Hydrogen in natural gas infrastructure: techno-economic assessment of repurposing existing grids

XXIX SUMMER SCHOOL "Francesco Turco" - Industrial Systems Engineering

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Agenda

1. Background and introduction to the THOTH2 project

2. Measuring devices installed in NG grids

3. Efforts for network repurposing

4. Conclusion and ongoing activities

Clean Hydrogen Partnership

1. Background and introduction to the THOTH2 project

Background

Gas grid appears to be the most worthwhile way of hydrogen delivery.

Why:

- Lowest greenhouse gas emission per kg of H_2 delivered
- Evolution of the existing asset for new business opportunities for operators

Research questions:

- H_2 concentration limits in natural gas networks remain debated among gas transmission system operators (TSOs)
- Uncertainty about thresholds affecting metrological and safety performance of measuring instruments
- Normative framework and testing methodologies for hydrogen - natural gas (H2NG) mixtures not well defined

Research gap & THOTH2 purpose

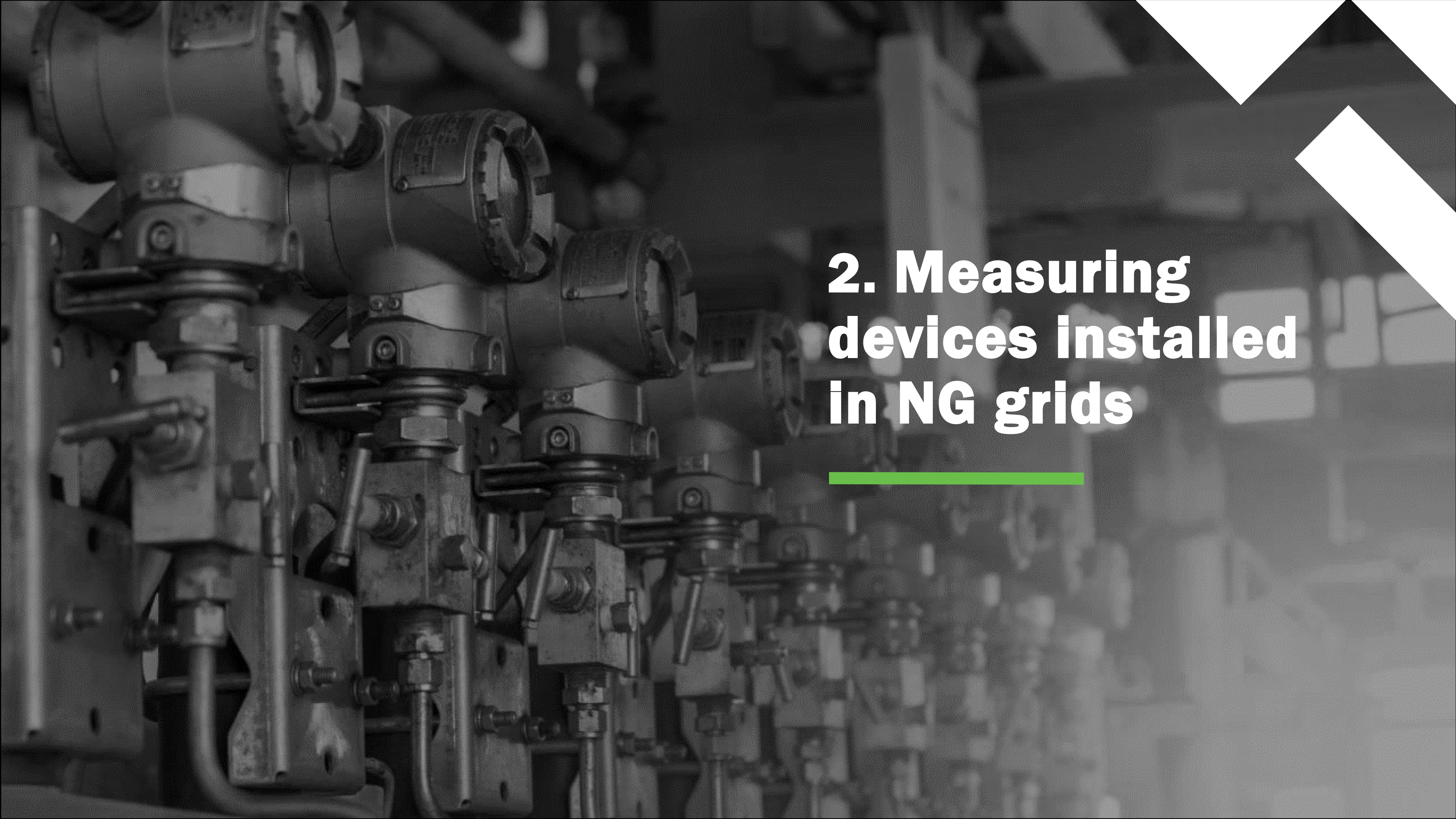
The introduction of hydrogen into the grid is still at the research stage to address various technological barriers. THOTH2 project focuses on the effects on **metrological performance of measuring devices.** Limited experimental data are available for high-pressure, high-flowrate measuring devices in gas transmission grids. Situation is better for distribution devices due to smaller size and different operating conditions.

