Clean Hydrogen Partnership

Shimmer

entsog

ENTSOG Gas Quality Workshop

How gas quality parameters will impact H2 admissibility

Shimmer project results WP4

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SINTEF

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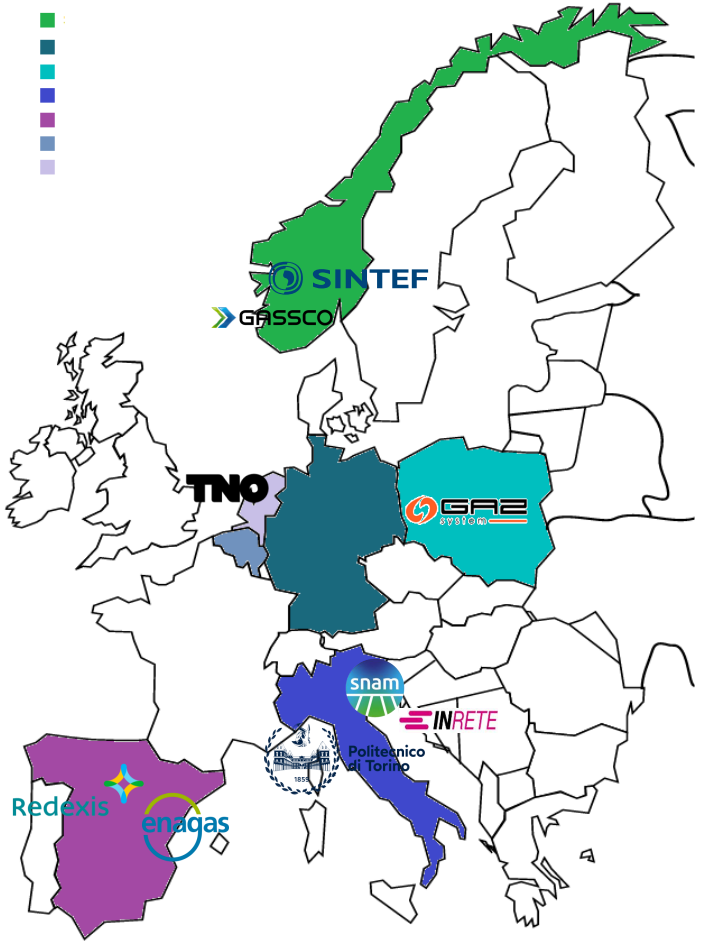
Introduction

- **Hydrogen blending in natural gas networks** supports the transition to a **low-carbon economy** while using existing infrastructure.
- **Technical and regulatory gaps** still exist, requiring adaptations and investments for **safe, reliable multi-gas network operation** and controlled gas quality.
- The Safe Hydrogen Injection Modelling and Management for European gas network Resilience (**SHIMMER)** project develops strategies for **higher and safer hydrogen integration** in European gas networks.
- Funded by the Clean Hydrogen Partnership (Grant Agreement No. 101111888).



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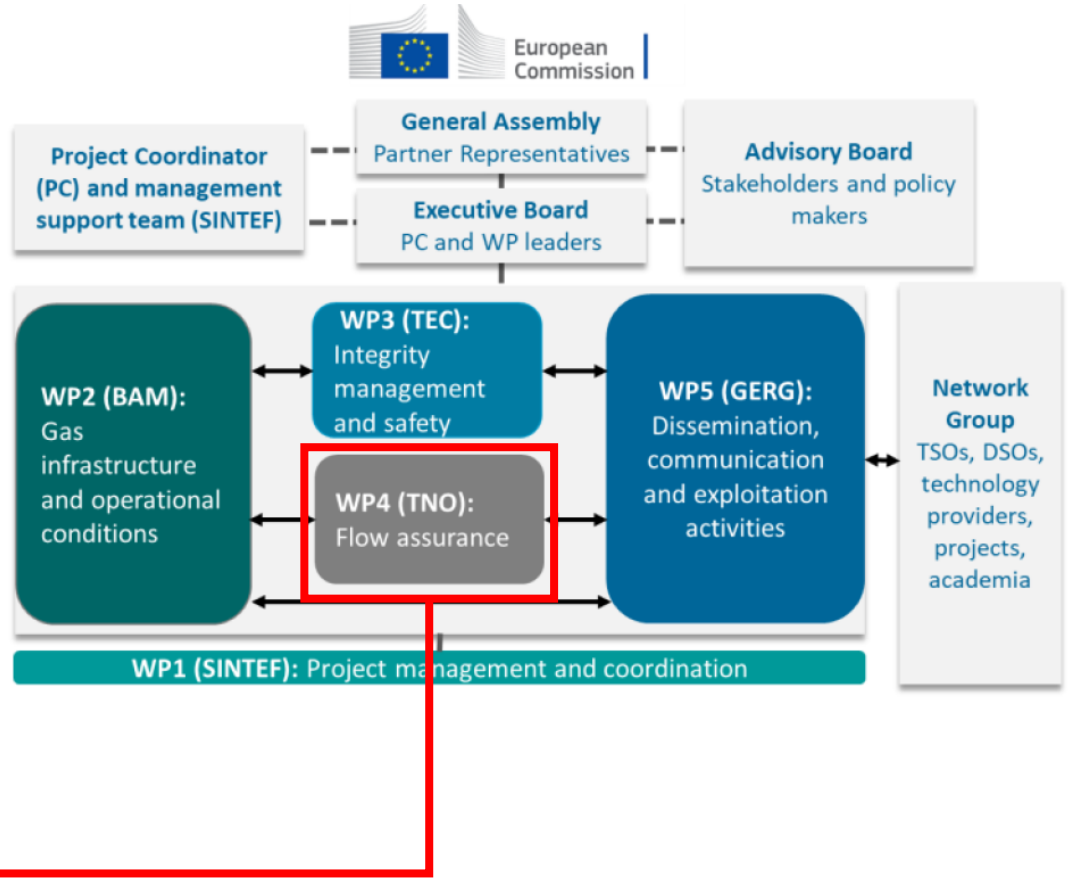
WP4 Flow Assurances Objectives

- Identify **system and engineering constraints** that may limit hydrogen acceptability in the networks.
- Analyze the **fluid dynamic impacts** of hydrogen blending.
- Assess the influence of **contractual constraints** on hydrogen admissibility.
- Define general guidelines on the **impact of gas quality parameters** on hydrogen blending limits.
- Develop **optimal operational strategies** and **best-practice recommendations** for the handling and control of hydrogen in natural gas infrastructure.



