Welcome to the HIGGS Online Event

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This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875091. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and Hydrogen Europe Research

https://www.higgsproject.eu

Agenda

Total Event Duration 10:00-12:00

1. Introduction to Fuel Cells and Hydrogen Joint Undertaking	Alberto García (Project Officer - FCHJU)
2. Introduction to HIGGS	Vanesa Gil Hernández (Project Coordinator – FHa)
3. Legal, regulatory and technical aspects	Alberto Carezo Alarcon & Lola Storch de Gracia (Redexis)
4. Testing Facilities	Javier Sánchez Laínez (FHa)
5. Techno-Economic Modelling	Luiz Carlos Reichenbach de Sousa (OST)
6. Pathway towards integrating H_2 in EU gas networks	Michael Walter (DVGW)
7. Conclusion	Felix Künkel (ERIG)

Project overview

27th of October 2020

Dr. Vanesa Gil
ARAID senior researcher at Aragon Hydrogen Foundation
HIGGS project Coordinator

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HIGGS-Hydrogen in Gas Grids: a systematic validation approach at various admixture levels into high-pressure grids

- **TOPIC:** H2020 HORIZON FCH 02-5-2019, on:

Systematic validation of the ability to inject hydrogen at various admixture level into high-pressure gas networks in operational conditions.

Low, (10%) medium (10-30 vol.%) and high hydrogen (up to 100% H_2) concentrations in high pressure (up to 80 bar) natural gas grids will be investigated.

- **Key parameters (hydrogen):**
  - 0-100% Hydrogen
  - Total gas flow in the loop ≈ 56 Nm^3/h
  - Maximum H_2 feeding rate: 0.8 kg/h
  - Purity: > 99,99 % (corresponding to electrolytic hydrogen)

FHa facilities, test platform site

- **Duration:** January 2020 – December 2022

- **Budget:** 2,107,672,50 €

HIGGS Consortium add-value

ARAGON HYDROGEN FOUNDATION, SPAIN: testing platform and injection system, hydrogen expertise

European Research Institute for Gas and Energy Innovation, BELGIUM: Communication and dissemination

Natural Gas Transmission System Operator (TSO, Spain)

Eastern Switzerland University of Applied Sciences, SWITZERLAND: Techno-economic modeling

German Technical and Scientific Association for Gas and Water, GERMANY: legal, regulatory and technical aspects

TECNALIA Research and Innovation, SPAIN: Material characterization protocol, membrane tehcnology

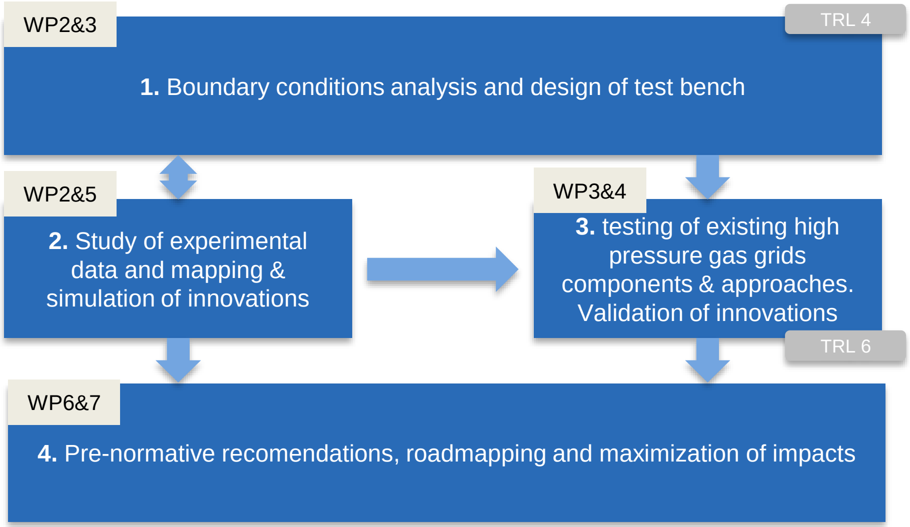
AIM

Pave the way to decarbonisation of the gas grid by…

1. covering the gaps of knowledge of the impact that high levels of hydrogen could have on the gas infrastructure, its components and its management.

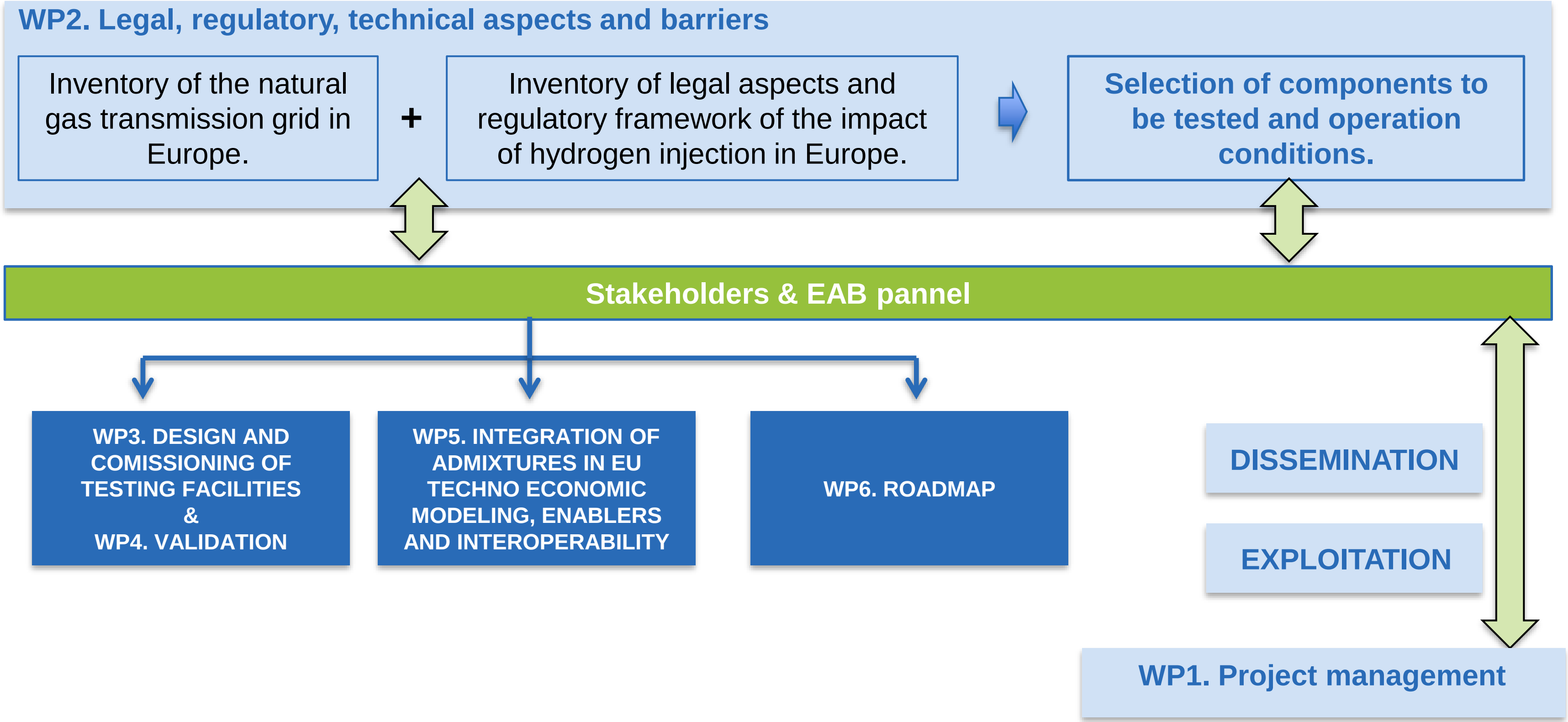
2. set up and operate, a research and development platform reproducing all the components of a high-pressure network and allowing testing of various accessories and appliances for various H_2/CH_4 admixtures.

