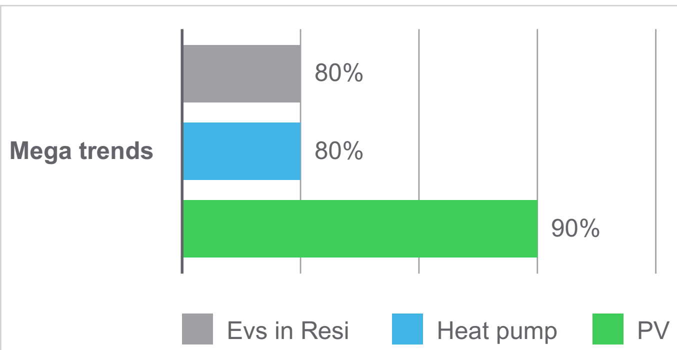
1. Solar Power Europe, Annual rooftop and utility scale installations in the EU

1. LV grid challenges and DSOs' strategies

Mega trends

PV rooftops, heat pumps, and EVs were ranked as the top 3 mega trends impacting the LV Grid.

Note: Those three mega trends are also reported by other DSOs in countries such as UK or Spain.



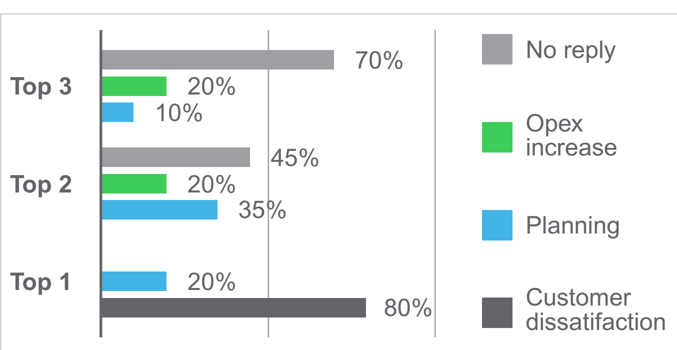
Challenges

Customer dissatisfaction is ranked by 80% of interviewed DSOs as the first challenge.

Planning and Opex increase are seen as the second challenge.

On the topic of customer dissatisfaction, DSOs foresee within the next three years a risk of SAIDI/SAIFI KPI increase from overvoltage at service delivery points and delayed PV connections.

It shall be noted that DSOs in the UK and Spain are already investing in new protections devices to actively decrease SAIDI/SAIFI KPI and Opex indirect costs. This may rebalance to a 50%/50% split between DSOs for the second challenge.



DSOs' plan for LVGMgt

90% of DSOs confirmed that they are working on a LVGMgt plan.

The time horizon for deployment of those strategies and corresponding solutions depends on each European country:

- In very few countries such as in UK, deployment has already started (in 3% of MV/LV substations so far) and should increase above double-digit penetration by Y2028.
- In countries such as Spain and Italy, several DSOs already performed large scale pilots (hundreds of substations) or are adding LVGrid sensors along their MV automation deployment when necessary.
- In other countries, more time is needed for proof of concepts.

2. Overview of key use cases

More than 25 uses cases were discussed with the DSOs. Those use cases can be grouped into the following six categories:

Use case categories	Short description	Example of use case
Capacity management (confirmed by 90% of DSOs)	Use cases are related to the LV grid feeders capacity monitoring in real time.	Monitor real-time LV feeder and transformer capacity.
Outage management (confirmed by 66% of DSOs)	Identify and manage faults occurring on the LV grid feeders from the fuse down to the cable/line.	Fuse blown detection (by phase)
LV flex, load, and gen control (confirmed by 55% of DSOs)	Leverage available control on loads and generation to release constraints on the LV feeders.	Solve grid violation using third party assets control.
LV modeling and simulation (confirmed by 55% of DSOs)	Create a digital twin of the LV grid and of the load and generation connected to it.	Service point delivery and phase mapping
Power quality (confirmed by 35% of DSOs)	LCTs such as PVs or EVs chargers are generating issues with voltage profile but also harmonics.	Check for unbalanced phases and make proposals to correct them.
Asset management (confirmed by 35% of DSOs)	Base and peak flows should increase impacting the aging of the grid assets, so use cases supporting asset management will be needed.	Estimate transformer life expectancy

The above six categories include uses cases supporting grid planning and operations.

