Institut de Robòtica i Informàtica Industrial

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UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

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Optimization-based control of renewable hydrogen production, storage and dispatchment systems for the transport sector

Author: **Pol Cardona**

Supervisor(s): **Maria Serra and Carlos Ocampo-Martinez**

MOTIVATION

- Hydrogen Refuelling Stations (**HRSs**) development is **pivotal** for the **adoption** of Fuel Cell Electric Vehicles (**FCEVs**), which are seen as the future of **sustainable mobility**.
- **HRSs** are Multi-Energy Systems (MESs) where **optimization-based operational** schemes are suitable for **lowering** CO2eq **emissions**, **maximize profit** and provide **safe** and **integrated operation**.
- **HRSs** are complex systems with **diverse** plant **topologies** and **specifications** (multi-storage, multi-compressors, multi-dispensers, etc.).
- **HRSs** provide **on-site** and **off-site hydrogen supply** topologies that can be **coupled** with **renewable energy sources** (RESs).

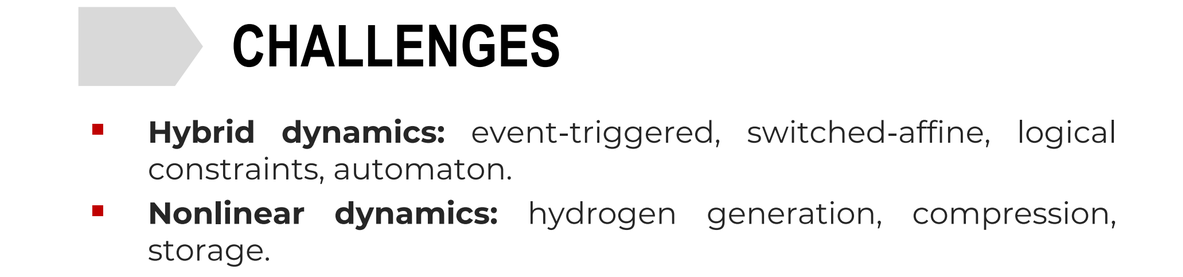
OBJECTIVES

- **Study** the **renewable hydrogen infrastructure** for the transport sector.
- **Identify** and/or **determine** interdependencies, **constraints**, **methods** and **KPIs** across **HRS** topologies, modelling and operational methods.
- **Develop** an HRS **optimization-based operational methodology** that is modular, **flexible** and **practical** for the current scenario and integrated future of H2 infrastructure.

CHALLENGES

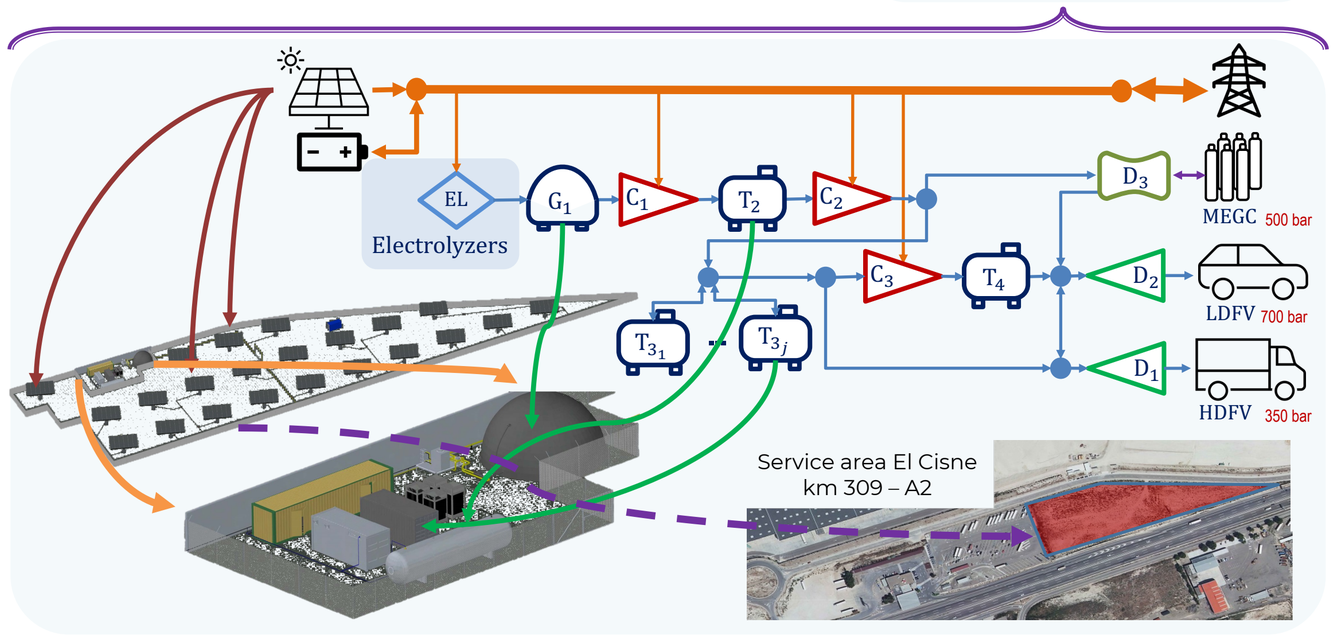
- **Hybrid dynamics:** event-triggered, switched-affine, logical constraints, automaton.
- **Nonlinear dynamics:** hydrogen generation, compression, storage.
- **Uncertainty:** hydrogen demand (time and magnitude), renewable energy, suppliers availability and price.
- **Topologies:** non-standardized HRS plants.
- **Modelling:** diverse approaches for simulation or control-oriented HRS modelling.
- **Integration:** communication and influence on suppliers and customers are crucial for optimizing resource allocation, either with a single HRS or multiple HRSs in a network.
- **Methods:** Centralized Model Predictive Control (C-MPC) and Decentralized MPC (D-MPC) schemes tailored for real HRS applications are not developed.

