Research theme title:
Distributed control of networked smart energy systems

Description:

A powerful solution contributing to the coveted green transformation is represented by the so-called energy community and zero/positive energy districts, i.e., groups of users located in a specific reference area, where all stakeholders –such as end-users, market players, practitioners, planners, and policymakers– actively cooperate to develop 'smart' energy systems, promoting the optimal exploitation of renewable sources and widespread use of distributed storage, and enabling the application of pervasive measures oriented to a neutral energy balance. Following this paradigm, several communities have explicitly stated specific objectives to transform their underlying energy systems into sustainable networks of self-sufficient prosumers and prosumagers. The added-value of these networked smart energy systems (NSESs) goes beyond economic benefits to wider sustainability payoffs, for instance, deferring the need of grid extension. Nevertheless, the full implementation of NSESs present various barriers. First, an organizational paradigm for the management of interdependent energy activities has to be defined according to predefined goals. However, independently from the implemented architecture, the success of NSESs relies on how the energy systems are optimally controlled. After all, final users expect a tangible financial and even higher sustainability reward from the operation of NSESs. As a consequence, the necessity of developing effective and optimal control frameworks tackling such an expected objective is imperative.

Overall Objective
The increasing energy demand and penetration of distributed generation and storage as well as the growing shift from traditional schemes to aggregative complex entities (i.e., NSESs) imposes a severe degree of complexity to power grids, thus requiring a radical change. Energy systems need to be arranged in intelligent networks, capable of receiving two-way energy flows, making producers and consumers interact in accordance with energy trading and sharing mechanisms, and determining consumption/generation/storage profile in advance. In this perspective, each energy system become a smart resource node within a networked virtuous infrastructure.
The overall objective of the PhD project is thus to define new control architectures and frameworks for NSESs, as enabling tools to transform the grid from a rigid system to a flexible and sustainable asset. In particular, control mechanisms integrating optimization, game theory, and learning will be developed aimed at making NSESs capable of conveniently trading local energy exchanges, optimally sharing common energy resources, leveraging on loads flexibility, pursuing instantaneous self-consumption, while reducing overall costs and improving sustainability

References:
Mignoni, N.; Scarabaggio, P.; Carli, R.; and Dotoli, M. "Control Frameworks for Transactive Energy Storage Services in Energy Communities," Control Engineering Practices, 130, 105364, 2023. doi: 10.1016/j.conengprac.2022.105364.
Scarabaggio P.; Carli, R.; Dotoli, M., "Noncooperative Equilibrium Seeking in Distributed Energy Systems under AC Power Flow Nonlinear Constraints", IEEE Transactions on Control of Network Systems (TCNS), vol. 9, no. 4, pp. 1731-1742, Dec. 2022, doi: 10.1109/TCNS.2022.3181527.
Carli, R.; Cavone, G.; Pippia, T.; De Schutter, B.; Dotoli, M., "Robust Optimal Control for Demand Side Management of Multi-Carrier Microgrids", IEEE Transactions on Automation Science and Engineering (TASE), vol. 19, no. 3, pp. 1338-1351, 2022. doi: 10.1109/TASE.2022.3148856.
Scarabaggio P.; Grammatico S.; Carli, R.; Dotoli, M., "Distributed Demand Side Management with Stochastic Wind Power Forecasting", IEEE Transactions on Control Systems Technology (TCST), vol. 30, no. 1, pp. 97-112, 2022. doi: 10.1109/TCST.2021.3056751.
Hosseini, S. M.; Carli, R.; Dotoli, M., "Robust Optimal Energy Management of a Residential Microgrid under Uncertainties on Demand and Renewable Power Generation," IEEE Transactions on Automation Science and Engineering (TASE), vol. 18, no. 2, pp. 618-637, 2021. doi: 10.1109/TASE.2020.2986269.

Type of scholarship:
DM 118/2023 – Project on PNRR (Italy's Recovery and Resilience Plan)

Hosting University
Polytechnic of Bari, Italy

Contacts:
Prof. Mariagrazia Dotoli (mariagrazia.dotoli@poliba.it) (*Polytechnic University of Bari*)
Prof. Raffaele Carli (raffaele.carli@poliba.it) (*Polytechnic University of Bari*)