WP4 Task and Deliverables

https://shimmerproject.eu/news-and-publications/deliverables/

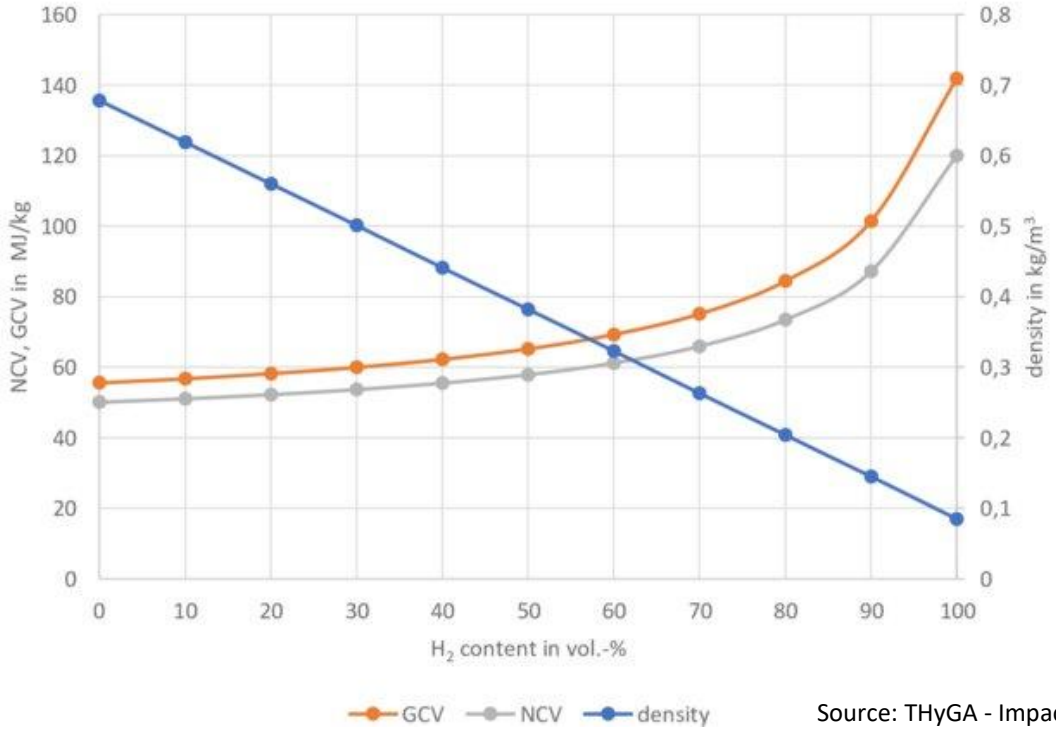
No.	Task Name
T4.1	Definition of network models and case studies: 3 TSO (Norway, Spain, Italy) and 2 DSO (Spain, Italy)
T4.2	Optimization of network design and needs for modifications
T4.3	Operational strategies for injection and flow transport management
T4.4	Evaluation of gas quality measuring technologies for effective network management

No.	Deliverable Name
D4.1	Report describing the defined simulated test cases, realistic scale testcase(s), and available operational models including required data set and format
D4.2	Tool for infrastructure optimization (investments and capacity): EMX
D4.3	Report documenting recommendations of mixing strategies and infrastructure needs
D4.4	Open-source fluid-dynamic model with gas quality tracking released with handbook and tutorials
D4.5	Report and guidelines on operational control strategies for injection in networks for the relevant cases and positioning of optimal monitoring points in the network
D4.6	Report on parametric analysis and out-of-domain generalization of results; analysis and guidelines for smart network operation
D4.7	Report with an overview of available gas quality measurement technologies and an evaluation on the performance

Hydrogen Blending: properties and effects

- Normal density: 0.089 kg/m³ ~1/8 of natural gas
- Heating value: 120 MJ/kg ~2.35x of natural gas

} ~3.3x the volume with pure H_2



Source: THyGA - Impact of hydrogen admixture on combustion processes –Part I: Theory

For hydrogen blends up to 20%:

- Meeting the same energy demand requires 16% higher flow at the consumer
- Pressure drop rises slightly (+11%)

$$\Delta P = f \frac{L}{D} \frac{\rho u^2}{2}$$

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Hydrogen Blending Regulation

- EU regulation limits hydrogen blending to **2% by volume** in natural gas at cross-border interconnection points.[1]
- The Spanish transmission network permits hydrogen blending up to **5%** when supported by a calculation tool. Hydrogen sensitive infrastructure and cross-border remain at or below **2%**.[2]
- During the project, DSO partners Redexis (Spain) and Inrete (Italy) are testing **5%** hydrogen blending in their grids.

- The Shimmer project studies hydrogen blending from **2% to 20%**.

[1] European Union. Regulation on the internal markets for renewable gas, natural gas and hydrogen. Brussels, 2024.
[2] Orden TED/181/2025, de 13 de febrero, por la que se aprueban las Normas de Gestión Técnica del Sistema Gasista de competencia ministerial, Boletín Oficial del Estado nº 50 de 27 de febrero de 2025

Overview of case studies and scenarios



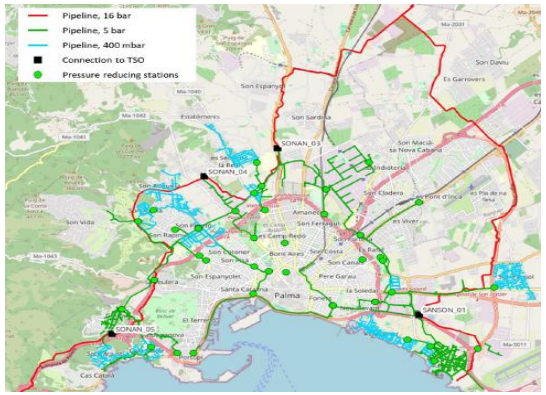
Sicily, Italy

- **Multiple** and **distributed hydrogen injection** from existing **utility scale RES**
- **Long-distance hydrogen transport:** H2 blending vs dedicated backbone

- **Underground Gas Storage systems management** and dispatch under blended gas conditions



