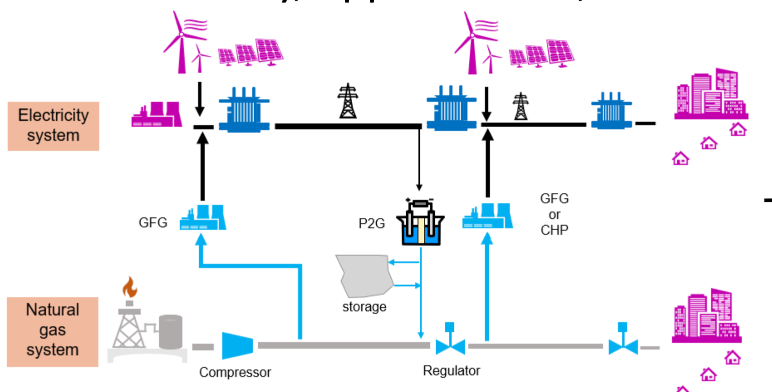
Decarbonising Gas: Building Models for Gas Networks Transition

UNIVERSITÀ DEGLI STUDI FIRENZE

THE UNIVERSITY OF MELBOURNE

1 - Overview and Motivation

- Low carbon fuels like H_2 emphasise the existing **interdependencies between energy infrastructures** [1].
- The differing properties of NG and H_2 necessitate **tailored models** to investigate the feasibility, opportunities, and risks of **future low-carbon gas networks** [2].



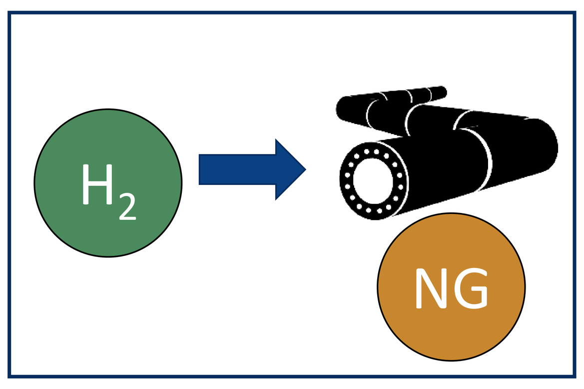
Detailed Networks Modelling

H_2 Blending Analysis

Net-zero targets

5 - Hydrogen Blending in Gas Networks

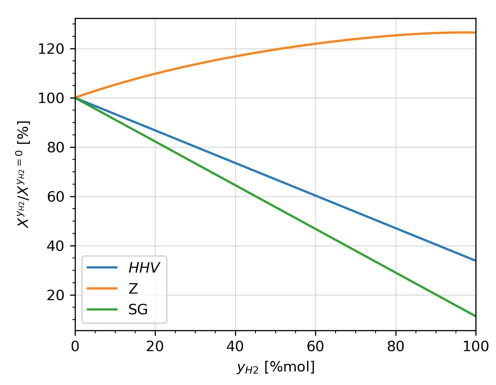
- Injecting H_2 in gas pipelines affects network operation



Adequacy

Reliability

Flexibility



- Can operators boost networks decarbonization while ensuring system safety?