3. regarding the influence on maintenance procedures for different H_2/CH_4 admixtures and validate technology development



HIGGS methodology

Strong interaction with
EXTERNAL ADVISORY BOARD (EAB) and STAKEHOLDERS



WP2- Legal, regulatory and technical aspects: identification and follow-up

Online Event – 27th October 2020

Alberto Cerezo - Lola Storch (Redexis)

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REDEXIS APPROACH TO HIGGS

1. About Redexis
2. Redexis approach to HIGGS Project as TSO
3. Redexis Contribution to HIGGS Project

WORK PACKAGE 2

1. Review from March Event
2. Where are we now?
3. Challenges

1. ABOUT REDEXIS

Redexis is a company engaged in the development and operation of natural gas transmission and distribution networks, the distribution and commercialization of liquefied petroleum gas and the promotion of renewable applications of natural gas and hydrogen.

Redexis is the third largest distributor of piped gas in Spain. Builds, operates and maintains over 9,498 km of modern distribution networks that supply natural gas in 40 Spanish provinces.

The Company builds infrastructure to transport this source of energy from the trunk or primary network delivery points to connection points reaching homes, businesses and industries throughout Spain, providing the best service in terms of safety and quality. In addition, Redexis is promoting vehicular natural gas through investments in new infrastructures for mobility.

REDEXIS, HYDROGEN PROMOTER

Redexis is committed to the development of renewable energies such as hydrogen, undoubtedly a key energy vector in a zero-emission context and the natural evolution towards a low-carbon economy

DISTRIBUTION OF NATURAL GAS

Redexis provides access to gas by building, operating and maintaining modern gas distribution networks spanning over 9,500 km.

NATURAL GAS TRANSMISSION INFRASTRUCTURES

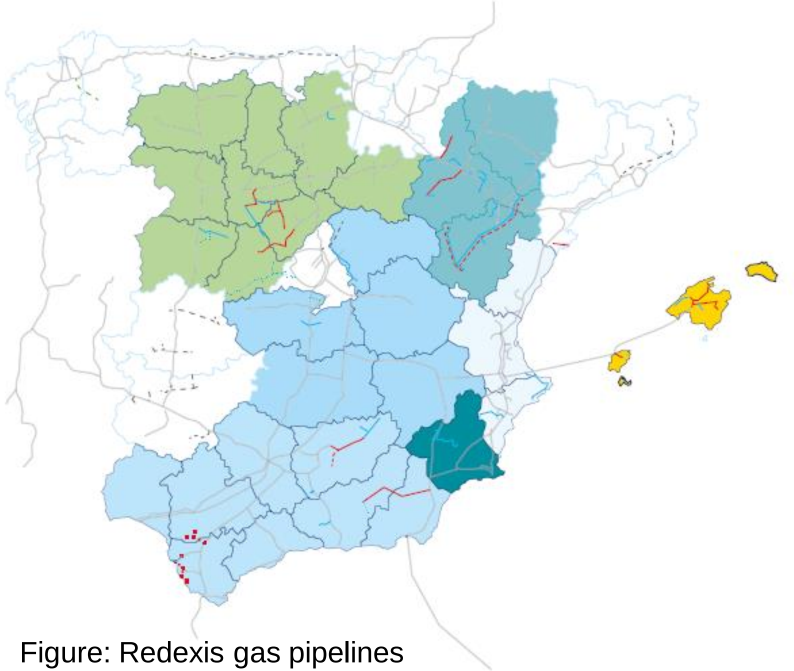
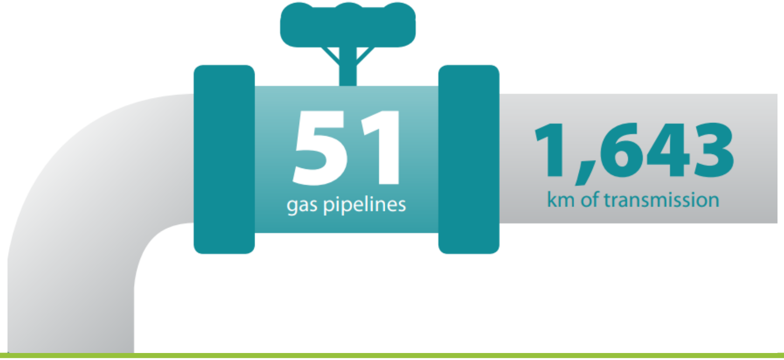


Figure: Redexis gas pipelines

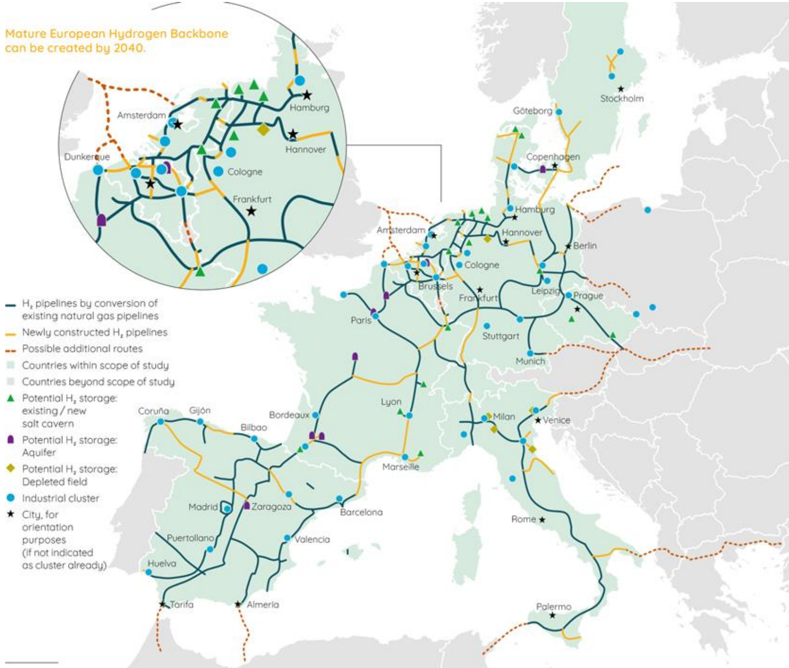
Redexis has installed and operates natural gas transmission infrastructure spanning over 1,643 km throughout ten Spanish Autonomous Regions, transporting gas at pressures in excess of 16 bar to industrial hubs and distribution network connection points, fully aligned to modern legislation and standards.



2. Redexis approach to HIGGS Project as TSO

2.1 Introduction

Europe’s natural gas infrastructure and Hydrogen injection



The Global network.

How will it affect…

- *… Transmission Operators?*
- *… Distribution Operators and final Users?*
- *… the capacity of the current network?*
- *…*

Why?

- *Reduction in the use of natural gas (decarbonization).*
- *A great network available.*
- *Solution to renewable electrical energy (energy storage).*

European Hydrogen Backbone Initiative 2020 https://gasforclimate2050.eu/publications/

2. Redexis approach to HIGGS Project as TSO

2.2 Redexis objectives as a transmission network operator (also as a Distributor and operator of NGV)

- Obtain clear conclusions on the effects that hydrogen injection can have on our networks, on the validity of the facilities that make up the network for the admission of Hydrogen, and on the changes / adaptations to be carried out.
- Define and understand the changes that must be made in the existing infrastructures, to allow this hydrogen injection, and the evolution of the changes based on the% of Hydrogen injected.
- Define the need to apply these changes in a preventive manner on existing facilities, and also on new gas pipeline projects whenever possible (for example, consider only certain grades of steel in new gas pipelines
- Establish the Regulations, Standards and Certifications (RSC) and the technical measures that allow the safe injection of Hydrogen in the networks and their operation.

2. Redexis approach to HIGGS Project as TSO

2.3 Redexis challenges as the only TSO among the partners of the HIGGS Project

- Correctly identify the Transmission facilities that allow a global vision of the European Infrastructure.
- Obtain sufficient information on the facilities to characterize the European Transmission Network.
- Properly select the elements and equipment of the Transmission network to be tested within the HIGGS Project, in accordance with the assigned budget, and the available resources and deadlines.

