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Planning for Transporting Hydrogen in the Portuguese Gas Transmission System

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Hydrogen Transport Planning in Portuguese Gas System

Detailed agenda covering EU context, REN system, safety, and phased hydrogen transport

1. EU context & drivers: European hydrogen targets and regulations
2. REN system overview & objectives: Portuguese gas system and project aims
3. Stage 1 (10% H_2): Hydraulics, equipment, safety considerations
4. Stage 2 (100% H_2): Capacity, materials, MAOP, ATEX compliance
5. Conclusions

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EU Hydrogen Infrastructure and Regulations

Key EU targets and regulatory frameworks for hydrogen transport

1 REPowerEU Targets

EU targets: production and import of H_2 by 2030 (10 Mt/year of domestic hydrogen production and 10 Mt/year of imports), contributing approximately 10% of the EU's total energy consumption by 2050.

2 Regulatory Framework

Regulations 2024/1788 and 2024/1789 establish the Hydrogen & Decarbonised Gas Market Package, enabling dedicated hydrogen transport networks with defined operational and safety standards.

3 Hydrogen Grid Development

The **European Hydrogen Backbone** and ENTSOG maps outline a phased hydrogen pipeline infrastructure rollout from 2030 to 2040, supporting cross-border hydrogen transport within the EU.

4 H2Med Corridor

The **H2Med corridor** connecting Portugal, Spain, France, and Germany is under development via the BarMar joint venture, with Portugal's infrastructure readiness as a key prerequisite.

Portuguese Gas Transmission System and Hydrogen Objectives

Overview of infrastructure, safety, and hydrogen blending goals

Transmission Grid Length

Approximately 1,375 km

Infrastructure Components

45 valve stations, 71 junctions

Delivery Stations Count

85 delivery stations total

Hydrogen Blend Safety

Safe 10% H_2 blend

Engineering Changes

Define changes for 100% H_2

Safety Framework

ASME B31.12 (2019) compliance

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Stage 1: Hydraulic Impact of 10% Hydrogen Blend

Analyzing pressure, velocity, and erosion effects for safe transport

- Delivery Pressure

  Maintained through modest inlet adjustments, ensuring overall pressure drop impact remains negligible within system operation parameters.

- Velocity Increase

  Flow velocity rises by approximately 8.7%, reflecting the effect of hydrogen blending on fluid dynamics in the pipeline.

- Erosional Index

  Shows a minor increase of around 1.4%, remaining safely within acceptable engineering limits to prevent mechanical damage.

- Operational Conclusion

  Current hydraulic conditions support the 10% hydrogen blend phase without necessitating mechanical resizing of pipeline components.

Stage 1: Equipment and Operational Adjustments for Hydrogen Transport

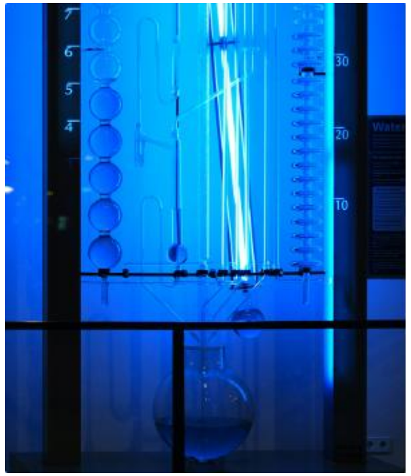
Key engineering and safety updates for hydrogen integration

Filters & Heat Exchangers

Sized adequately with control and PRV headroom.

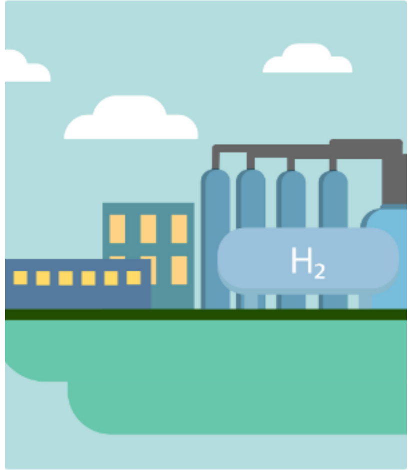
Boiler Duty Cycles

Reduced by2.64% with no operational constraints.



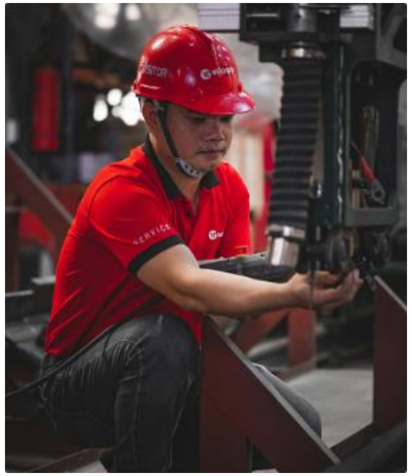
Chromatography Compatibility

Danalyzer 500 incompatible; replacement needed.



