SUCCESS STORIES

optima.smart, phase balancing to resolve low voltage grid congestion

The increasing integration of self-consumption photovoltaic generation, electric vehicles and other single-phase loads is increasing unbalance in low voltage grids. When generation and consumption are not evenly distributed across the phases, effects arise that limit grid performance and affect power quality, including overvoltages on some phases and undervoltages on others, power quality events, high neutral currents and increased technical losses.

In many cases, the power quality events affecting customers are not caused by inadequate voltage at the transformer station, but by a local issue: the uneven distribution of loads across phases. For this reason, acting only on voltage at the transformer station does not resolve them.

optima.smart is a power electronics solution installed on low voltage lines that transfers energy between phases in real time, without supplying or consuming net energy from the grid (except for equipment losses, approximately 3%). In this way, it reduces voltage unbalance both upstream and downstream of its connection point.

Unlike a voltage regulation solution at the transformer station, **optima.smart** acts locally along the line where the unbalance is concentrated.

This solution has **two main benefits:**

- **Voltage unbalance reduction**

The first evidence of optima.smart's impact is the reduction in unbalance at its connection point and, as a direct consequence, the balancing of phase voltages.

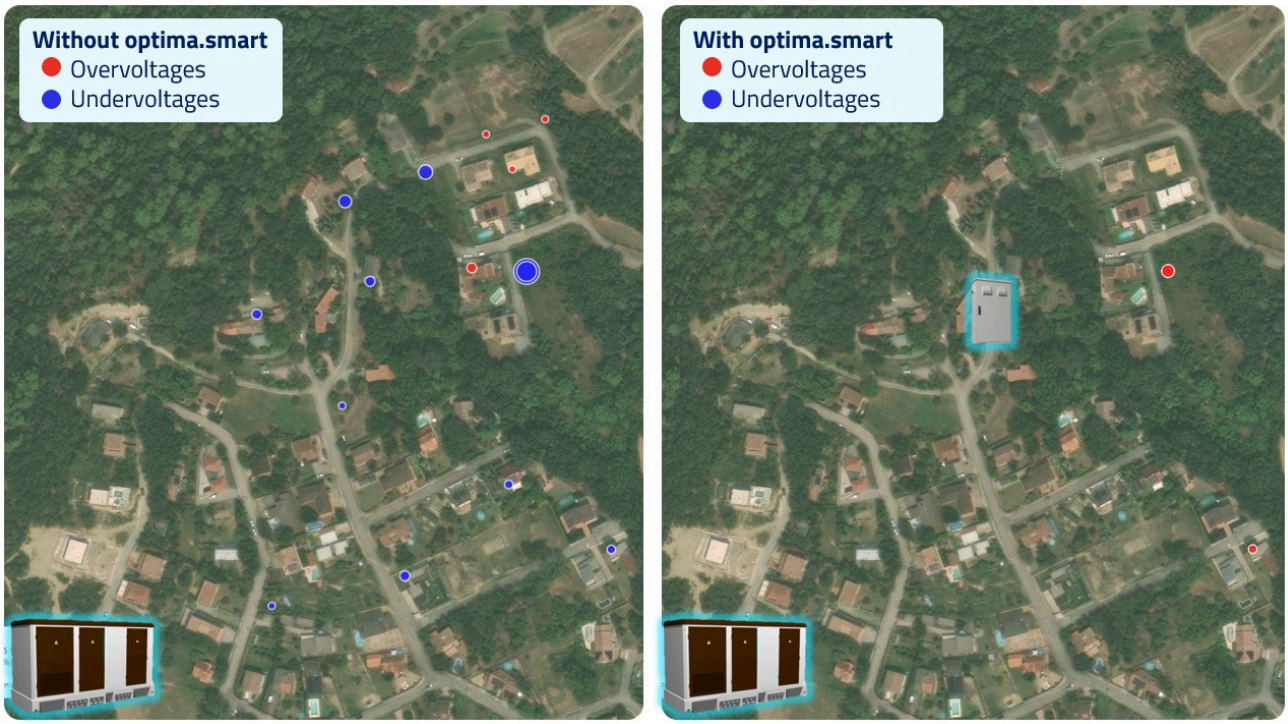


Commissioning tests at one of the pilots analysed provide a clear comparison between both scenarios. Before the equipment was activated, voltage unbalance reached values close to 11%, with significant differences between phase voltages: one phase dropped to 215 V, while the other two recorded values well above 240 V.