THOTH2 aims to:

- Develop and perform new testing protocols to assess hydrogen limits in current NG instrumentation
- Provide recommendations to technical committees for standardization
- Suggest research targets for new measuring technologies, leveraging existing knowledge

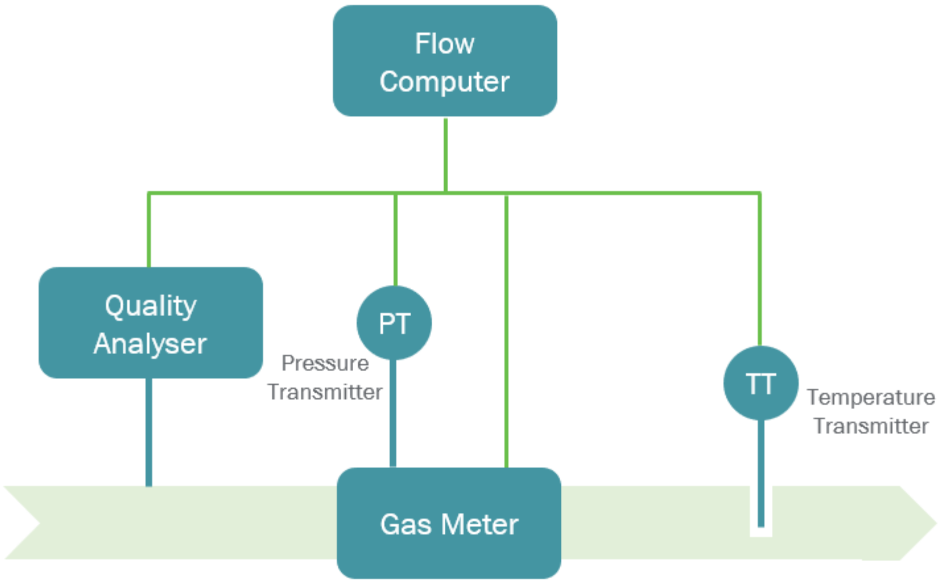
The Consortium includes four EU TSOs covering almost 40% of the total European transmission grid, research institutes and national metrological institutes.

2. Measuring devices installed in NG grids



Measuring devices installed in NG grids

Scheme for energy measurement based on volume measurement



Categories of measuring devices

- Gas meters
- Gas chromatographs
- Pressure and temperature transmitters
- Dew Point analyzers
- Leak detectors
- Volume converters

Fundamental gas flow measurements

- Volume → Gas meters
- Quality → Quality analisers

Volume measurement in gas flows

Gas meters

- **Volume totalisers**
- **Flow rate meters**

Volume totalisers

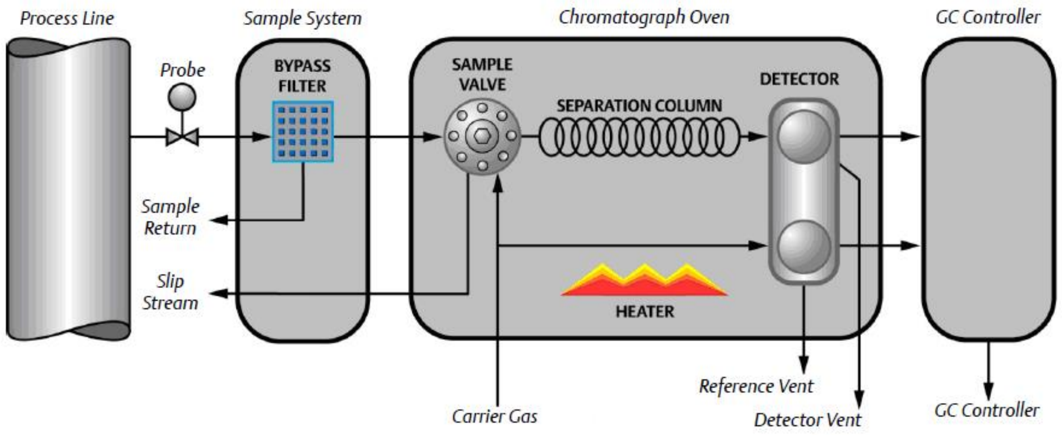
- **Rotary piston** — Featured by two counter-rotating rotors activated by the pressure difference between the inlet and outlet.
- **Turbine** — The flow passes through an inlet straightener to a bladed rotor that rotates in the measuring chamber. The motion is transferred to the counting mechanism.
- **Diaphragm** — The fluid passes through chambers with deformable walls, isolating a known volume in two measuring chambers. The operation repeats filling and emptying phases, counting each cycle.