3. Redexis Contribution to HIGGS Project

Main tasks and responsibilities within "HIGGS project"

REDEXIS will actively participate in all HIGGS WPs, as operator of high-pressure grids:

WP2 (Legal, regulatory and technical aspects: identification and follow-up)

- Redexis will provide information in transmission facilities and in the RCS and legal status for operation of gas grid (Inventory and Equipment)
- The results of WP2 will be input for work packages 3 to 6 in the project.
- A strong interaction between the mentioned work packages, the consortium members, RSC bodies as well as to the panel group will be needed.

WP3 (Design, preparation and commissioning of testing facilities)

- *Redexis* will support the technical design of the admixture facility and testing loop, leading the task on potential update and needs for upscaling the research platform

WP5 (Techno-economic modelling and validation, enablers and interoperability)

- Redexis will support the activities mainly as background information provider to develop the baseline cases for the technoeconomic modelling,
- Redexis will overview the data required for the modelling, together with an active support on the definition of recommendations

WP6 (Description of pathway towards integrating H2 in EU gas networks)

- *Redexis* will support the activities on preparing a document compiling the recommendations and next steps towards implementing a pathway to allow higher concentrations of hydrogen in transmission gas grids at EU level (interoperability, grid management and cross border issues)

WP 2 Legal, regulatory and technical aspects: identification and follow-up

Update October 2020

1. Review from March Event
Legal, regulatory and technical aspects

Start month 1 **End month** 19

Partners involved

DVGW (leader)

FHa

Redexis

Main Objective is to…

…provide updated information to HIGGS on present

- **regulations,**
- **standards and**
- **certifications**

for the equipment and infrastructure of high pressure grids, together with

- **components characteristics**

to identify and follow up those critical aspects where HIGGS will continue the investigations and needed innovations with respect to the current state of the art

Specific Objectives are:

1. **Investigation** on the present regulations, standardizations and certifications (RSC) of the EU
   a) on limitations with respect to hydrogen concentrations in the gas system
   b) on the corresponding standards.
2. **survey** on existing equipment in natural gas grids.
3. **Identification of and recommendations** for most critical RSC bottlenecks
4. **Setup of mitigation measures** for existing gas appliances and gas system

-> enabling the end users and operators to operate the entire gas system safely without forcing the operators/owners to replace equipment and appliances before their end-of-life, when it comes to higher hydrogen concentrations in natural gas.

1. Review from March Event
How will the objectives be achieved

Tasks carried out in the Workpackage

- **Mapping and update of RCS at EU level: barriers and enablers**
- **Detailed look at Natural Gas equipment and infrastructure**
  - Inventory and quantification of existing assets
  - Hydrogen sensitivity of assets elements with good knowledge availability
  - Covering gaps on hydrogen sensitivity knowledge base

INVENTORY AND QUANTIFICATION OF NATURAL GAS TRANSMISSION FACILITIES' SURVEY										
Operator, Association or Organism Name:										
Type:	Transmission Operator / Association / Organism / ...									
Country(s) for which information is provided:										
PIPELINE										
Length (km) depending on pipe steel quality and on diameter										Len
Diameter	API 5L Gr B	API 5L Gr X42	API 5L Gr X60	API 5L Gr X70	API 5L Gr X80	Other (to be specified)	Other (to be specified)	TOTAL		≤ 59 bar
2"								0,00		
3"								0,00		
4"								0,00		
6"								0,00		
8"								0,00		
10"								0,00		
12"								0,00		
14"								0,00		
16"								0,00		
18"								0,00		
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28"								0,00		
30"								0,00		
32"								0,00		
34"								0,00		
36"								0,00		

1. Review from March Event
Present and near future activities

Data collection and analysis

Gathering information on NG equipment and infrastructure in quantities:

- Pipeline materials, age and length
- Installations in the gas net like
  - Compressors
  - Underground storages
- Replace time
- Present hydrogen sensitivity
- Preparing dedicated information on the most sensitive assets

→ Necessary for the material tests

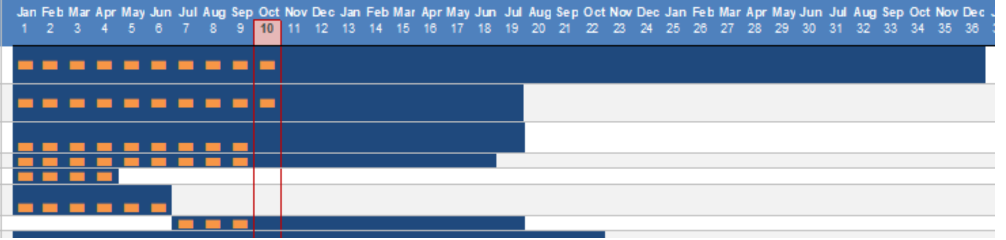
Mapping and updating Regulations, Codes and Standards in the EU

- Review State-of-the-Art documents from
  - CEN-CENELEC Sector Forum Energy Management
  - AFNOR
  - Marcogaz
  - DVGW
- Strong observation on the regulation to hydrogen injection (concentration)
  - Present
  - Near future
  - future

2. Where are we now?

Project Title	Hydrogen In Gas GridS: a systematic validation approach at various admixture levels into high-pres
Project Aronym	HIGGS
Start	01.01.2020
Actual Month	10
Show status	actual

No.	Work Package/Task	Responsible	Planned Start	Planned Finish	Actual Start	Actual Finish	Done in %	Status -1:critical 0: delayed 1: OK
1	WP1 - Management and coordination	FHa	1	36	1	36	27%	
6	WP2 - Legal, regulatory and technical aspects: identification and follow-up	DVGW	1	19	1	19	50%	
7	T 2.1: Mapping and update of RCS at EU level: barriers and enablers	DVGW	1	19	1	19	45%	
8	T 2.2: NG equipment and infrastructure	REDEXIS	1	18	1	18	45%	
9	*T2.2.1. Inventory and quantification of existing assets*	*REDEXIS*	*1*	*4*	*1*	*4*	80%	
10	*T2.2.2. Hydrogen sensitivity of assets elements with good knowledge availability*	*REDEXIS*	*1*	*6*	*1*	*6*	100%	
11	*T2.2.3 Covering gaps on hydrogen sensitivity knowledge base*	*REDEXIS*	*7*	*19*	*7*	*19*	20%	



WP2 CHRONOGRAM

Task 2.1: Mapping and update of RCS at EU level: barriers and enablers.

Task 2.2: NG equipment and infrastructure

Task 2.2.1. Inventory and quantification of existing assets

Task 2.2.2. Hydrogen sensitivity of assets elements with good knowledge availability

Task 2.2.3 Covering gaps on hydrogen sensitivity knowledge base

2. Where are we now?

Hydrogen in Gas Grids

What?......................

Task 2.1: Mapping and update of RCS at EU level: barriers and enablers.

Task 2.2: NG equipment and infrastructure

- **Task 2.2.1**. Inventory and quantification of existing assets
- **Task 2.2.2.** Hydrogen sensitivity of assets elements with good knowledge availability
- **Task 2.2.3** Covering gaps on hydrogen sensitivity knowledge base

How?......................

- a review on existing RSC in Europe and member countries on allowed hydrogen concentrations in the gas system will be performed.
- **Questionnaires for RSC**
- **Deliverable 2.2: Assessment document of RCS barriers and enablers at EU level**
- **Survey** (facilities)
- refining process to improve the accuracy of the modelling results
- **Deliverable 2.3: Final document Review on specific technical, RCS barriers, enablers and innovations**
- by contact to knowledge owners

Next steps….