ATEX Provisions

Adequate up to 25% H_2; check instrumentation.



Operations & Maintenance

Prioritise valve leak repairs.

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Stage 1: Safety and Leak Detection Strategy

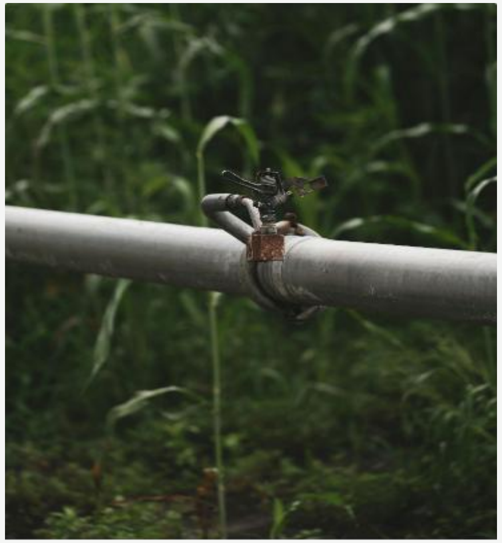
Technical protocols for hydrogen transport safety and detection

Leak Detection System

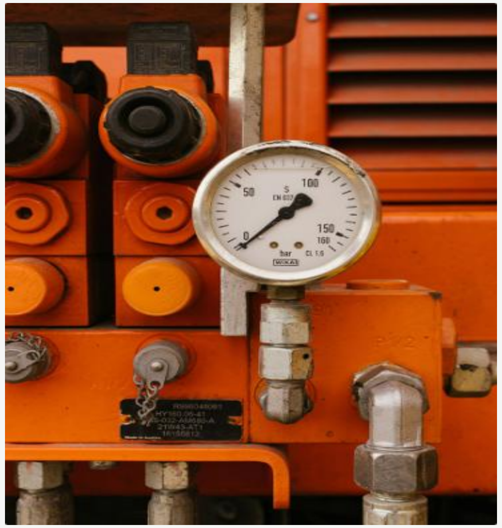
Methane based detection

Odorant Compatibility

Tetrahydrothiophene
Thiophane (THT) compound: OK



Venting and Purging



Hot Tapping Controls

Stage 1: Block Valve Spacing and Depth of Cover Assessment

Technical review of spacing compliance and cover depth shortfalls

Block-valve spacing generally compliant

One 19 km stretch flagged

Depth of cover shortfalls present

Observed across all pipelines

Justification needed for spacing gap

Technical rationale mandatory

Risk-based remediation required

Per UKOPA/GP/1 guidance

Stage 2: Hydrogen Transport Challenges, 100% Hydrogen

Addressing capacity, pressure drop, and compression needs

Reduced Energy Capacity

Hydrogen Energy Capacity Decreases By Approximately 77% Compared To Natural Gas, Necessitating About 2.5 Times Higher Volumetric Flow For The Same Energy Delivery.

Compression And Reinforcement

Operationally, Local Compression Stations And/or Pipeline Structural Reinforcement Are Likely Required To Maintain System Integrity And Performance Under Increased Flow Conditions.

Increased Pressure Drop

Significant Pressure Drop (ΔP) Occurs Along Key Pipeline Corridors, Although Erosional Velocity Limits Remain Within Safe Operational Thresholds.

Stage 2: Materials Review and MAOP Strategies

Detailed comparison of stress limits and pressure strategies under two options

Aspect	Option A (prescriptive)	Option B (performance based)
Stress Limits	Conservative limits without **H_2 testing** → lower MAOP	**H_2 testing** enables higher stress limits; representative lines near 60–65 barg (thin-wall dependent)
Pressure Strategy	Lower MAOP and possible capacity constraints	Selective replacement/re-classification restores original pressure targets where needed
Safety Protocols	Enhanced caution due to lack of H_2 validation	Validated with hydrogen-specific testing protocols
System Impact	Reduced throughput potential	Maintains original system capacity with targeted interventions
	Material conservatism to mitigate risks	Strategic material upgrades and classifications for optimization

Stage 2: Equipment and ATEX Upgrades

Upgrading instrumentation for hydrogen safety and compliance

Chromatographs upgrade

Replace or qualify for 100% hydrogen

Valves and elastomers

Risk-prioritised legacy equipment change-out

ATEX compliance upgrades

Upgrade to Gas Group IIC classifications

Hazardous zone validation

Validate equipment for enlarged zones

Stage 2: Venting and Purging Procedures for 100% Hydrogen

Technical overview of hydrogen venting, blowdown, and safety protocols

Blowdown Temperature Limits

Maintain $T_{min} > -10$ °C For Line Integrity

Hydrogen JT Effect

Controls Wall Cooling During Depressurisation

Flare-based Disposal

Preferred Disposal Method With Backpressure Check

Purging Sequences and Flammability Range

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Stage 2: Hazardous Area Classification & Detection Enhancements