Regarding grid operations, the real-time monitoring of feeder heads at the MV/LV substation location appears as the foundation of several other use cases. More than half of DSOs also confirmed that control will be part of their strategy. In some utilities, it should be deployed at same time as monitoring devices are installed.

However, there is one approach to control which differs depending on the sequence of asset types to be used by DSOs (grid or third-party assets). Two groups of DSOs were identified in Europe: about half of the DSOs expect to initially use their own assets, i.e grid assets, to solve constraints in the LV grid before leveraging third party assets through flexibility. The other half will directly use flexibility to manage the constraints on the grid.

As an example, EDP REDES Spain published at Cired in Roma in Y2023 a very interesting article[2] of DSOs willing to first leverage their grid assets before using flex services provided by Prosumers.

2. 2023 Cired round table LV grid – EDP Redes spain vision final

3. Regulations to support LVGMgt and first inputs to business case

Regulations

More than 60% of DSOs mentioned existing regulations dealing with flexibility services, PV connections, PV inverters specifications, and more. With the exception of the UK (RIIO-2), necessary regulations are not yet in place to support LVGridMgt and all use cases listed in next chapter.

70% of the DSOs are expecting new regulations supporting LVGMgt. Some of them are already under definition such as the article 14.a in Germany. Among those regulations, five topics were discussed with the utilities: flexibility, DSO Perf KPIs, DERS and PV integration, and revenue models.

The CapEx-driven model is still dominant in Europe and will lead reinforcement of the LV grid to increase the capacity hosting. This mechanism drives a tariff increase. However, the trend of increased tariffs in Europe will not be sustainable and new solutions will be needed.

Flexibility for LV grid is seen as a valid option in the future. Under the umbrella of flexibility, there are several axes discussed with utilities including grid codes, LV grid connection, or market-based procurement.

First inputs to business case

The entire business case of LVGMgt is under creation. However, a large-scale pilot done by ENWL in UK is already providing some insights. **This three-year project is named "Smart Street[3]"**. It includes the study of the benefits provided by a new architecture deployed at the LV grid level including OLTC, LV breakers, and linkboxes piloted by an ADMS/DERMS.

The overall business case[4] highlights several benefits of energy-saving done by end customers (about £70/year), the release of LV grid capacity (improvement by 30% leading to CapEx deferral), and reduced network losses. Net present value for 180 MV/LV substations is estimated at £16,55M by 2030 and £49,71M by 2050.

ENWL also estimated greenhouse gas emission reductions of 7% to 10%.

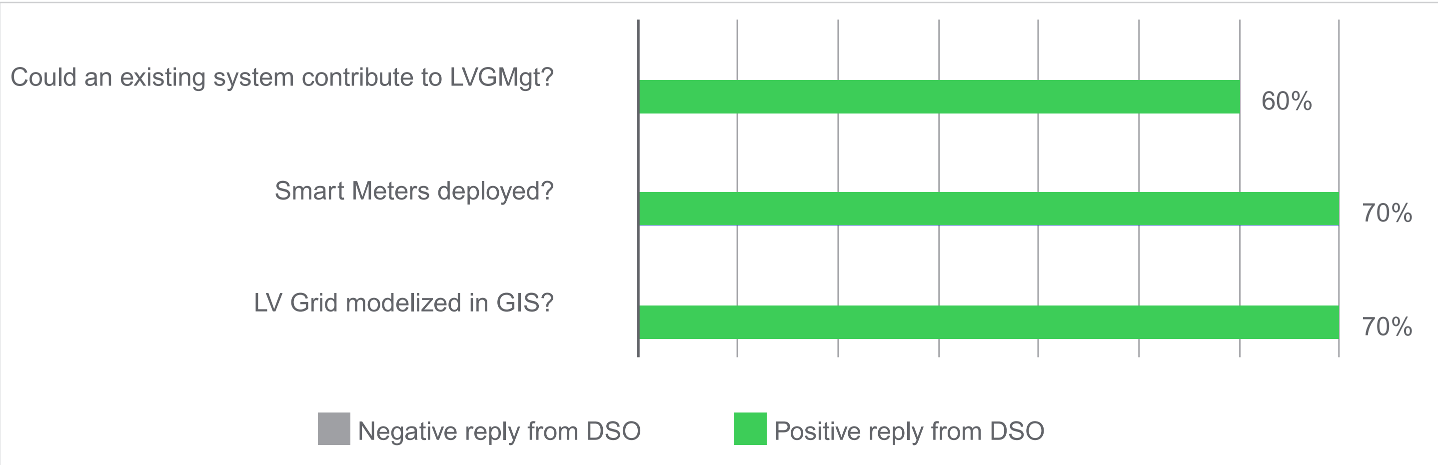
The Smart Street initiative is seen as the first step in autonomous LV network Management.