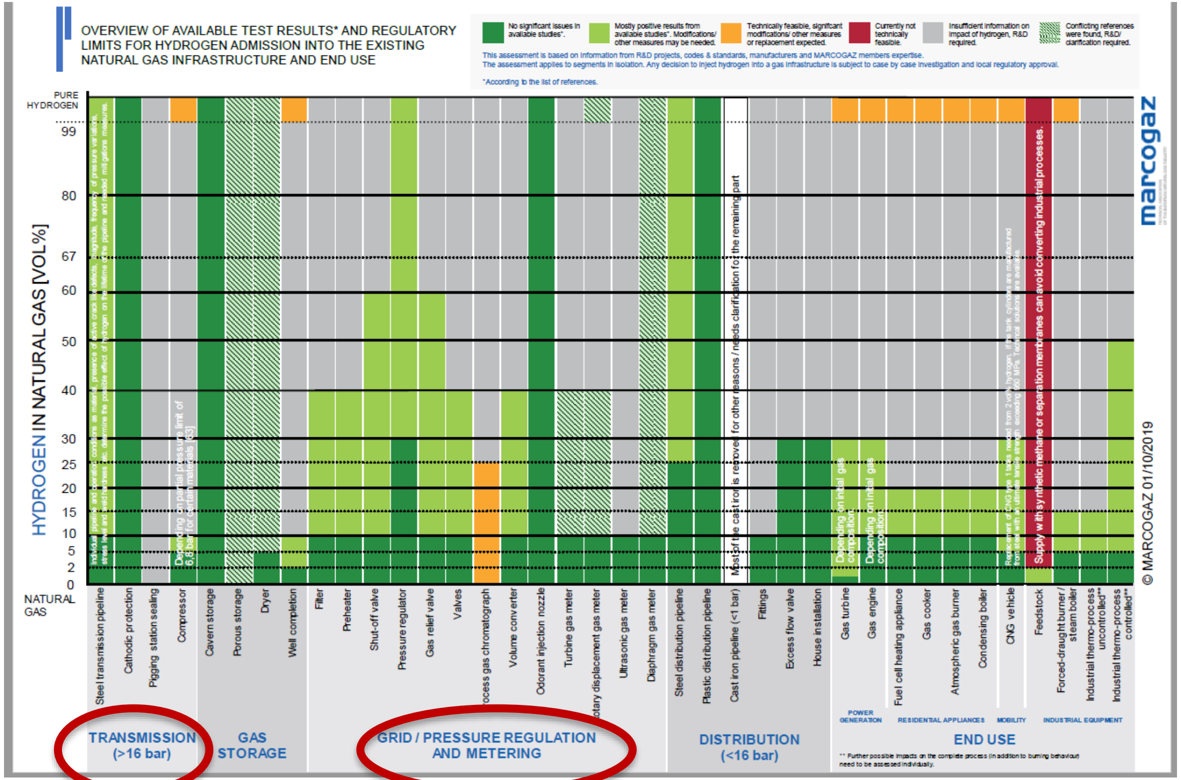
As a whole for WP2:

Interpretation of survey results, questionnaires results and final public deliverable (Month 19)

Deliverable 2.2: Submitted to EU in 2020, expected to be public during 2021.

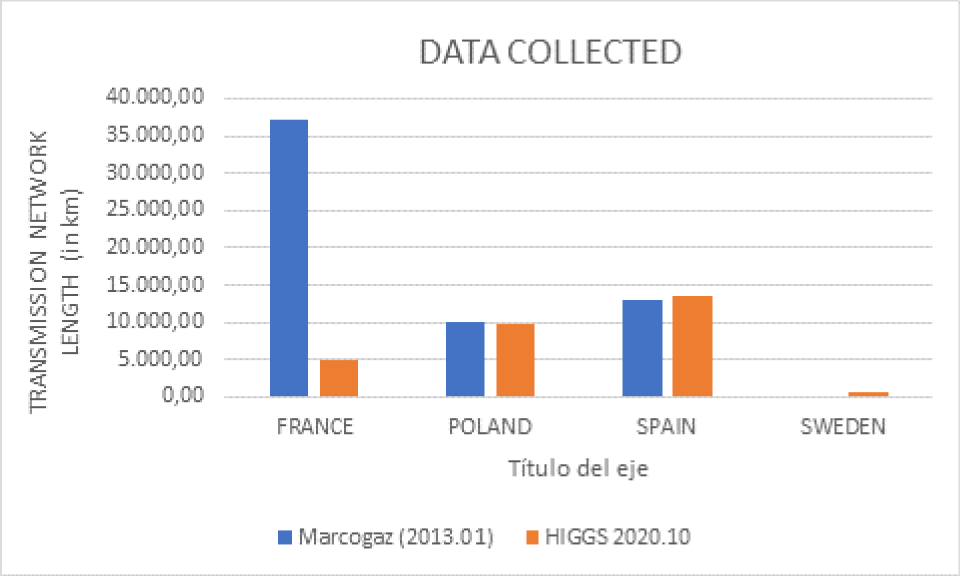
Deliverable 2.3: Will be submitted to EU in June 2021, Expected to be public in due course

2. Where are we now?



We are focusing on Transmission and Grid/pressure regulation and metering since the Project main challenges concern these facilities

2. Where are we now?.... Data collected to date



- surveys were sent to the complete TSO members of Marcogaz and different TSO directly (Marcogaz members)

- To date, we have obtained responses from 9 operators (1 French, 1 Polish, 1 Swedish and 6 Spanish).

3. Challenges

- We request collaboration from TSOs and associations to obtain sufficient information on both infrastructures and RSC (Regulation, Standards and Certification)

- We are delighted to have bilateral meetings to deepen into the scope of the work that we need to develop, clarify any concept of the surveys, etc.

- For those organizations that collaborate, we offer the possibility of sending them the public result of the deliverables as soon as they are approved on demand

Outlook and next steps

Next steps

- Collect data on equipment in transmission gas grid asap (TBD)

→Participants welcome:

Michael Walter: michael.walter@dvgw.de
Armin Bollien: armin.bollien@dvgw.de
Alberto Cerezo: alberto.cerezo@redexis.es
Javier Sánchez: jsanchez@hidrogenoaragon.org

WP3-Design, preparation and commissioning of testing facilities

Online Event – 27th October 2020

Dr. Javier Sánchez (FHa)
jsanchez@hidrogenoaragon.org

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875091 'HIGGS'. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

Outline

- Background and objectives
- Design of the R&D platform
- Next steps

Background

Need for reseach

- After hydrogen is produced, the goal is to **transport** it with the minimum investment. **Current gas grid** is a possibility.

- However, the different components of the gas grid are not designed for the transport of high amounts of hydrogen and the **impact** of transporting high amounts of this gas **is unknown**. R&D is therefore necessary to check the technical readiness of the gas infrastructure and decide suitable modification measures.

  →Infrastructure and auxiliary facilities:

  Pipelines Positions Scraper traps

  Regulation and metering stations Compressor stations

  Storage Gas analysis and sensors Flow measurement

  Seals welding connections

- Lastly, once transport is done, there is the need to **extract** hydrogen from the **admixture**. Processes based on **membranes** are considered as the most promising technologies for <20% H_2/CH_4 content.

Design, preparation and commissioning of testing facilities

Main Objective is to…

…To develop the **R&D platform** where the **experimental validation** of components will be carried out during HIGGS project.

Specific Objectives are:

Design and implementation of a R&D testing platform composed of:

-**an injection platform** that recreates the **injection of** different flows of **electrolytic H_2 into a natural gas** with variable composition.

-**- a testing loop** designed to work up to 80 bar, including the main **components** needed to recreate the operational environment **of a high-pressure gas grid,** with continuous control of parameters such as gas quality, flow and pressure.