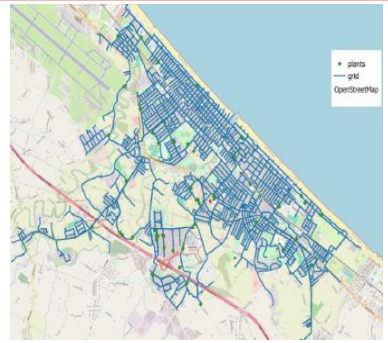
Ebro Valley, Spain



Palma de Mallorca, Spain

- Hydrogen **propagation dynamics** throughout **complex meshed network**

- **Multiple blending injection from city gates** with pressure-controlled valve
- Two pressure levels



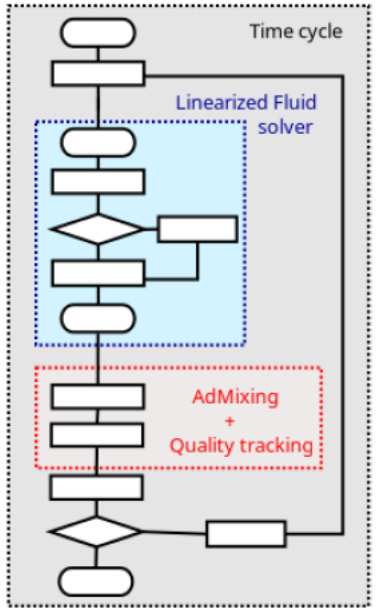
Riccione, Italy

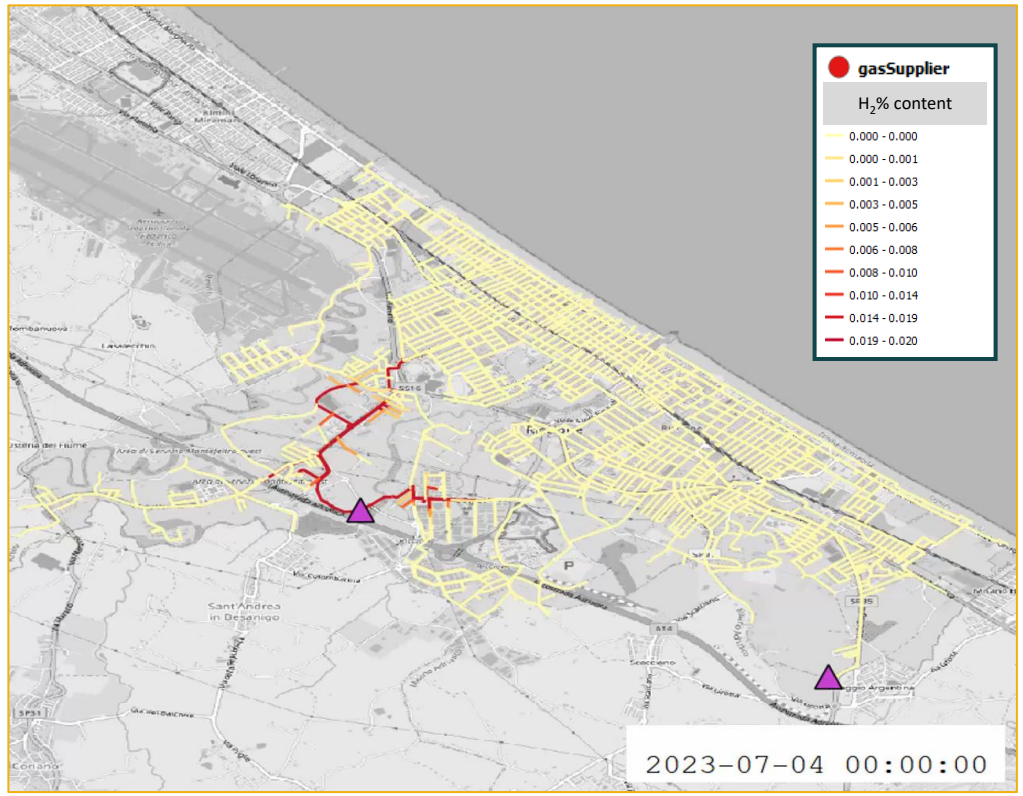
Methodological Approaches

Defining networks, boundary conditions and scenarios

Gas network model with gas composition tracking

Evaluation of operational strategies for injection and transport





Example simulation output: Riccione, Italy

This WP4 also develops an open-source gas network simulator by Politecnico di Torino: https://github.com/shimmerhydrogen/shimmer

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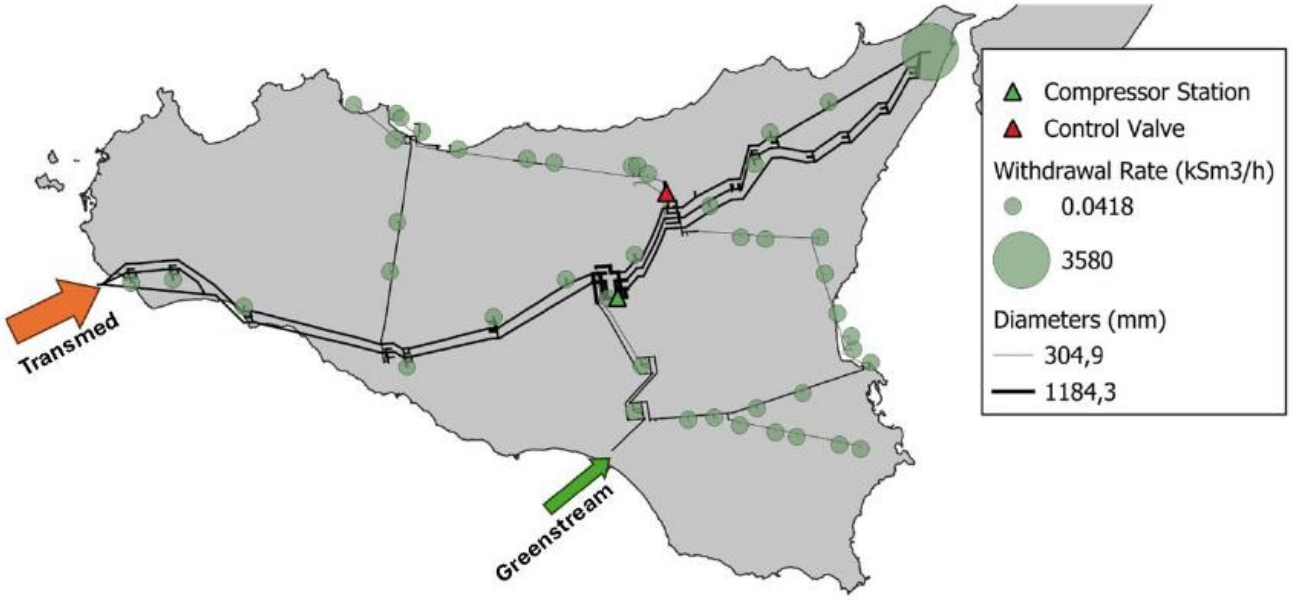
Results Analysis: Sicily, Italy