Flow rate meters

- **Ultrasonic** — They measure velocity using ultrasonic transducers by timing the travel of ultrasound pulses or detecting frequency shifts through the Doppler effect.
- **Thermal mass** — They monitor fluid cooling effects on a heated element. The power needed to maintain temperature, or temperature difference, reflects the mass flow rate.
- **Coriolis** — They use vibrating tubes to measure flow through Coriolis force. Oscillation shifts due to fluid flow cause phase differences from the symmetrical no-flow state.

Quality measurement in gas flows

From the second half of the 20th century, chromatographs replaced chemical absorption and combustion methods for gas composition analysis due to their accuracy and cost-effectiveness.



Working principle

The gas components are separated inside a small tube called a column, where the moving gas phase interacts with a stationary phase. To facilitate detection, the sample gas is mixed with a carrier gas, selected based on the specific application and the components to be identified. Separation occurs due to the different speeds at which the components travel through the column. Downstream of the column, a detector identifies the components of the mixture. The most common detectors are those that measure changes in thermal conductivity between two thermistors.

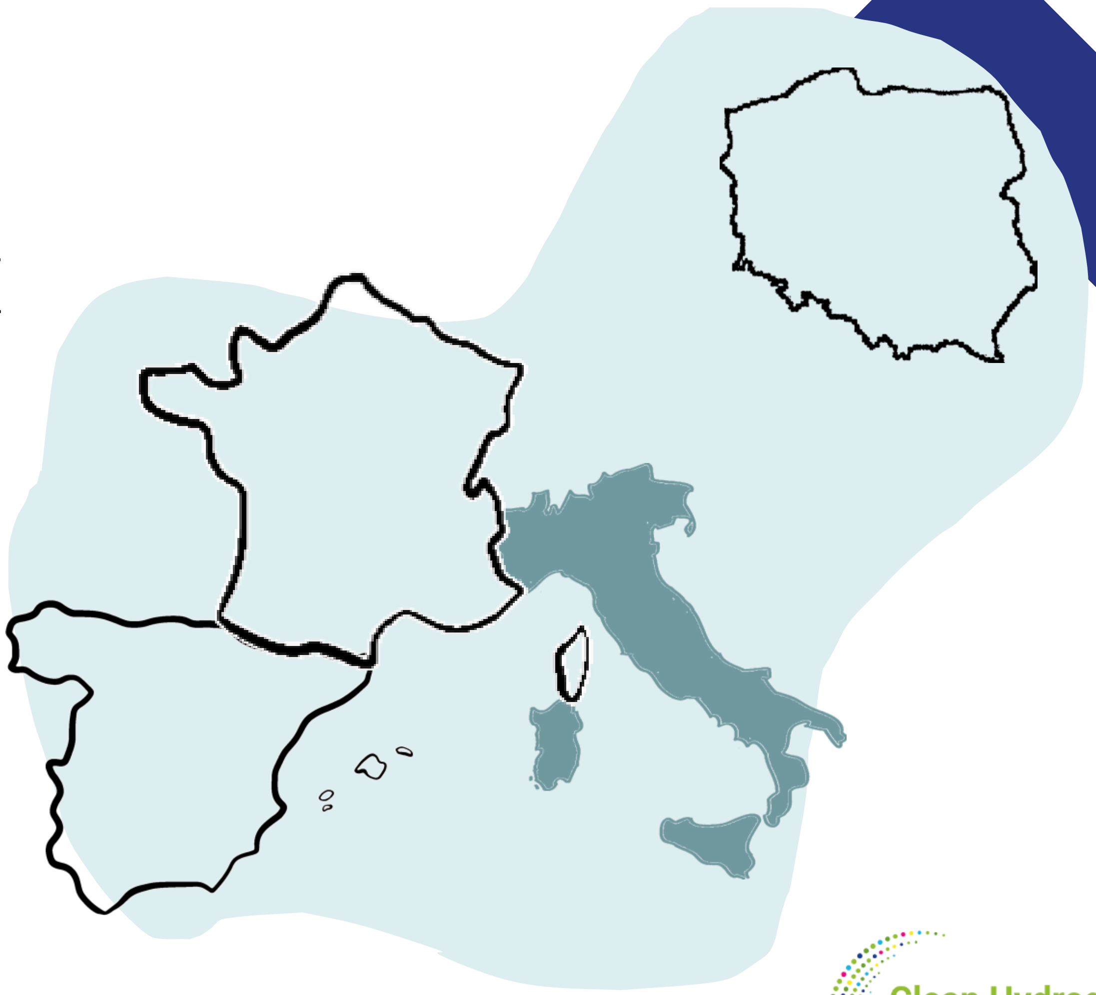
3. Efforts for network repurposing

Overview of the measuring devices in NG grids

Understanding the most commonly installed devices in the gas grids is essential for achieving the project objectives. WP1 developed an overview of the current state of metering devices in the gas network.

The **methodology** followed these steps:

1. Request data from the TSOs partners
2. Quality check to ensure accuracy and completeness
3. Data analysis and categorization
4. Examination of technical datasheets and manuals
5. Data anonymization and normalization

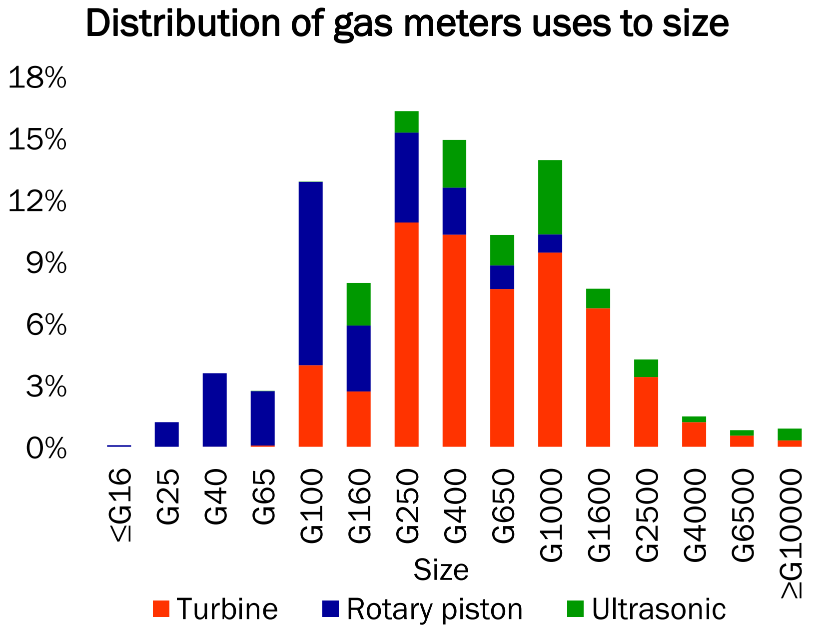


Results:
Italian transmission network

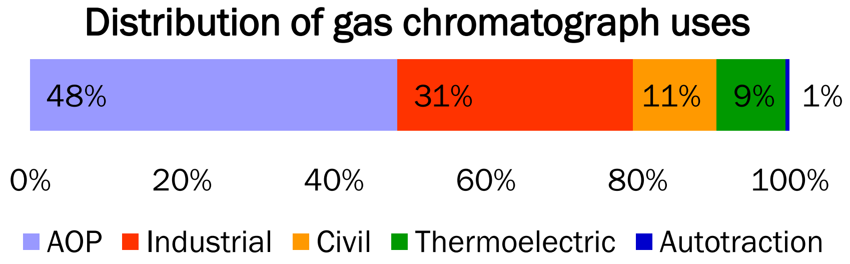
Approximately 30 fiscal gas meters per 100 km are installed. There are 33 manufacturers of gas meters, with 4 leading producers accounting for over 60% of the total **market share.**

Technology Share:

- Turbine represent 58% of installed units. Predominantly used in pipelines larger than G100.
- Rotary piston makes up 28% of installed units. Most used in pipelines smaller than G400, with a peak at G100.
- Ultrasonic meters make up 13%, with a distribution pattern similar to turbines but at a lower rate.