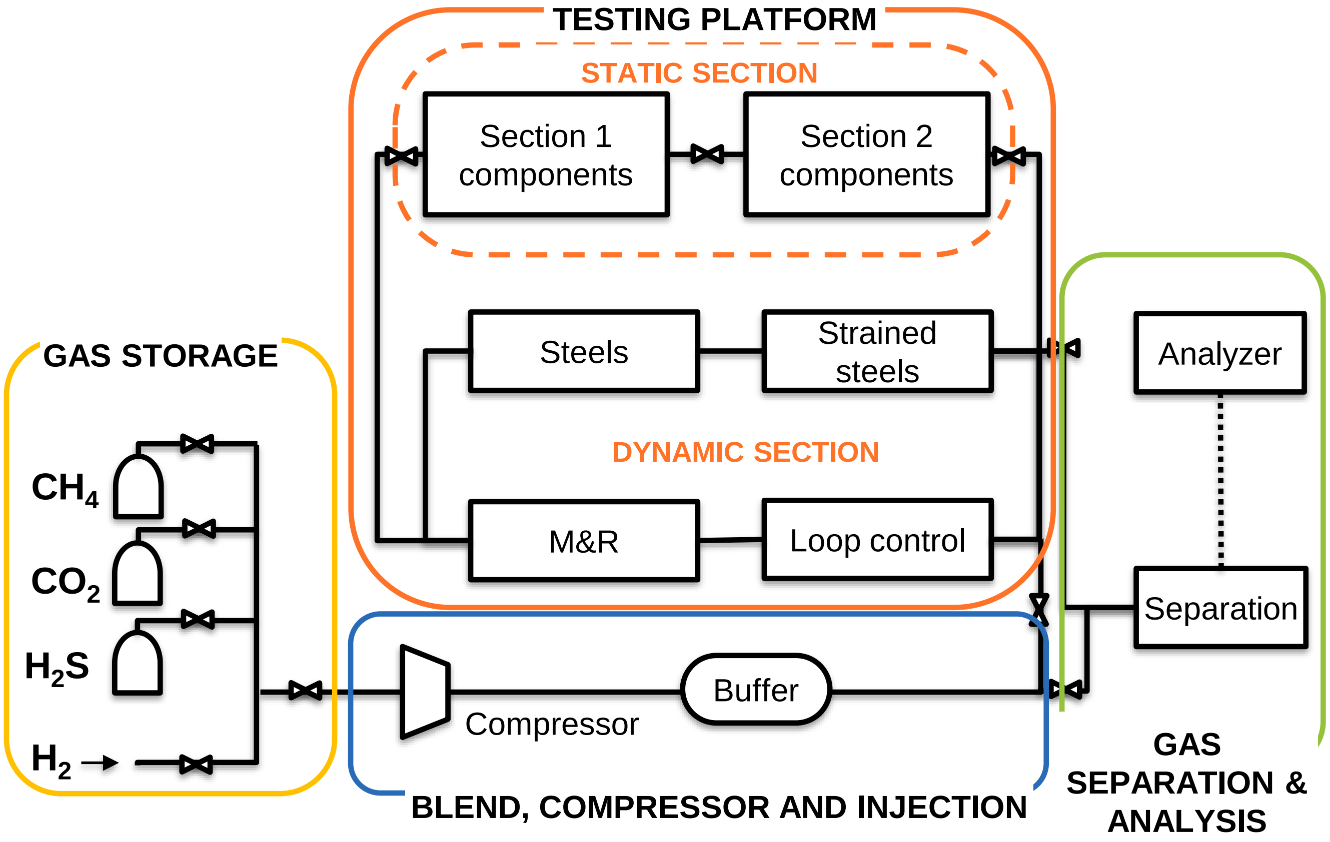
- a hydrogen purification prototype based on **membrane technology for separation of H_2/CH_4** mixtures at high pressure including first lab-scale testing of its components-

Design of the R&D platform: site at FHa

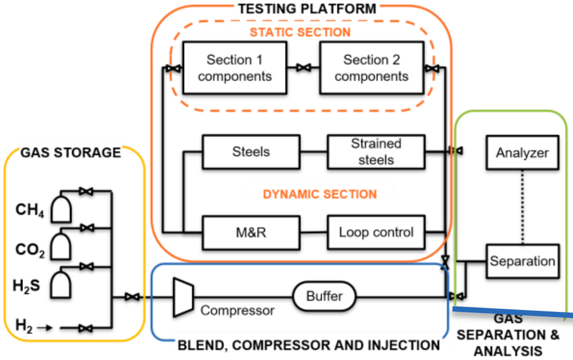
Design parameters for…

- **Hydrogen**
  - 0-100% Hydrogen
  - Total gas flow in the loop ≈ 56 Nm^3/h
  - Maximum H_2 feeding rate: 0.8 kg/h
  - Purity: > 99,999 % (corresponding to electrolytic hydrogen)
- **Natural Gas**
  - Operating pressure
    - 60-80 bar
  - Impurities depending on the origin to simulate
    - CO_2
    - H_2S
    - Etc.

Design of the R&D platform: overview



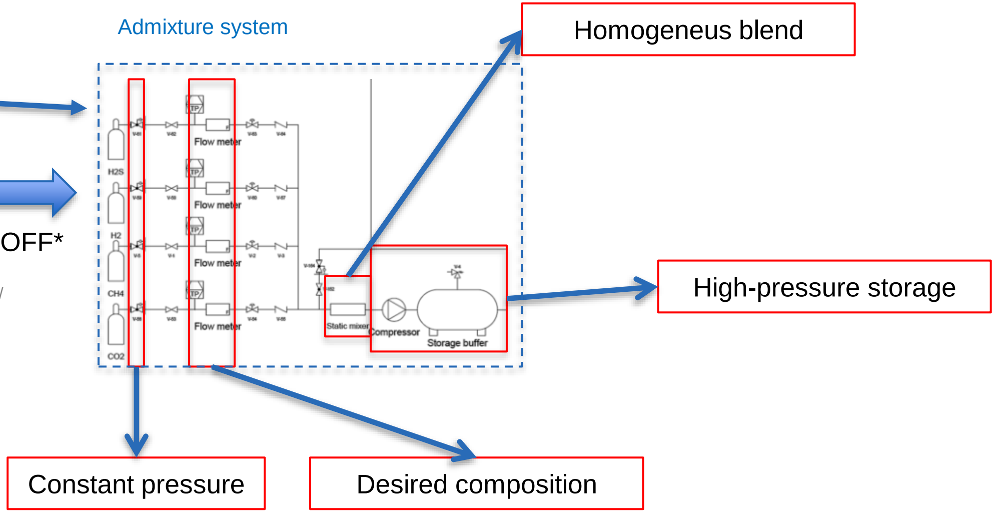
Design of the R&D platform: Admixture system



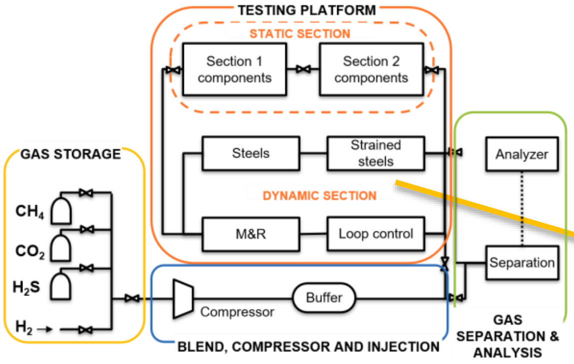
Injection of hydrogen blends from 0 to 100% H_2
Maximum pressure 200 bar

From ELY4OFF*

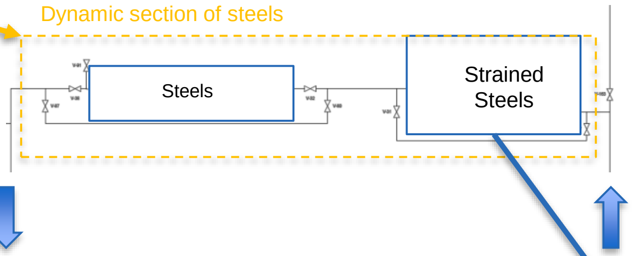
*http://ely4off.eu/

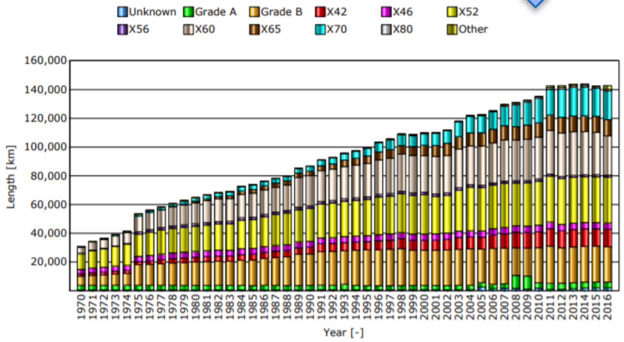


Design of the R&D platform: Dynamic section of steels



Selection of typical steels in the European gas grid
Embrittlement and corrosion effect of hydrogen