Topology:

- 2-3 parallel pipeline DN350-DN1200
- 75 bar Maximum Allowable Operating Pressure (MAOP)
- 2 entry points (Algeria and Libya)
- 1 compressor station
- 45 exit points



Possible scenarios:

- Repurposing one of parallel line
- 20% blending injection at Transmed or Greenstream
- H2 injection in multiple locations in the grid

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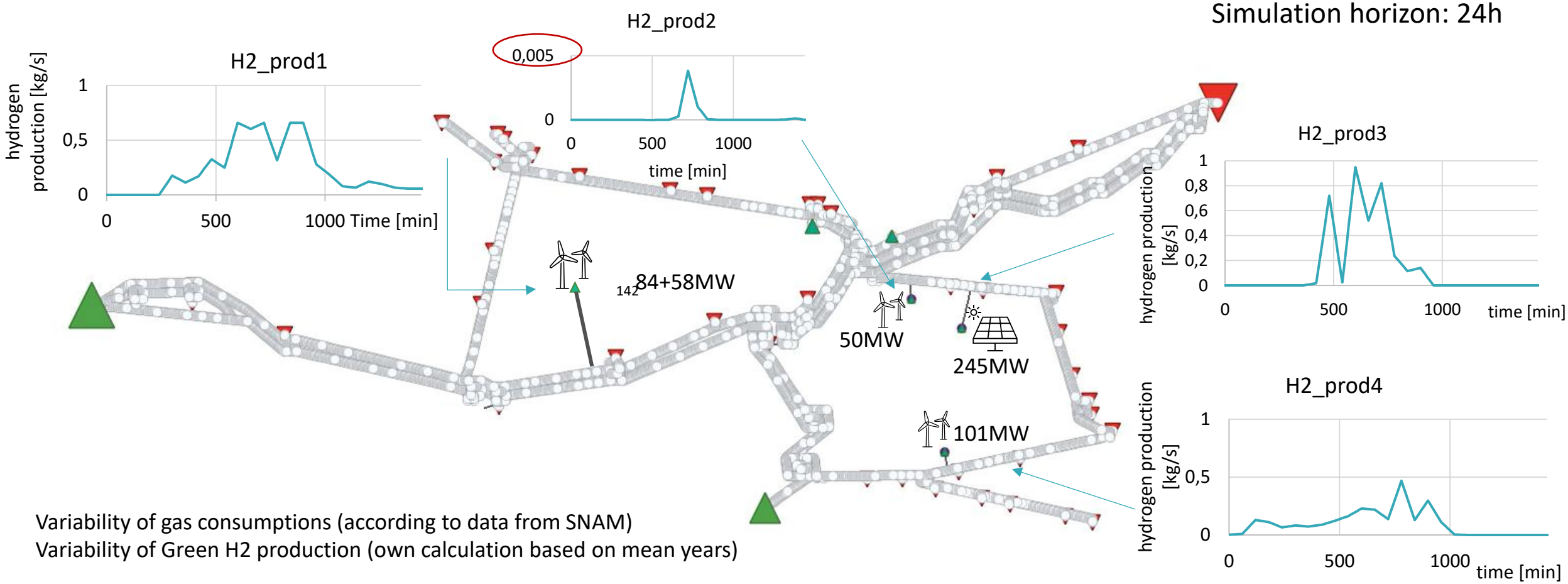
Multiple and distributed hydrogen injection from existing utility scale RES

Distributed Hydrogen injection

Winter case tested
Simulation horizon: 24h



Variability of gas consumptions (according to data from SNAM)
Variability of Green H2 production (own calculation based on mean years)

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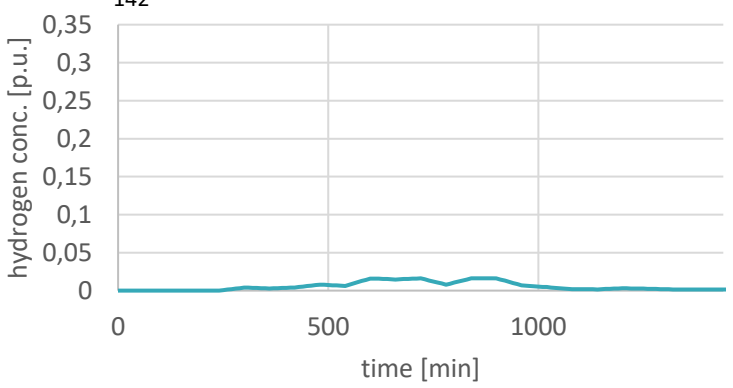
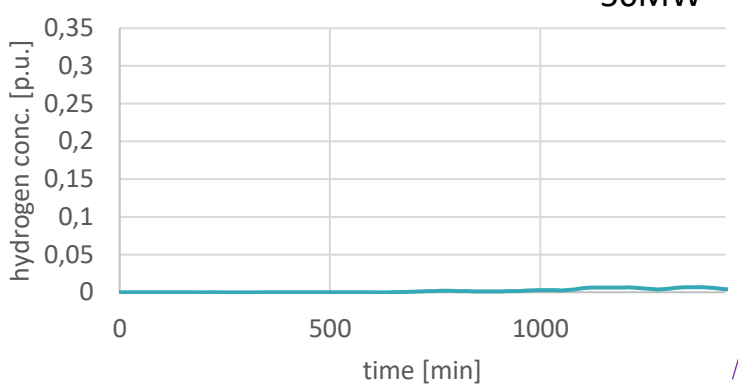
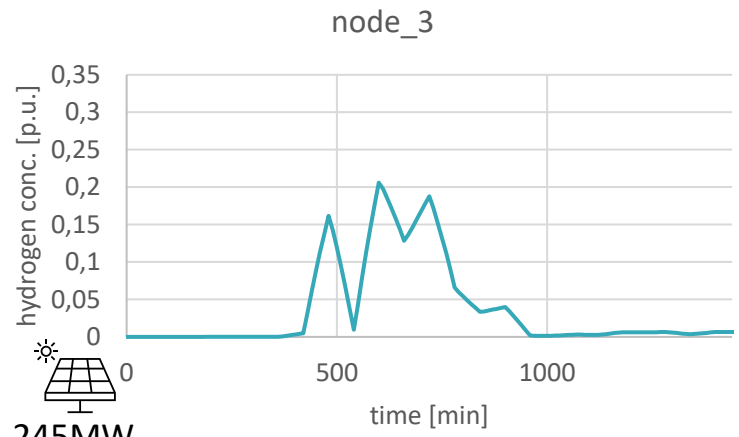
Multiple and distributed hydrogen injection from existing utility scale RES