Simulation and Optimization Gas Network Frameworks

2 - Gas Network Modelling Methodology

Data collection → Tool → Validation

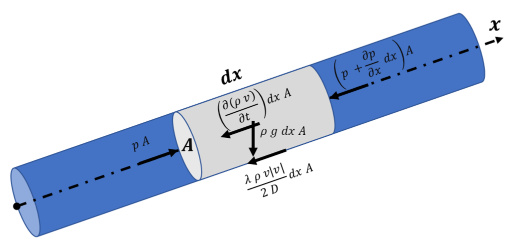
Topology

Geometry

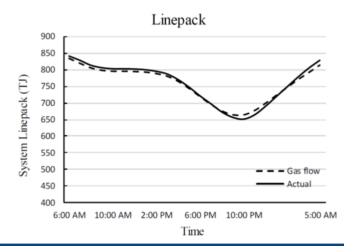
Constraints

Gas Demand

Gas Pipeline Hydraulics

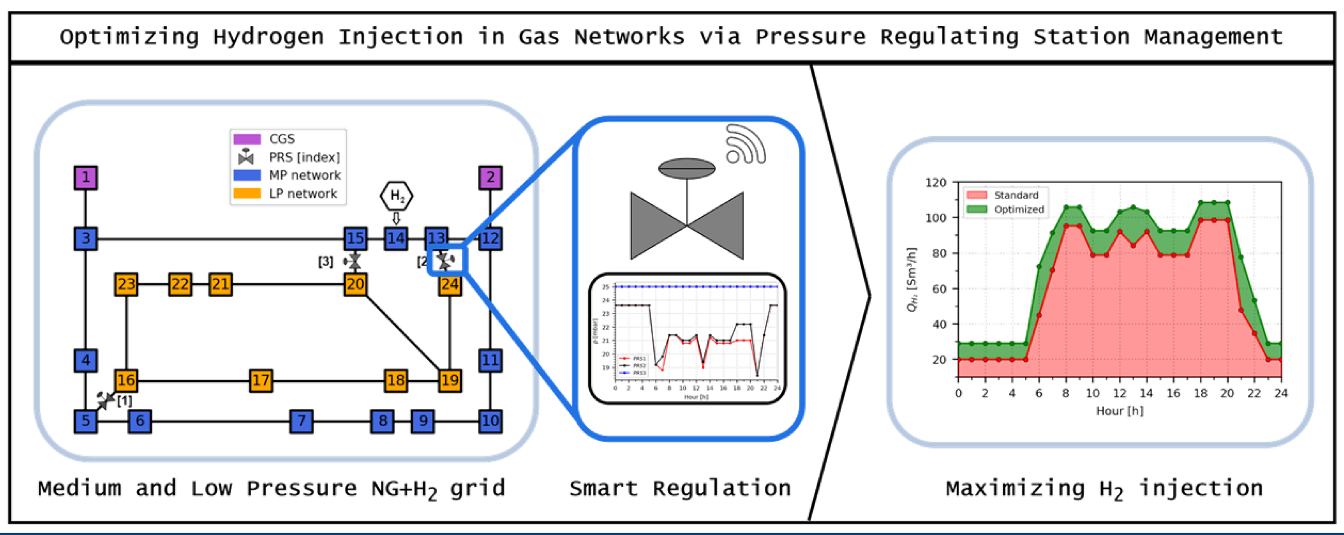


Model Validation



6 –Distribution Networks Insights

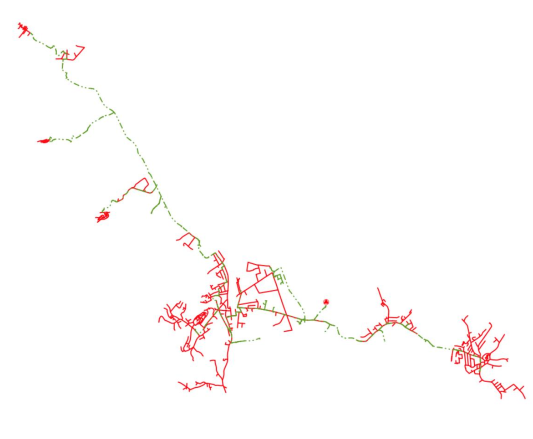
- Localized **H_2 injections** in meshed networks **can benefit** from **smart pressure modulation** at regulating stations [3].
- **Bi-directional gate stations** can increase the connectivity between distribution and transmission network.



3 – Gas Networks Features

Distribution Networks

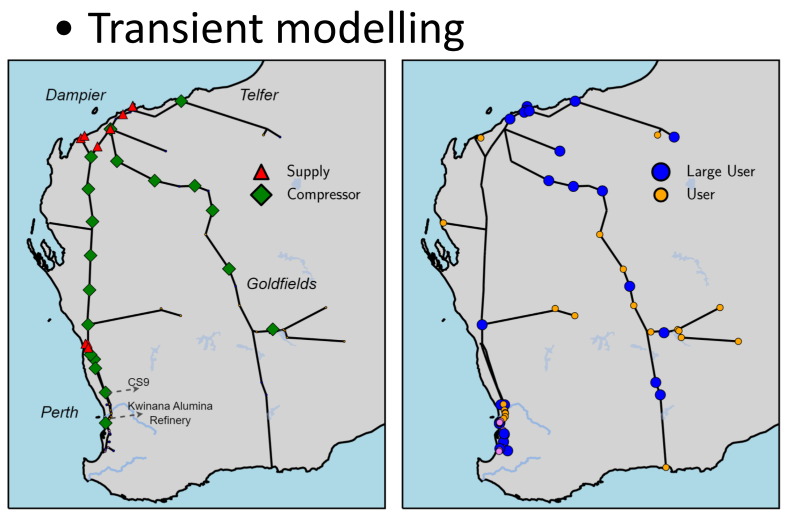
- Low pressure and flow rates
- Steady-state modelling



