Massimiliano Ferrara

Integration of hydrogen technologies in distribution grids

Tutors: Prof. F. Mottola, Prof. D. Proto
co-Tutor: Eng. Antonio Ricca (ENEA)

Cycle: XXXIX Year: Second

Candidate's information

- M.Sc. degree in Electrical Engineering – Università degli Studi di Napoli Federico II
- DIETI Research group: Power Systems (IIND-08/B)
- PhD start date: 01/11/2023
- Scholarship type: company-funded scholarship
- Partner company: ENEA Research Centre, Portici
- Periods abroad: 2 months, at Haute École d'Ingénierie et de Gestion du Canton de Vaud (HEIG-VD)
- Periods in company: 7 months

Summary of study activities

Ad hoc PhD courses:

- **Solar cells: modelling and applications**: course on solar cells and photovoltaic modules modelling, with highlights on fault detection and elements of LTSpice simulation.
- **I pilastri della trasformazione digitale**: wide-spanning course teaching the concept of interoperability and fundamental Europen and Italian regulatory notions at the basis of modern digital transformation projects.
- **Matrix Analysis for Signal Processing with MATLAB Examples**: course teaching fundamental matrix analysis theoretical notions and showing how they can be applied to solve real signal processing engineering problems.

Summary of study activities

Doctoral schools:

- **Hydrogen Summer School 2025 – ENEA**: “Progetti sull'Idrogeno: Innovazione e Sostenibilità”.

Seminars:

- I attended 16 seminars, for a total of 5,5 credits. Full list on TRAR.

Research areas

My research revolves around the topic of "**green hydrogen**", i.e., hydrogen that is produced through the electrolysis process, using energy provided by renewable sources.

The main focus is on the development of **planning and control strategies** for the **integration of hydrogen** production, storage, and re-electrification technologies in the power system.

Research activity: context

Green hydrogen is a **promising energy vector**:

- decarbonization of hard-to-abate industry sectors
- use in the transport sector
- seasonal energy storage

However, the **development** of a green hydrogen economy **is falling behind** compared to previous growth estimates, mainly due to high technology costs and slow-rising demand.

Solutions to these problems can be found in:

- better coordination with other distributed energy resources (DERs)
- leveraging incentive schemes
- optimized sizing of the devices
- participation in ancillary grid services

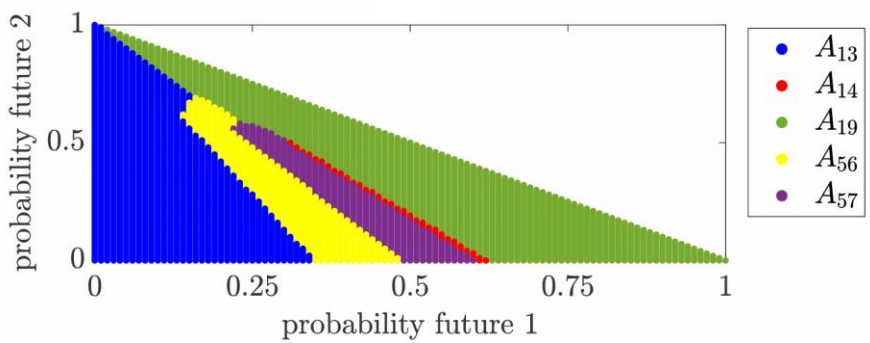
Research activity

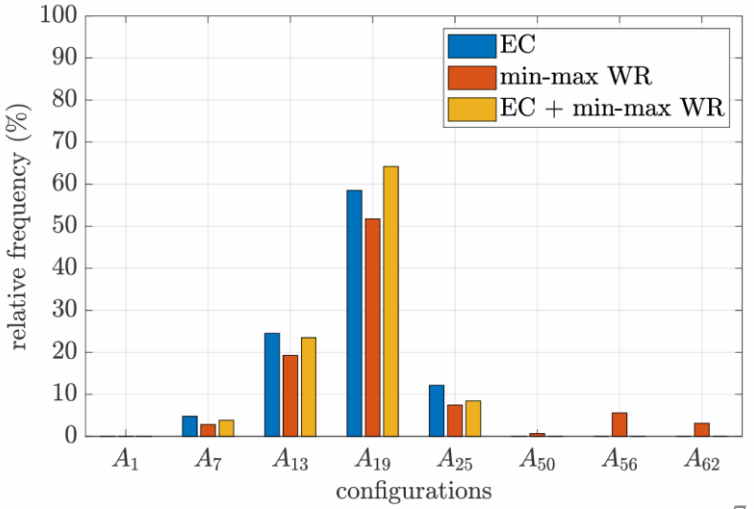
Sizing of electrolyzers and batteries accounting for uncertainties

- **Objective:**

Definition of an optimal sizing tool for an electrolyzer (EL) and a battery participating in a Renewable Energy Community (REC), accounting for uncertainties on renewable generation, load demand, and electricity price.