84+58MW
142

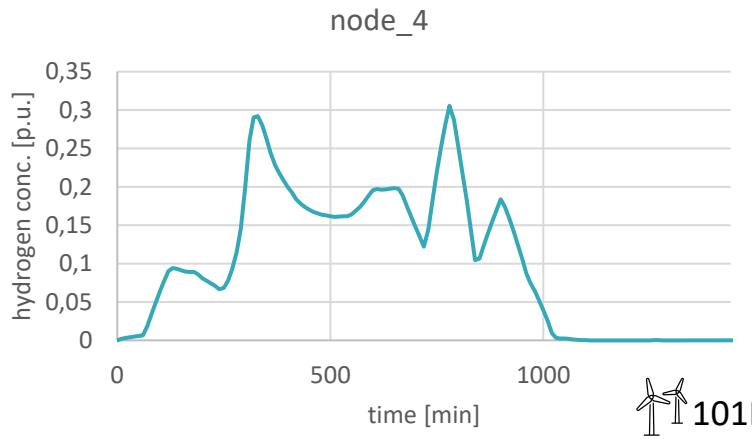




50MW

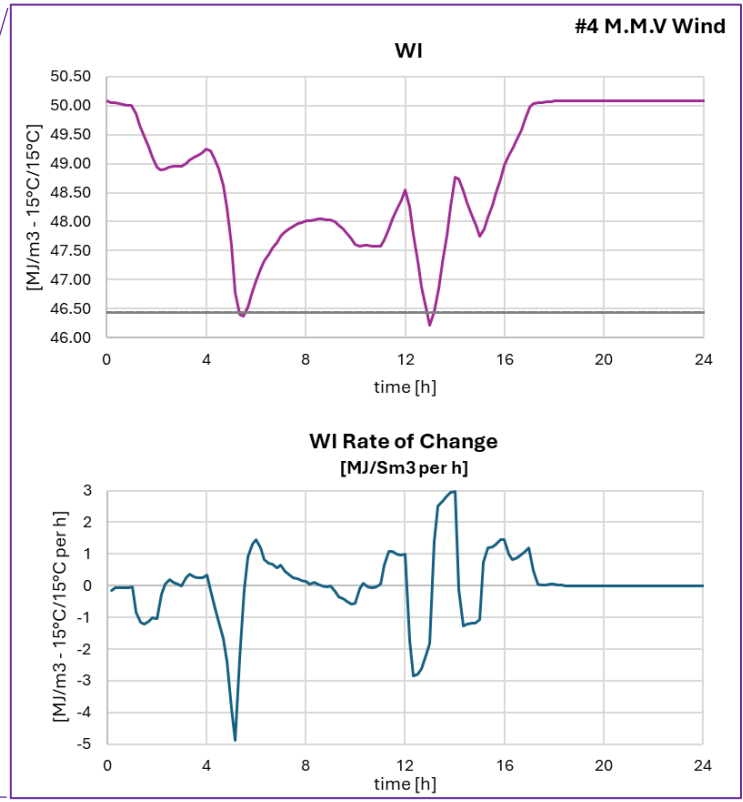


245MW



101MW

Impacts on Quality Parameters



EN 16726:2025 – Annex F (informative)

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Insights from H_2 multiple and distributed injection

- **Distributed hydrogen injection** is **locally flow-constrained**, because similar injection rates can generate very different hydrogen concentrations **depending on network location**

- **Multiple hydrogen injection** points require **coordinated operation**, because upstream injection consumes downstream blending margin with time delays

- Distributed hydrogen injection requires **dynamic gas-quality assessment**, because **Wobbe Index rate of change** may become **critical** even when absolute WI limits are mostly respected

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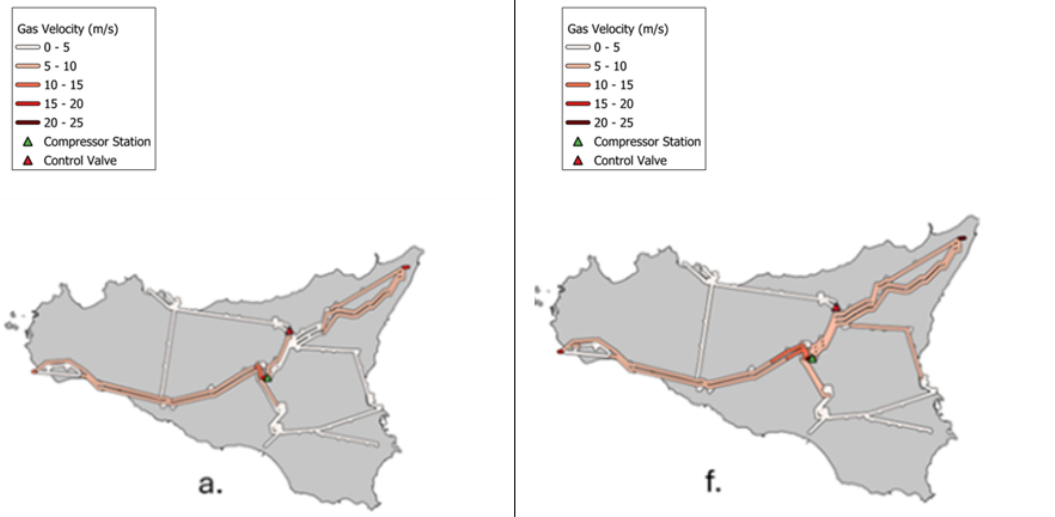
(Some) H2 blending analysis summary



TSO Network

- H_2 blending can **increase** flow rates, pressure drops, and compressor power, special concern in **saturated pipelines**.

