

# **Integration of PV and EVs in unbalanced residential LV networks and implications for the smart grid and advanced metering infrastructure deployment**

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**Abstract—** Voltage unbalance is a relevant problem that causes a less efficient operation of the system due to higher energy losses and lower hosting capacity. Unbalance has been often neglected by distribution system operators (DSOs) due to the lack of monitoring data in the low voltage (LV) grid. However, the massive deployment of smart metering in recent years in many countries provides DSOs with very valuable information to detect unbalance. Moreover, in the current context of increasing presence of single-phase distributed energy resources (DER) connected to LV networks, such as electric vehicles (EVs) and photovoltaic (PV) generation, unbalance is bound to increase.

This article presents the technical assessment of the expected impacts of future integration of EV and DG in the LV network. Three-phase loadflow analyses has been carried out to evaluate energy losses and voltage profiles in in various rural and semi-rural residential LV grids in the presence of different degrees of phase unbalance and varying penetration degrees of PV and EV. Furthermore, this work discusses the implications for the deployment of supervision and monitoring solutions based on advanced metering infrastructure (AMI). Their implementation should be prioritized in more loaded and longer networks where high integration of DER is expected so that unbalance can be detected and corrective actions can be applied.

**Index Terms—** Advanced metering infrastructure, electric vehicle, electricity distribution, photovoltaic generation, unbalance.

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