- **Methodology:**
  - Scenario analysis based on life cycle MILP simulations;
  - Application of Decision Theory criteria: *expected cost*, *min-max weighted regret*, *stability areas*.





Research activity

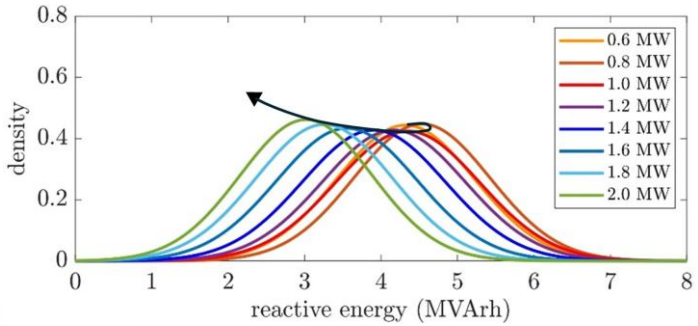
Scheduling of distributed resources accounting for uncertainties and participation in voltage regulation

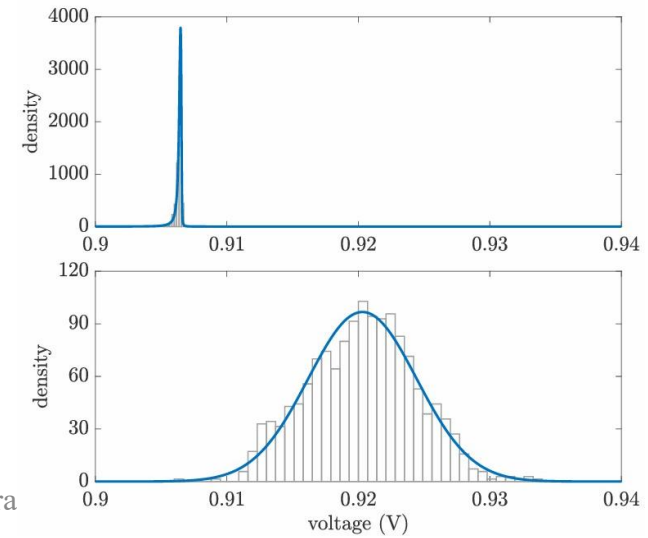
- **Objective:**

Probabilistic study on the participation of ELs and other DERs in the voltage regulation service, in the context of RECs.

Assessment of the effects of different reactive power procurement methods at increasing renewable penetration levels.

- **Methodology:**
  - MILP formulation of optimal scheduling problems;
  - Modelling of capability curves, and centralized and decentralized reactive power procurement;
  - Montecarlo simulations.





Research activity

Sizing, control, and performance evaluation of a P2H2P system with participation in frequency regulation

- **Problem:**

Participation in frequency regulation services can increase the economic viability of ELs and FCs. However, in a full Power-to-Hydrogen-to-Power (P2H2P) configuration, the allocation of capacity to this purpose needs to account for seasonal storage objectives and, potentially, battery competition.

- **Objective and methodology:**

Proper assessment of the value of ancillary services for green hydrogen devices, by means of the definition of an optimal planning strategy for a P2H2P system providing seasonal storage and frequency regulation services to the grid.

This work is ongoing, and it is the topic of my research period abroad at HEIG-VD.

Research products

[J1]	Ferrara, M., Mottola, F., Proto, D., Ricca, A., Valenti, M., *Integrating Green Hydrogen Production and Electrical Energy Storage in Energy Communities Under Uncertainty,* **Applied energy,** (under review)
[J2]	Ferrara, M., Mottola, F., Proto, D., *Enhancing Voltage Regulation through Renewable Energy Communities under Uncertainty,* **IEEE Transactions on Industry Applications,** (submitted)

Third year plans

- Completing the multi-vector system control application developed at HEIG-VD, with Python implementation
- Deeper study of the benefits of ancillary services for hydrogen technologies
- Laboratory activities at ENEA:
  - Direct tests on electrolyzer + metal hydride storage system
  - Implementation of control strategies in grid emulation environment
- PhD thesis writing.

Thank you for your attention!