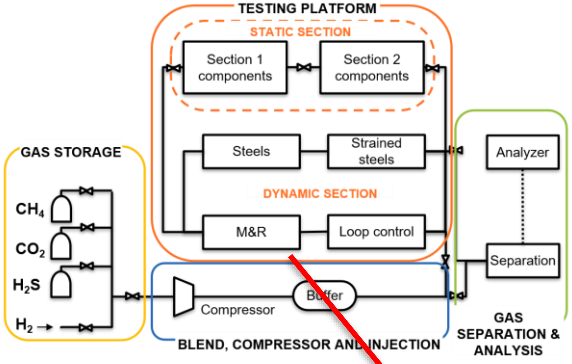




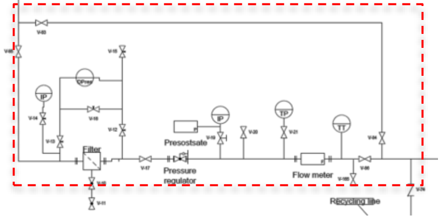
Source: 10th EGIG-report 1970-2016

C-ring, U-bend and 4-point bend specimens

Design of the R&D platform: Dynamic section of components



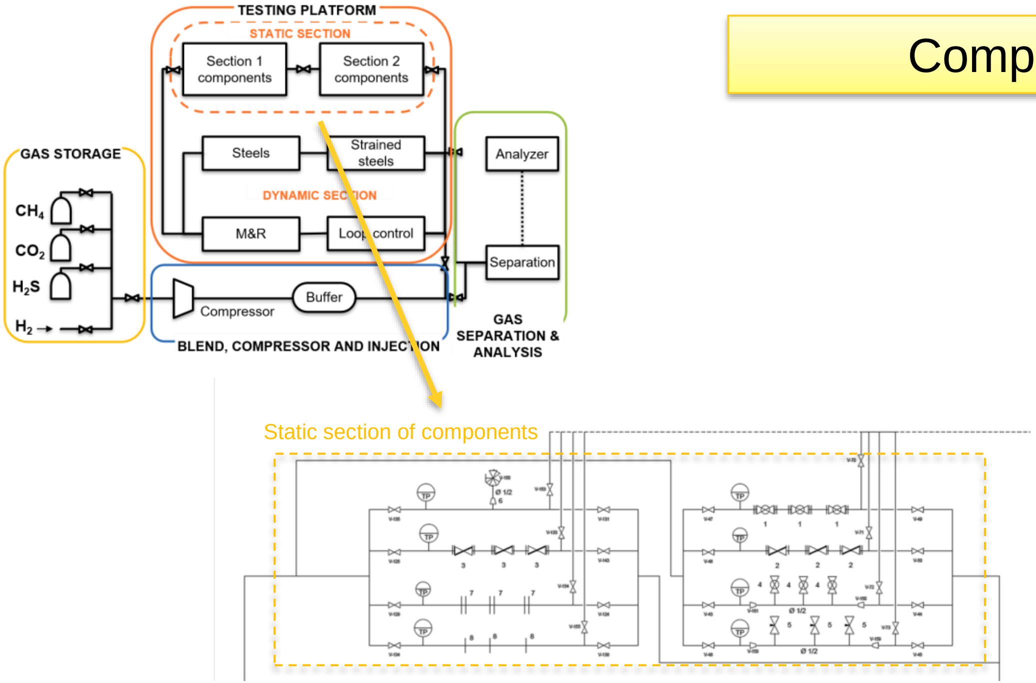
Dynamic section of components



“Pseudo” M&R Station
Effect of hydrogen on material

- Filter
- Pressure regulator
- Flow meter

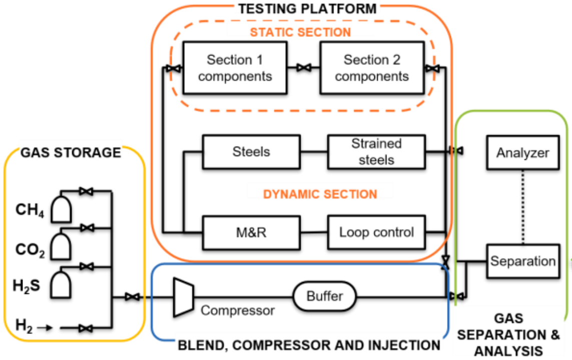
Design of the R&D platform: Static section of components

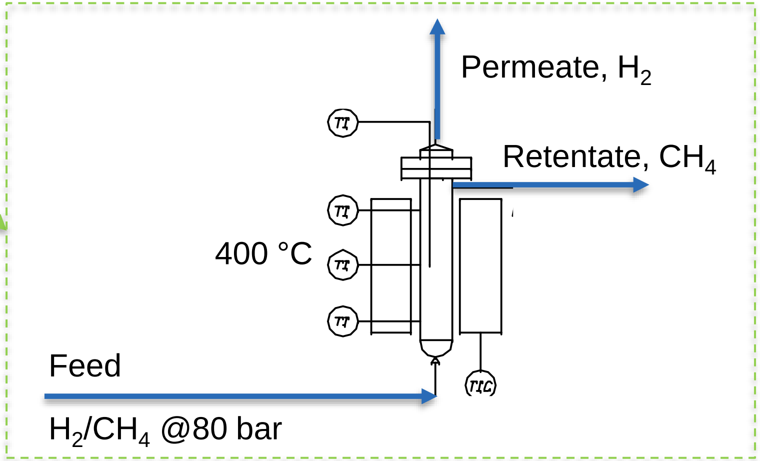


Components susceptible to leakage

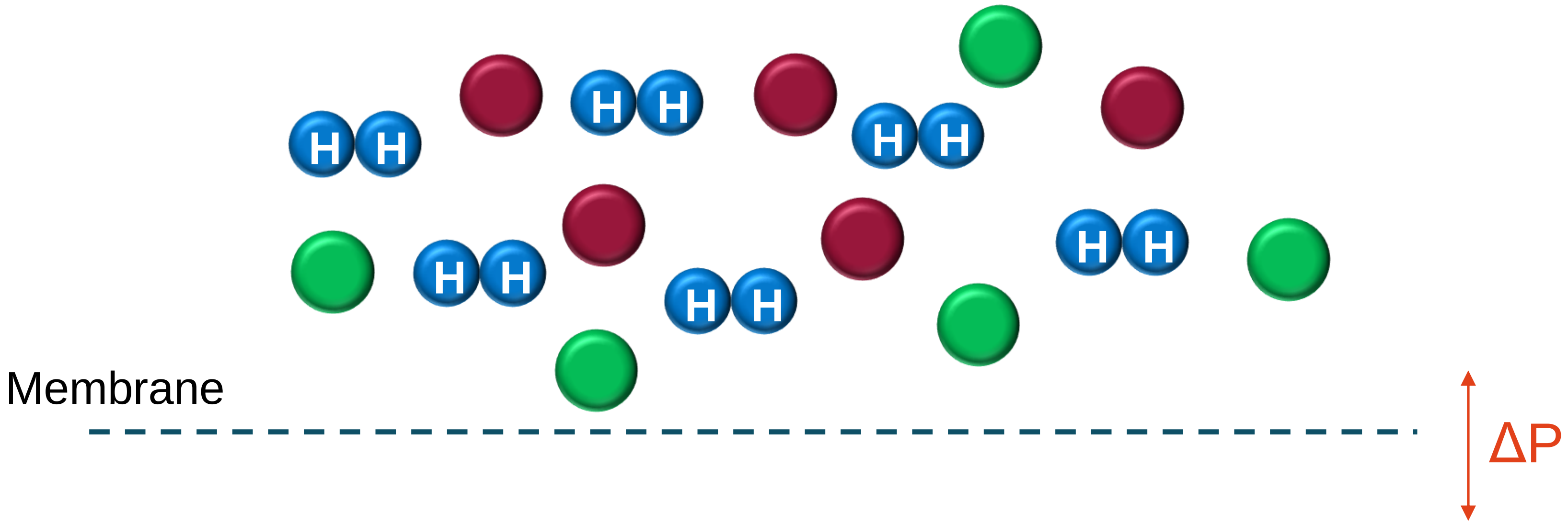
Component category	Type	Connection (size and technical standard)
Valve	Ball	RF
Valve	Butterfly – Lug type	RF
Valve	Plug	RF
Purge	Ball valve + screw cap	SW, ½”
Purge	Needle valve + screw cap	SW, ½”
Manifold	Manifold 1 via, with 2 NPT valves	½”
Connection	-	Flange
Connection	-	Threaded joint