Once optima.smart is in operation, average voltage unbalance at the connection point remains at around 0.1%, well below the 2% reference value established by UNE-EN 50160. As a result, the voltages of the three phases converge and show virtually identical behaviour.

In the pilots analysed, a significant proportion of the recorded events was directly associated with voltage deviations caused by phase unbalance. Consequently, after optima.smart was commissioned, the number of recorded events was reduced by up to 94%, while their cumulative duration was reduced by more than 95%.

This behaviour differed at each site. In one case, undervoltages associated with phases operating at lower voltage levels predominated; in the other, the main issue was overvoltages caused by one phase operating at higher voltage levels. Although the specific situations were different, both originated from an uneven distribution of loads and generation across the phases.





The figures above show that, before the equipment was installed, overvoltage and undervoltage events were distributed across a large part of the grid, with some customers experiencing a high number of events. After optima.smart was installed, the number of affected customers was significantly reduced and the remaining events were concentrated at specific points in the grid.

Therefore, the main effect of optima.smart is not only the direct elimination of power quality events, but also the mitigation of the phase unbalance that causes many of them. Once this unbalance has been reduced, the remaining events can be more clearly attributed to other grid-related causes, making them easier to identify and enabling specific corrective measures to be defined.

- **Neutral current reduction and lower losses**

In a four-wire low voltage grid, phase unbalance causes current to flow through the neutral conductor. This current generates conductor losses through the Joule effect.

On the lines analysed, before **optima.smart** was deployed, neutral current could exceed phase current. By improving phase balancing, **optima.smart reduces the current flowing through the neutral conductor and decreases current differences between phases, directly reducing the technical losses associated with these conductors.**

Results:

- Voltage unbalance reduced to **around 0.1%.**
- Up to a **94% reduction in the number of power quality events and a reduction of more than 95% in their cumulative duration** in the cases analysed.
- Lower neutral current and reduced associated technical losses.

Conclusion

optima.smart addresses one of the main challenges arising from the large-scale integration of single-phase resources into low voltage grids: voltage and current unbalance between phases.

Its operation improves voltage balancing along the line, promotes a more even distribution of load and helps mitigate the power quality events associated with this phenomenon. It also enables better use of existing infrastructure capacity and facilitates the integration of new loads and distributed energy resources.

Once the effects of unbalance have been mitigated, the DSO can more clearly identify other phenomena affecting the installation and prioritise specific actions to address the causes that continue to constrain grid performance.

Testimonials

> optima.smart is a solution that addresses the grid's dynamic challenges dynamically, solving issues that traditional static solutions cannot. Everything changes, including the way electricity is consumed. The integration of distributed generation or loads such as EVs cannot be properly addressed with traditional solutions, whereas this type of device adapts its behaviour to the grid's dynamic changes – **UFD.**

> By installing optima.smart, we have reduced unbalance on the LV line, optimising the voltage profile and limiting the current flowing through the neutral conductor and the associated losses. This experience has enabled us to positively assess the potential of this solution to facilitate the integration of new demand and generation into the low voltage grid – **CMH.**

> The implementation of optima.smart has virtually eliminated undervoltage issues, reducing the time outside regulatory voltage limits by almost 90%. It has also reduced current imbalance by 80.6% and neutral conductor current by 64.2%, relieving the most heavily loaded phase and cutting thermal losses by more than one third. The result is a more stable grid with greater available capacity, without the need to reinforce existing cabling or oversize the transformer**. – Bassols.**

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