Long-distance hydrogen transport: *H2 blending vs dedicated backbone*



(a) reference case: state-of-art operation with natural gas

(f) hydrogen blending without pressure derating (ASME B31.12

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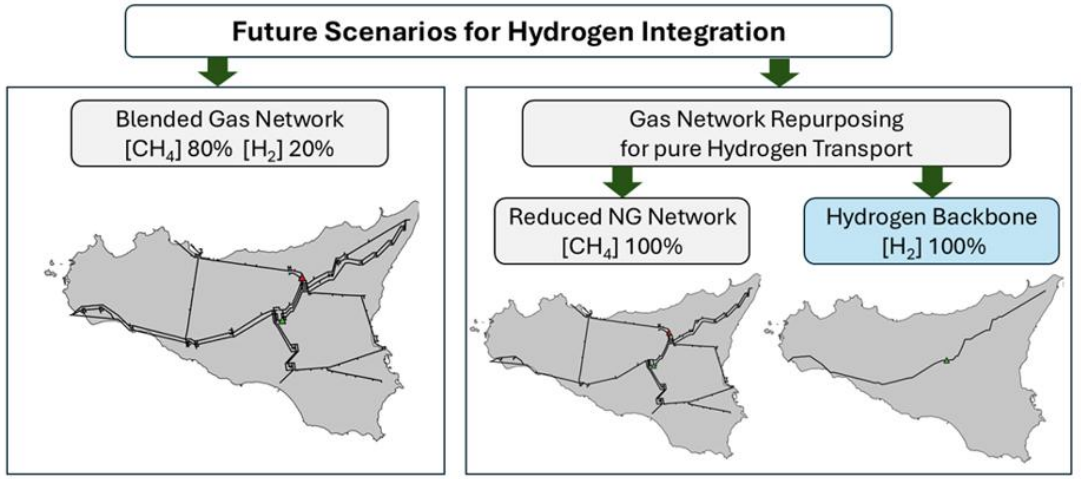
(Some) H2 blending analysis summary



TSO Network

- H_2 blending can **increase** flow rates, pressure drops, and compressor power, special concern in **saturated pipelines**.
- Pipeline **repurposing enables** larger-scale hydrogen transport, provided that parallel pipelines are available, and **security of natural gas supply is maintained**.

Long-distance hydrogen transport: *H2 blending vs dedicated backbone*



0.7 Mt/year H_2
with 20 vol%

→ *Blending supports early deployment*

~30% less residual gas capacity

2.5 Mt/year H_2
dedicated backbone

→ *Backbone enables at scale deployment*

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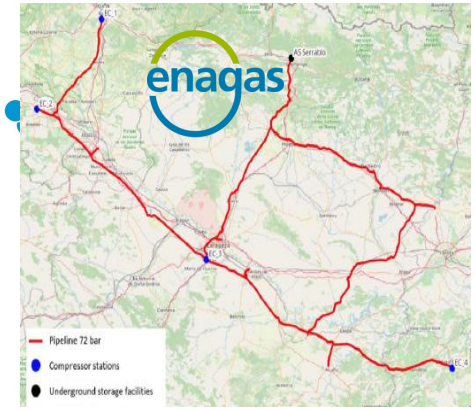
(Some) H2 blending analysis summary



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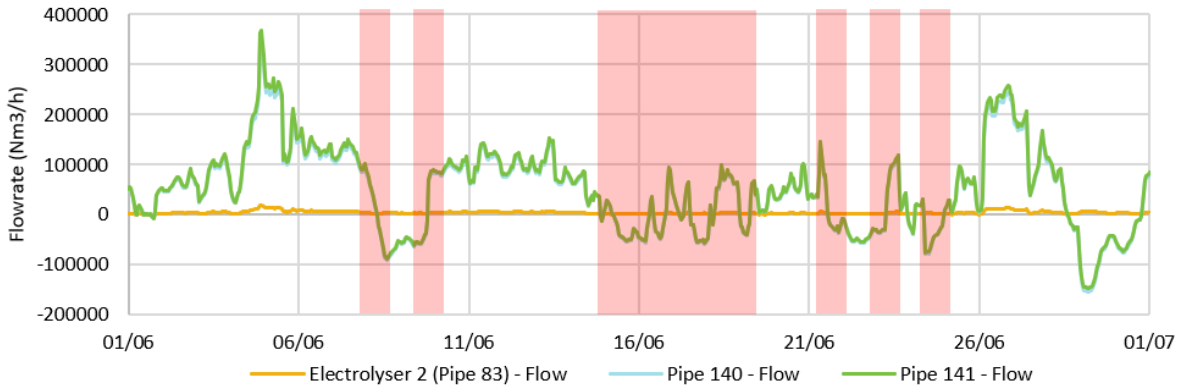
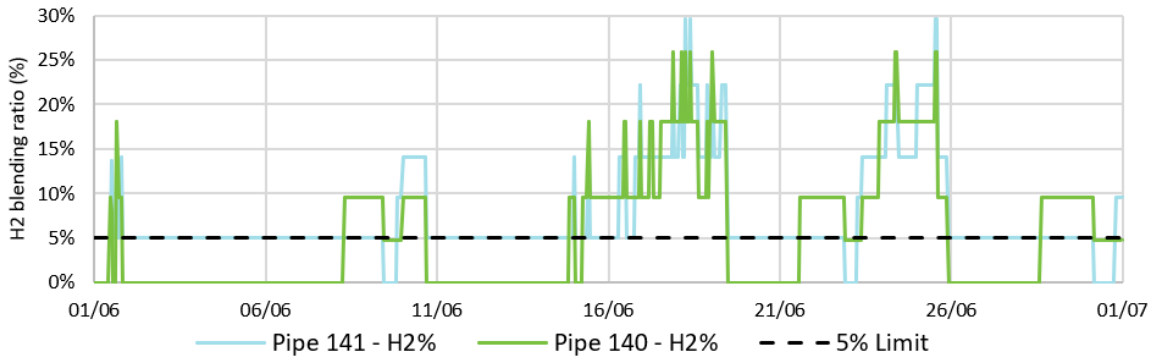
- Pipeline **repurposing enables** larger-scale hydrogen transport, provided that parallel pipelines are available, and **security of natural gas supply is maintained**.
- In **bidirectional main pipelines**, gas quality must be **continuously monitored** to prevent hydrogen **accumulation** during flow reversals.





