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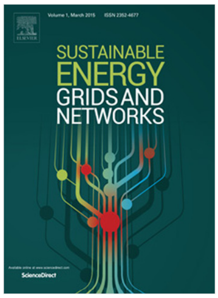

Lessons learnt from real-time monitoring of the low voltage distribution network

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Lessons Learnt from Real-Time Monitoring of the Low Voltage Distribution Network

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***Abstract*—Up to now, the evolution of the distribution network toward the smart grid model has been essentially focused on two non-intersecting areas: medium voltage network automation and smart metering. The former one is mainly focused on improving the quality of service, studying and deploying fault location, isolation and service restoration systems, while the latter has been addressed to improve the customer relationship management, promote the customer awareness and enable new smart home services. In most cases a deep investigation of the low voltage network has been left disregarded, even if it represents the asset bridging the medium voltage level up to final customers. This network segment is probably the most affected by regulatory actions promoting intermittent renewable generations, distributed storage, heat pumps and the growing diffusion of electric vehicles utilization. The paper describes a field demonstrator of the FP7 European project IDE4L, where an extensive analysis of the low voltage network has been performed by means of an innovative use of smart meters and the installation of sensors on the medium-to-low voltage substation.**

***Index Terms*--smart grid, low voltage network, smart metering, distributed measurement system.**

I. Introduction

THE transition towards smart grids has gradually taken place in several areas of Distribution Networks (DNs). Solutions and systems already applied in transmission networks have been progressively integrated at the Medium Voltage (MV) level of DNs, scaled-down in terms of features and costs to meet their requirements. A typical example of such evolution is represented by the increase in monitoring and control technologies for MV level applications [1]. Fault Location, Isolation and Service Restoration (FLISR) technologies are one of those that have gained sustained attention in the past few years. FLISR solutions have been investigated from both a theoretical and practical viewpoint and they are now at a deployment stage [2], [3].

The overall interest of Distribution System Operators (DSOs) to realize reliable MV networks is motivated by the opportunity to have reduce power losses and customer inconvenience from power disruptions. Moreover, in several countries, better performance is also encouraged by Performance-Based Regulation (PBR), in which incentives are tied to specific metrics of service quality [4]. The application of a similar approach to voltage quality is under evaluation by some regulation authorities [5] and some authors have already started to investigate this field [6].

Other than MV networks evolution, also smart metering initiatives have been promoted as a way to improve customers' relationship management and to foster their awareness on their energy habits [7]. Indeed, awareness is considered a first significant step toward a better energy consumption [8]. Smart house services can then take advantage from the availably of customer's energy data to boost this process, providing benefits for the whole energy system, too [9]. A significant portion of the whole electricity consumption is indeed related to houses, and a clever load management can greatly improve the power systems performance. To this end, Demand-Side Management (DSM) mechanisms [10] can be applied. These technologies are designed not just to reduce customers' bills, to save energy or to improve customers' comfort, but also to use energy in a more efficient way by means, for example, of load shifting to off-peak hours, demand adaptation to renewable sources supply, reactions to emergency conditions [12].

In smart grids studies and implementations, one of the least explored field is represented by the Low Voltage (LV) network, the infrastructure spanning from Secondary Substations (SSs) up to final customers. This segment is probably the most affected one by international regulatory changes that are promoting Renewable Energy Sources (RESs), as a way to reduce greenhouse gas emissions, diversify the energy supply, diminish the dependence on imported fuels and, more in general, allow the transition to more sustainable energy paradigms [13]. Despite these obvious benefits, the integration of RESs represents a major challenge: renewable generation is variable and uncertain [14]. Therefore, the wider and wider presence of RESs is making the management of the LV network more and more difficult [15]. Thus, monitoring the real operating conditions of the LV networks in terms of power flows, phase unbalances, voltage levels and other power quality indicators becomes essential

to efficiently operate these kinds of networks.

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