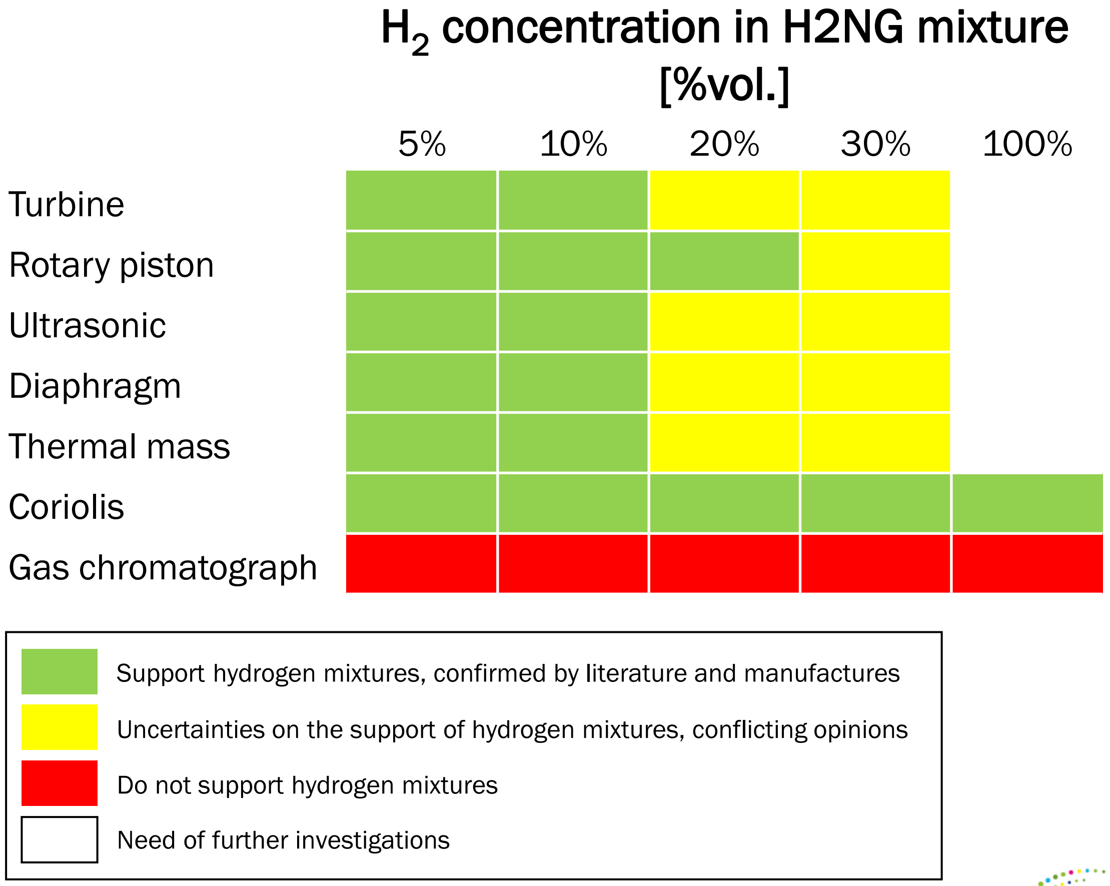
Approximately 400 gas chromatographs are installed, with 48% located in the Aree Omogenee di Prelievo (AOP). There are eight producers, with two of them covering 65% and 28% of the market.



H2 effect on metrological perfomance

Information about the permissible hydrogen concentrations for various measuring technologies has been gathered from existing literature and through direct contact with manufacturers.

Gas chromatographs require significant modifications to be used with hydrogen and therefore need to be completely replaced. Although Coriolis meters are considered suitable for all H2 concentrations, their current adoption is very limited.



4. Conclusion and ongoing activities

Program roadmap

- Overview of measuring devices installed in the NG grids. Collaboration with EU Project PNRR NEST (Spoke 4 and Spoke 7) to further analyze the Italian case
- Literature review on the performance of measuring devices and framing of the regulatory status
- Selection of devices to be tested and assignment to laboratories

  Different technologies and models have been selected accordingly to a prioritization procedure and laboratories have been chosen based on their capabilities
- Definition of the testing protocols
- Execution of the tests

  It is the most challenging task because due to the logistical complexity of moving the instruments thousands of kilometres across Europe
- Estimation of the economic effort for the reuse of the network

Thank you

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