WORK PLAN



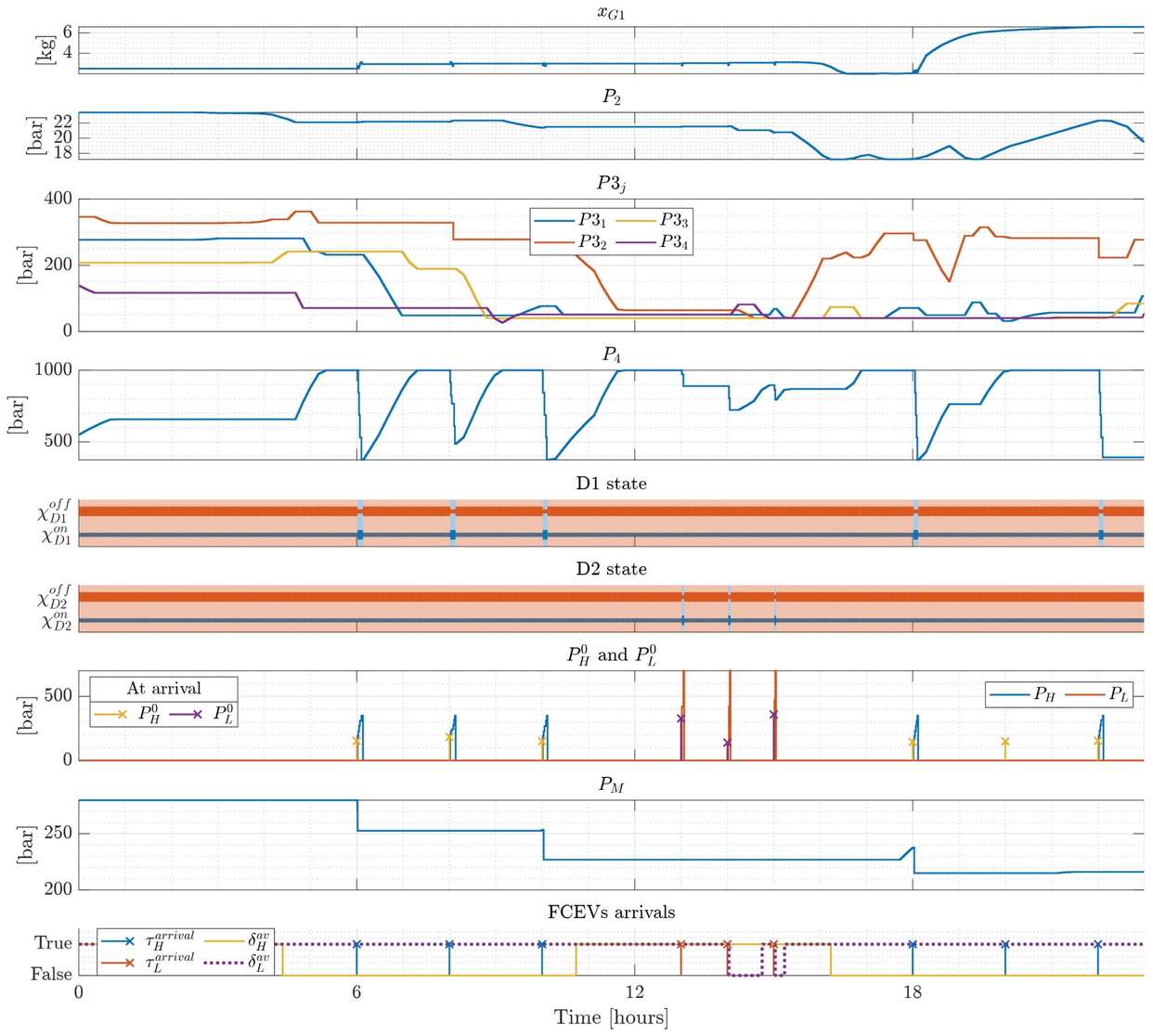
OPPORTUNITY

- Project **PTI-TRANSENER+ [TRE2103000]** is developing a renewable grid-connected flexible HRS testing facility in Zaragoza, Spain, the first in Spain with comparable specifications.



CURRENT RESULTS

- **Hybrid Model Predictive Control**: Horizon=4h; Solver=Gurobi; Ts: 10min; Control-Oriented Model: Mixed-Logical Dynamical (MLD), Solver Time: < 1min. Demand arrivals and initial pressure is unknown
- Simulation-oriented model: MLD: Ts: 1min



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Research Plan defense: October 2026

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Publications

[1] Cardona, P.; Costa-Castelló, R.; Roda, V.; Carroquino, J.; Valiño, L.; Serra, M. (2023): **Model predictive control of an on-site green hydrogen production and refuelling station**. International Journal of Hydrogen Energy 48 (47), pág. 17995–18010.

[2] Cardona, Pol; Costa-Castelló, Ramon; Roda, Vicente; Carroquino, Javier; Valiño, Luis; Ocampo-Martinez, Carlos; Serra, Maria (2024)**: Modelling and operation strategy approaches for on-site Hydrogen Refuelling Stations**. International Journal of Hydrogen Energy 52, pág. 49–64.