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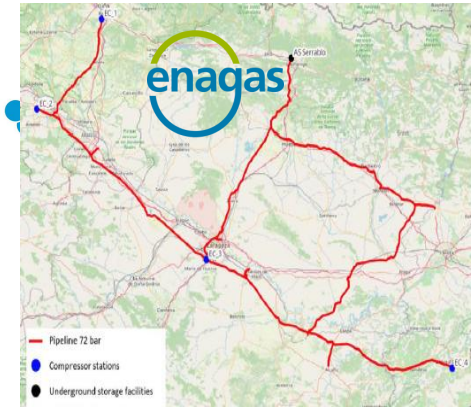
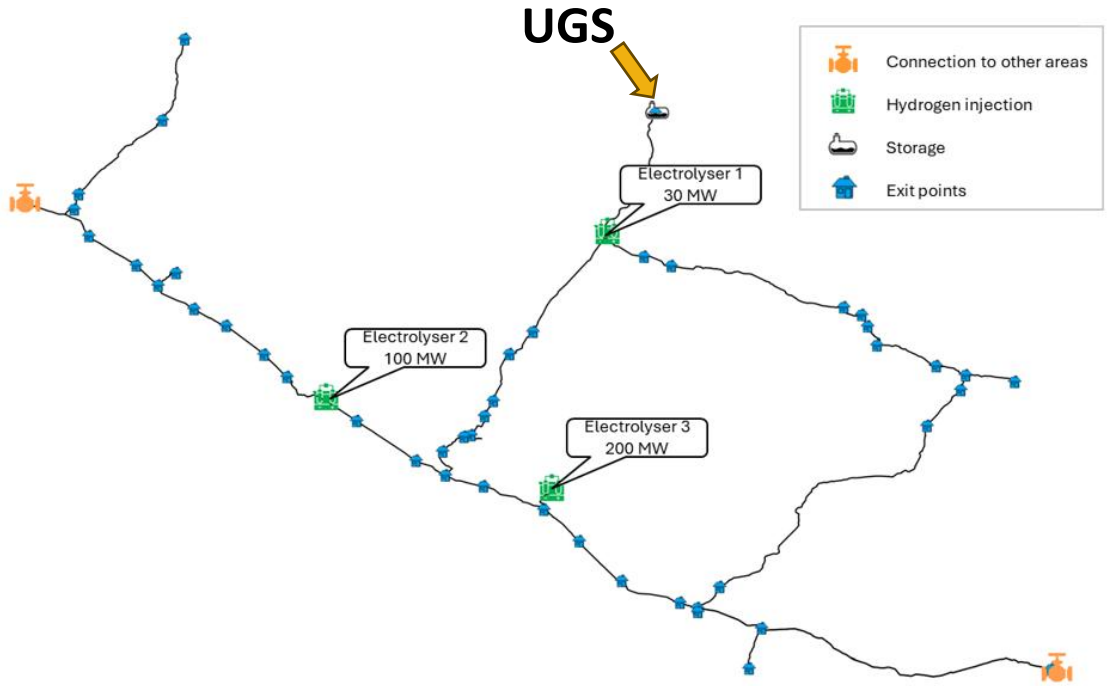
(Some) H2 blending analysis summary



TSO Network

- H_2 blending can **increase** flow rates, pressure drops, and compressor power, special concern in **saturated pipelines**.
- Pipeline **repurposing enables** larger-scale hydrogen transport, provided that parallel pipelines are available, and **security of natural gas supply is maintained**.
- In **bidirectional main pipelines**, gas quality must be **continuously monitored** to prevent hydrogen **accumulation** during flow reversals.
- UGS can provide controllable natural gas injection to **dilute hydrogen-rich mixtures** and maintain blending limits.

Underground Gas Storage systems management and dispatch under blended gas conditions



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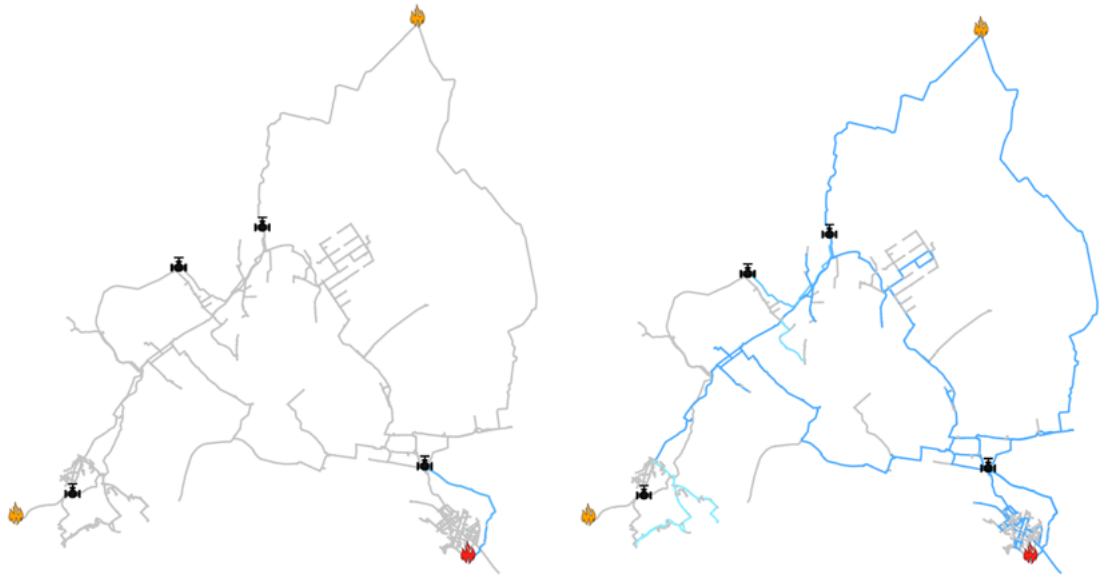
(Some) H2 blending analysis summary



DSO Network

- Hydrogen propagation in DSO networks is **time dependent**, with delays between injection and delivery to consumers. Therefore, **steady-state analysis** alone is **insufficient**.
- **Volume-based** billing may create **unfair costs** for hydrogen-enriched consumers; **energy-based** billing should be considered.