Design of the R&D platform: Membrane module

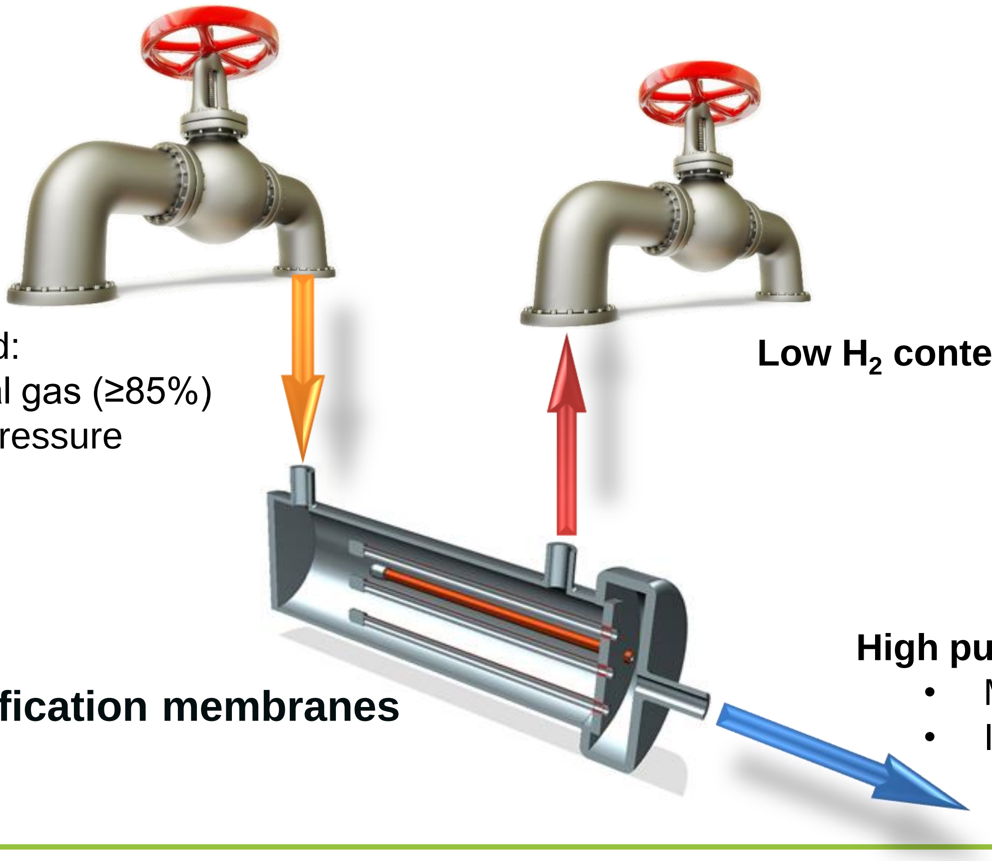




Design of the R&D platform: Membrane module



Design of the R&D platform: Membrane module



Design of the R&D platform: Membrane module

Types of hydrogen separation membranes to be tested

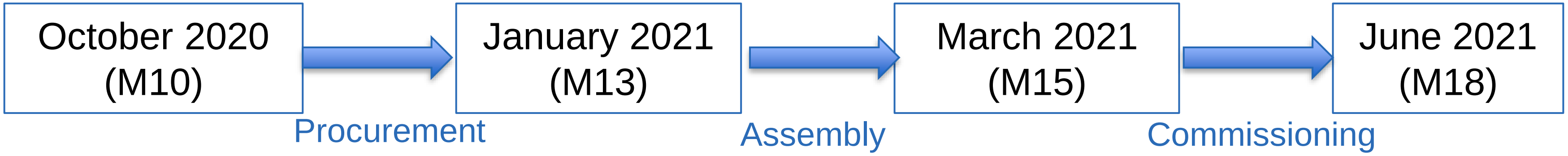
Thin Pd-based supported membrane (up to 5 µm thick)

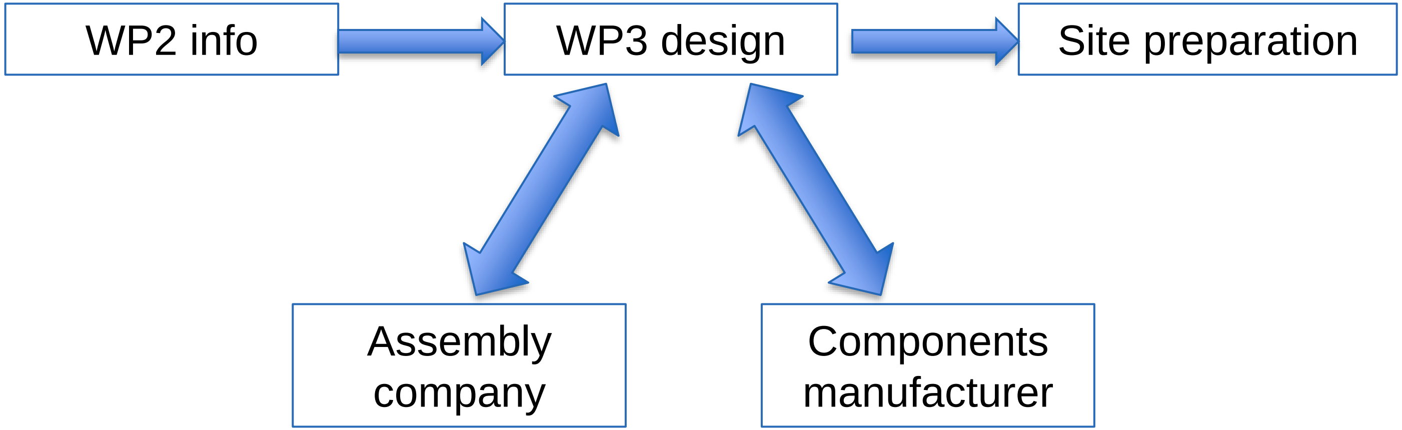
Thin carbon molecular sieve membrane (~3 µm thick)

Polymeric hollow fiber membranes

	Pd-based	Carbon-based	Polymeric-based
Operating temperature	300-500 ºC	Up to 250 ºC	Up to 150 ºC
H2 permeance	High	Moderate	Low
H2 perm-selectivity	High	Moderate	Low
Cost	Moderate	Low	Low

Future development of WP3





Work Package 5
Techno-economic modelling and validation, enablers and interoperatibility

HIGGS Online Event – 27.10.2020

Dr. Luiz Carlos R. de Sousa
Robin Leonhard

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HIGGS Hydrogen in Gas Grids

Partners

- **OST – Ostschweizer Fachhochschule** (Formerly HSR)
- **Fundación Tecnalia R&I (TECNALIA)**
- **Redexis Gas, S.A. (REDEXIS)**
- **Fundación Hidrógeno Aragón (FHA)**