3. Smart Street project / ENWL

4. Distribution Network Operator Innovation Roll-Out Mechanism (IRM) Submission Pro Forma

4. Available data and solutions within DSOs to support LVGMgt.

Having in mind the challenges and expected use cases to support LVGMgt, we surveyed DSOs on their existing capabilities to access necessary data through their existing systems.



The number of interviewed DSOs with an LV grid already modelized in their GIS is relatively high. We do not know whether it is representative of the majority of the European DSOs. It shall also be noted that quality of data should likely be at stake even if 45% of interviewed DSOs are confident in the quality of their data.

Deployment of smart meters is already well advanced in Europe (starting in Germany). With the exception of the UK, DSOs have direct access to the data. A PLC-based AMI such as in Spain, France, and Italy provides interval data over night and alarms in near real-time. A new generation of smart meters was installed in the Nordics with higher performance up to load collection every 15 minutes from LTE-4M smart meters. **Smart meters are useful for several use cases related to grid planning. However, 55% of interviewed DSOs confirmed that real-time monitoring was a preferred solution for grid operations**. The same analysis is also valid in UK.

DSOs running a modern ADMS underlined their willingness to extend this solution to the LV Grid. Some of them in the Nordics or in Germany already did it for some LVGMgt use cases.

5. Examples of LVGMgt use cases already implemented in Europe and Australia

Southern Europe: real-time monitoring use case

Real-time monitoring of LV feeder heads is a fundamental use case. It is performed either through the installation of standalone sensors or along MV automation. For instance, some DSOs have deployed a Schneider Electric MV/LV RTU solution called T300 with necessary LV sensors. Using the communication capabilities of the T300 to their ADMS, DSOs are optimizing their Opex.

In the near future, devices such as the T300 will be virtualized, and edge computing capabilities will be added. It should unblock several LVGMgt use cases.

Australia: dynamic operation envelop use case

In southern Australia, DSOs such as SAPN or Evo Energy are running their grid with a high penetration of residential PV roof top. For instance, approximately 35% of SAPN customers have a PV system installed[5].

Since the 1st of July 2023 and in line with the SA Government Dynamic Export requirements, SAPN kicked off the roll out of the Flexible Exports trial. In the selected areas, customers willing to install or to upgrade PV installations will have the choice to be limited at 1,5 kW export by phase, or to connect their inverter through the internet in order to receive Dynamic Envelop on daily basis from the DSOs. It will allow them to export up to 10 kW per phase.

From the DSOs perspective, numerous calculations are performed thanks to their DERMS system. In summary, the load and generation will be forecasted and an estimate of the load flows will be performed. In the case of a potential grid rules violation, the DERMS will limit the PV export and send setpoints to the PV inverters. For further information, the following reports are publicly available:

https://www.evoenergy.com.au/emerging-technology/initiatives/der-integration-and-automation

https://www.sapowernetworks.com.au/industry/flexible-exports/

https://www.sapowernetworks.com.au/connections/connect-solar-and-ev-chargers/flexible-exports-eligibility/

https://youtu.be/rNE2cHN-_es?si=xvpeNY3t7PdG2Igo

5. SA Power Networks Distribution Annual Planning Report 2022/23 to 2026/27

Conclusion

LVGMgt is driven by the energy transition: Electrification started with the supply side thanks to the renewable generation, and will continue with the demand side through the electric vehicles or heat pumps. DSOs are interconnecting both sides thanks to the grid and their LV grid. Consecutive constraints on the infrastructure call for active management of the LV grid.

Although the need for active management of the LV grid is just emerging, there is a consensus under creation among the interviewed utilities for a list of use cases and a new and complete architecture from the MV/LV substation up to the enterprise level. MV/LV substations should also apply the virtualization of automation devices with edge computing capabilities.

The LVGMgt domain should be an area of innovation for the next decade with major disruptions at all levels deployed by DSOs to support the energy transition.

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