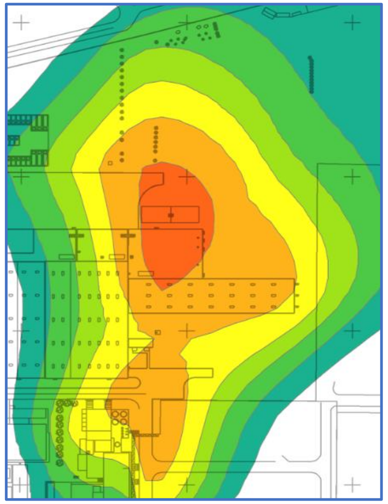
Standards, zones, modelling, and detection upgrades for hydrogen transport

Standards Applied IGEM/SR/25

Compliance with IGEM/SR/25 and Supplement 1 ensures regulatory adherence.

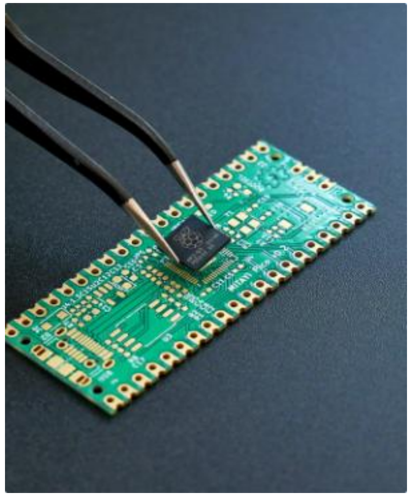
Zone 2 Expansion

Zone 2 area substantially enlarged due to 100% hydrogen service risk.



Dispersion and Dilution Modelling

Modelling finalizes hazardous boundaries and optimizes stack siting locations.



Enhanced Detection Systems

Ultrasonic and hydrogen-capable detectors with 2-out-of-n voting implemented.

Mandatory Portable Detectors

Portable hydrogen detectors required for safe AGI access protocols.

Stage 2: Integrity Management in H_2 Pipeline Transport

Techniques and considerations for defect detection and pressure cycling

Hydrogen exposure reduces defect tolerance and

Hydrogen presence decreases pipeline defect tolerance while increasing vulnerability to damage from repeated pressure cycles, necessitating careful integrity management.

In-line inspection methods vary by defect type and environment

Magnetic Flux Leakage (MFL) is preferred for corrosion detection; Ultrasonic Testing (UT) targets cracks but requires couplant; EMAT is suitable in gas but has higher detection thresholds.

Crack detection thresholds challenge current inspection tools capabilities

Target crack detection thresholds are approximately 2.5–3.5 mm, which may exceed the sensitivity limits of existing in-line inspection technologies, posing a risk for undetected defects.

Pressure cycle data conversion and management ensures pipeline integrity

SCADA pressure data should be converted to stress cycles using rainflow analysis to assess and control cycle severity, thus maintaining pipeline structural integrity over time.

Stage 2: Risk-Based Mitigation for Third-Party Interference

Prioritising and implementing protective measures to reduce risk effectively

Prioritisation based on consequence and exposure

Focuses on risk from third-party interference

Concrete slabbing as primary mitigation

Provides robust physical protection layer

Protective mesh supplements concrete slabbing

Enhances interference resistance effectively

Markers and surveillance for additional safety

Supports early detection and deterrence

QRA confirms slabs as ALARP solution

Risk reduced reasonably and practicably

Technical approach aligns with hydrogen transport

Ensures safety in Portuguese gas system

Comparative Overview of 10% vs 100% Hydrogen Transport

Technical comparison of hydraulics, materials, equipment, integrity, and safety

Area	10% H_2 (blend)	100% H_2
Hydraulics	Negligible ΔP; adjust setpoints.	Energy ↓ 77%; +250% flow; may need compression.
MAOP/Materials	Awareness of B31.12; minimal constraints.	Option B supports 60–65 barg (thin-wall dependent); Option A more restrictive.
Equipment	Minor ΔP on filters/HEX; chromatographs may be incompatible.	Higher ΔP/duty; chromatograph replacement; ATEX IIC; valve/elastomer change-out.
Integrity	Keep survey cadence; prioritise DoC remediation.	Crack thresholds 2.5–3.5 mm; manage pressure cycles; ultrasonic detection.
Safety	Some zone expansion; vent manifolding; controlled hot taps possible.	Whole-site Zone 2 likely; prefer flare; acceptable depressuring Tmin in assessed cases.

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