Distribution Network in Italy

Transmission Networks

- High pressure and flow rates
- Transient modelling

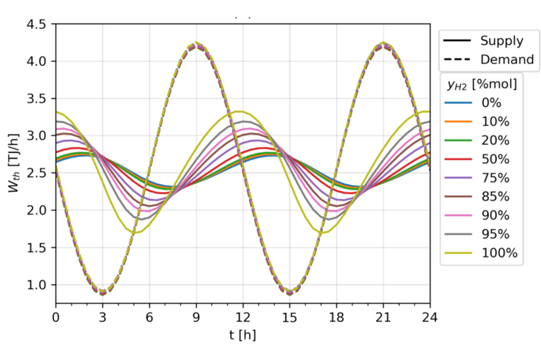


Western Australia Gas Network

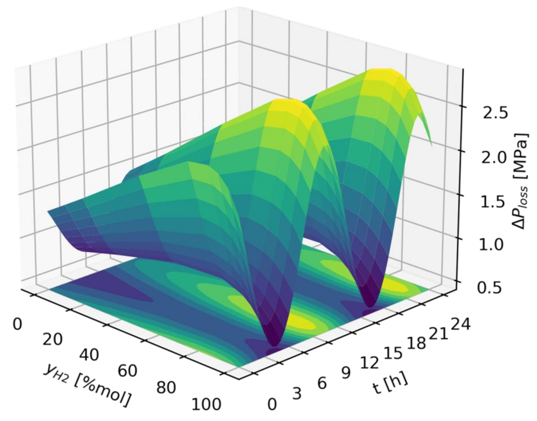
7 – Transmission Networks Insights

- **Faster dynamics** and **larger pressure swings** [4]→ Increased stress and fatigue.
- **Pressure losses increase** → Larger compressor stations.
- **Reduced Linepack** → Increase operating pressure, looping pipelines.

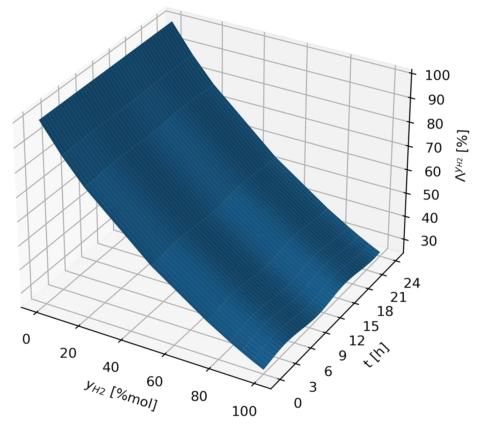
Pipeline Dynamics



Pressure losses



Linepack



4 – Constraints

- The mathematical model captures the real behaviour of the network if and only if the operating constraints are properly modelled

Capturing Actual Operating Constraints

- **Pressure regulators** capacity
- **Pipeline** capacity
- **Gas supply** capacity
- **Compression station** capacity
- **Nodal pressure** limits
- Gas **composition** and **quality**

8 - Conclusions

- **Gas network models are essential** to investigate the impact of H_2 on real networks.
- Rethinking the role of distribution network requires **sensors**, meters and **digitalisation.**
- Fluid-dynamic **feasibility** of transporting **20%mol H_2** blends in Western Australia.
- Maintain the same flexibility requires **higher operating pressure** and/or **infrastructure investments.**

Market Operator

DSOs, TSOs

Policymakers

References

[1] I. Saedi, S. Mhanna, and P. Mancarella, "Integrated electricity and gas system modelling with hydrogen injections and gas composition tracking", Applied Energy, 2021, DOI: 10.1016/j.apenergy.2021.117598.

[2] Guzzo, G., Cheli, L., Carcasci, C. (2022). Hydrogen blending in the Italian scenario: Effects on a real distribution network considering natural gas origin. Journal of Cleaner Production, doi:10.1016/j.jclepro.2022.134682

[3] Guzzo, G., Francesconi, M., Carcasci, C. (2024). "Smart management of pressure regulating stations to maximize hydrogen injection in a gas distribution network," IJHE,, doi: 10.1016/j.ijhydene.2024.04.332.

[4] Guzzo, G., Carcasci, C. (2023). Unsteady Simulation of a Gas Pipeline with several Hydrogen Blends. European Fuel Cells and Hydrogen Piero Lunghi Conference.

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