PhD Program in Computer Science and Systems Engineering, XXX
Cycle 2015-17, DIBRIS, University of Genova

Proposal of Research Theme: Sustainable planning and control of distributed power and energy systems

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Research area(s): Sustainable energy and environmental systems, optimization, smart grids, distributed control, hierarchical control, optimal control.

Description:
The increase in the use of renewable energies, the emergence of distributed generation and storage systems, and, in general, the concept of “smart grids”, have given rise to the necessity of defining new decision and control schemes for planning and management purposes. Currently, a major challenge is represented by the lack of a unified mathematical framework including robust tools for modeling, simulation, control and optimization of time critical operations in complex multicomponent and multiscaled networks. The difficulty of defining effective real time optimal control schemes derives from the structure of a power grid, and, specifically, from the presence of several issues: renewable and traditional power production, bidirectional power flows, dynamic storage systems, demand response requirements, and stochastic aspects (such as uncertainties in renewable, prices, and demand forecasting). This results in optimization problems, which are generally intractable within a real time optimal control scheme, if all components of the whole system are represented at a full level of detail. Moreover, the new regulation related to new market entrants and schemes requires a revision and improvement of distributed energy management systems planning and management, as well as their coordination in order to optimize self-consumption and energy distribution.

The proposed PhD research activity will fall within this framework and has the objective of developing and applying tractable approaches for planning and optimal control, taking into account stochastic issues (i.e., intermittent renewables, demands, prices) and considering different possible architectures (multilevel, decentralized, distributed). In particular, the formulation of the optimization and control problems will be based on realistic electrical models, considering both active and reactive power, as well as stability and protection requirements. Moreover, different energy distribution systems will be taken into account in relation to polygenerative systems: district heating, buildings heating and cooling, with the associated storage systems, water, and gas distribution networks. Finally, different kinds of demands will be taken into account (heat, cool, electricity), as well as electrical vehicles with charging/discharging cycles within a smart grid.

References