2-4 weeks delay

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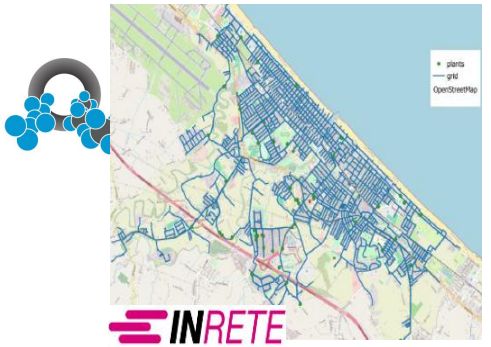
(Some) H2 blending analysis summary



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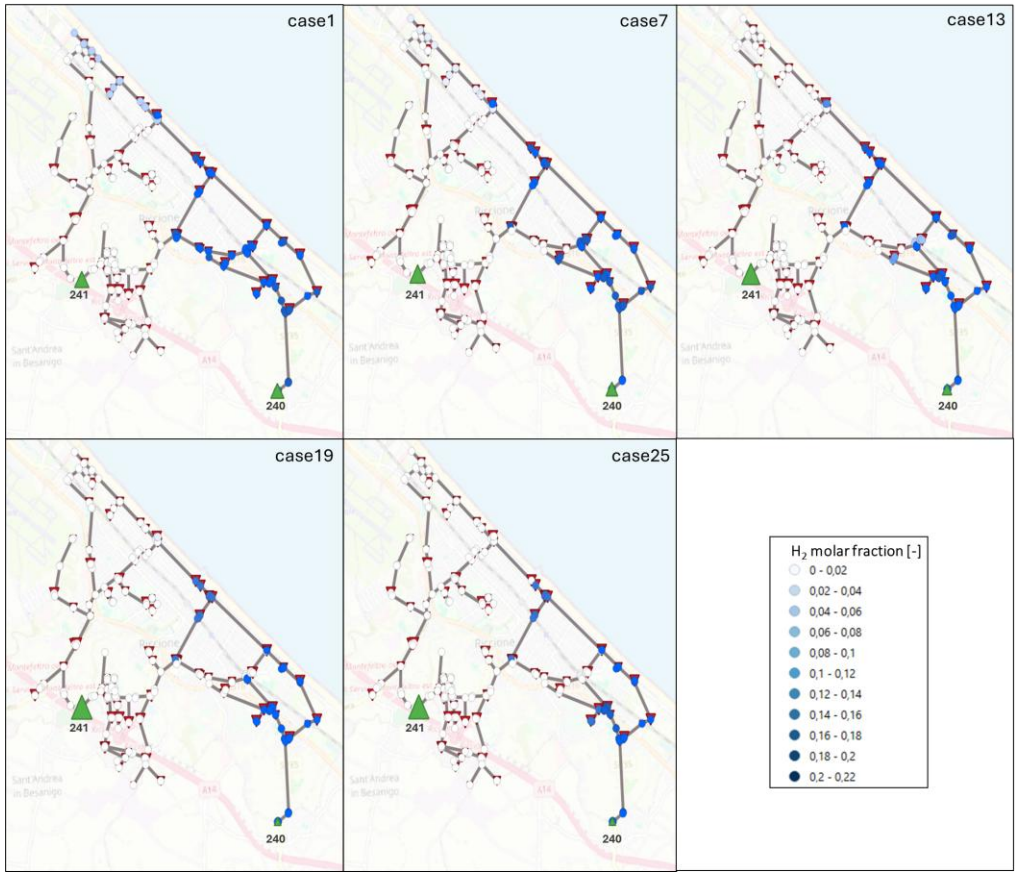
- **Volume-based** billing may create **unfair costs** for hydrogen-enriched consumers; **energy-based** billing should be considered.
- Hydrogen from the TSO can **create uneven concentrations** in DSOs (multiple CGS), requiring close TSO-DSO coordination.
- In **multi-entry networks**, hydrogen distribution depends on **pressure-driven flow balancing**, allowing DSOs to manage propagation through pressure control and **avoid critical consumer areas**.



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Conclusion

1. Hydrogen Admissibility at TSO

- Admissibility depends on blending limits, hydraulic performance, gas-quality dynamics, and infrastructure compatibility.
- Transient modelling is essential to assess hydrogen propagation and mixing.
- Harmonized standards and coordinated operation are crucial for safe integration.

2. Hydrogen Admissibility at DSO

- Hydrogen concentration varies with network topology, flow conditions, and pressure regulation.
- Pressure regulation can help manage hydrogen distribution and gas quality.
- Consumer compatibility and energy delivery equivalence must be ensured.
- TSO–DSO coordination is essential for gas-quality compliance.

Hydrogen admissibility should be assessed dynamically at the system level, considering network hydraulics, gas-quality propagation, infrastructure limitations, and end-user requirements rather than relying solely on fixed blending thresholds.

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Clean Hydrogen Partnership

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THANK YOU

The project is supported by the Clean Hydrogen Partnership and its members.

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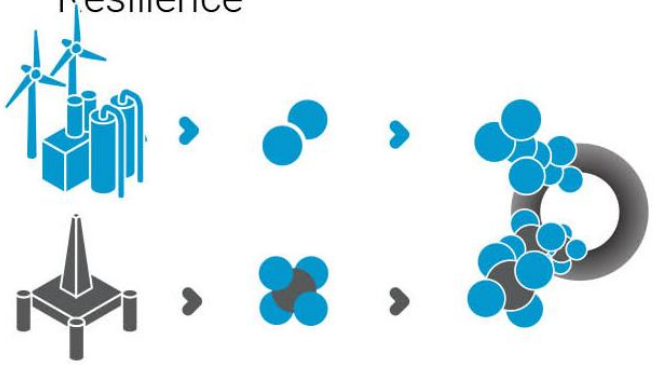
Safe Hydrogen Injection Modelling and Management for European gas network Resilience



Injection

Flow assurance

Monitoring

Quality

Integrity

Safety

Regulations and guidelines

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