PhD thesis:
"Power Losses Estimation and optimization in low-voltage large-scale smart grids"

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Abstract

Sustainability is a key aspect to ensuring a safe, reliable and affordable energy system for the future. In low voltage distribution networks, this can be achieved by means of an adequate incorporation of renewable-based distributed energy resources such as Photo-voltaic panels, Electric Vehicles and Energy Storage, as well as and a better understanding of the network's behaviour in terms of power losses and use of electricity.

In the last decade, distribution utilities have deployed smart metering infrastructure to improve the knowledge of the networks in terms of load demand and network state. These means that new useful and valuable data is available from customers consumption, network use, and power flows. This data can be transformed into valuable knowledge with development of new tools and methods based on machine learning.

Smart grids normally operates in unbalanced conditions due to the fact that the customers are not connected equally between phases (single-phase loads). This means that simplified models that only considered single-equivalent are not valid, and the three-phase models has to be considered in order to calculate the power flows in the network and so to evaluate the amount of power losses.

The integration of those resources also could lead to contingencies such as over-voltages and overloading if is not well planned. Additionally those resources exhibit a intermittent behaviour, for instance PV production depends on the weather conditions, solar radiance and ambient temperature. This fact introduce a considerable am mount of uncertainty in the operation of the distribution networks. In the demand-side, some customer's smart metes could also report consumption pattern with high dispersion due to metering or changes in the customers behaviour. Therefore uncertainty has to be explicitly be considered in the methods and algorithms used to operate the network.

To allows and optimal integration of distributed resources and guarantee quality power supply, flexibility mechanism are introduced in the smart grids in both demand side and generation side. In demand side the mechanism are known as demand-shift and consist in move the energy consumption from early and late hours to the central hours, where the maximum peak of PV power generation is injected. In the generation side, the peak of power generation is curtailed changing the power factor of the inverter AC/DC that connected the PV array to the network.

By doing this, the amount of active power introduced in the network is reduced and so the local power losses.

This thesis raised from two main smart grids research projects: European project IDE4L and the national project OSIRIS.

The main contribution of the thesis are two-fold:

- Power losses estimation in unbalanced large-scale smart grids with high penetration of distributed resources
- Robust flexibility scheduling in unbalanced smart grids under uncertainty