Work Package 5

Main Objective

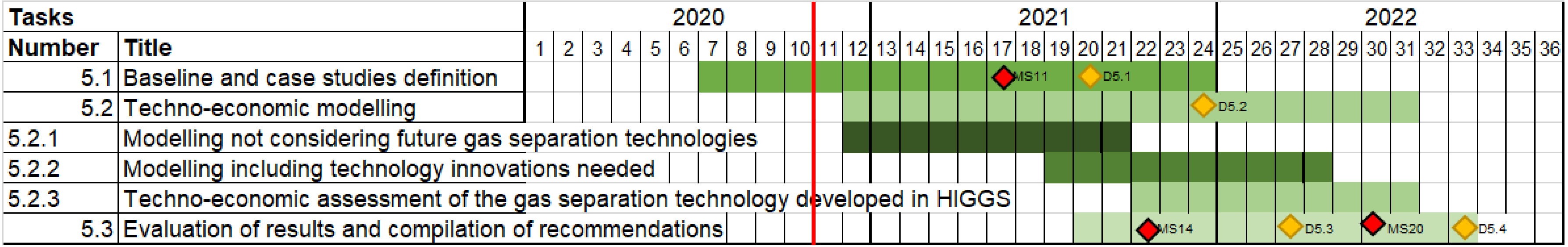
To develop **operation strategies** and **business implications** of increased and variable contents of hydrogen in the high-pressure transmission grid. Show how **increased hydrogen content** in the high pressure gas grid can contribute to the overall goals of **reduced carbon emissions** from the energy sector

Specific Objectives are:

1. **Define case studies** for operator of high pressure gas grids, gas buyers or gas producers injecting hydrogen.
2. **Define generic structures** of the high-pressure transmission grid relevant in the European context.
3. **Compile a numerical model** to describe technical operation and business impacts of high pressure grid.

Work Package 5

Timeline



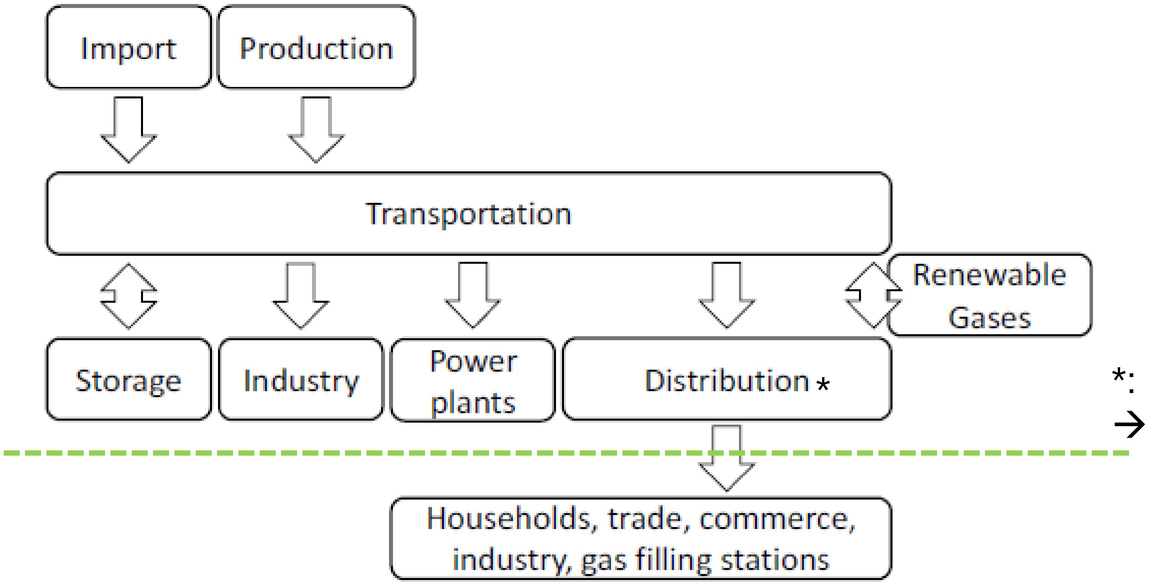
Milestones

#	Title
MS11	Alignment with WPs for baseline definition
MS14	Summary and first set of conclusions to inform WP6
MS20	Main key points drafted to provide information to pathway (WP6)

Deliverables

#	Title
D5.1	Report on baseline, assumptions and scope for techno-economic modelling
D5.2	Complete description of the model, including case studies
D5.3	Intermediate report: key findings on potential and enablers
D5.4	Techno-economic validation: main conclusions and recommendations

Work Package 5 – Scope

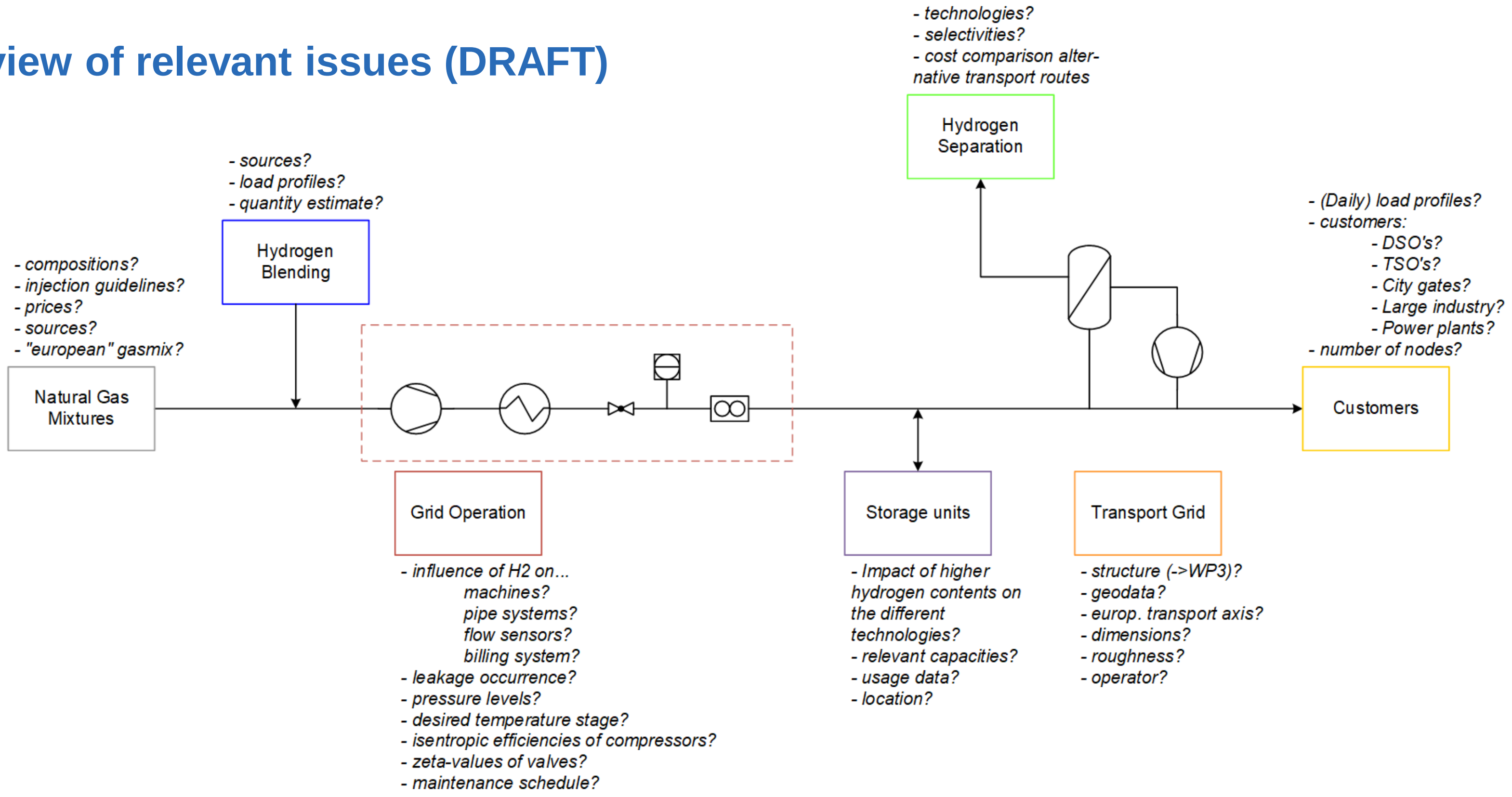


*: No modelling of the distribution network
→ Boundary is city gate

Source: STORE&GO

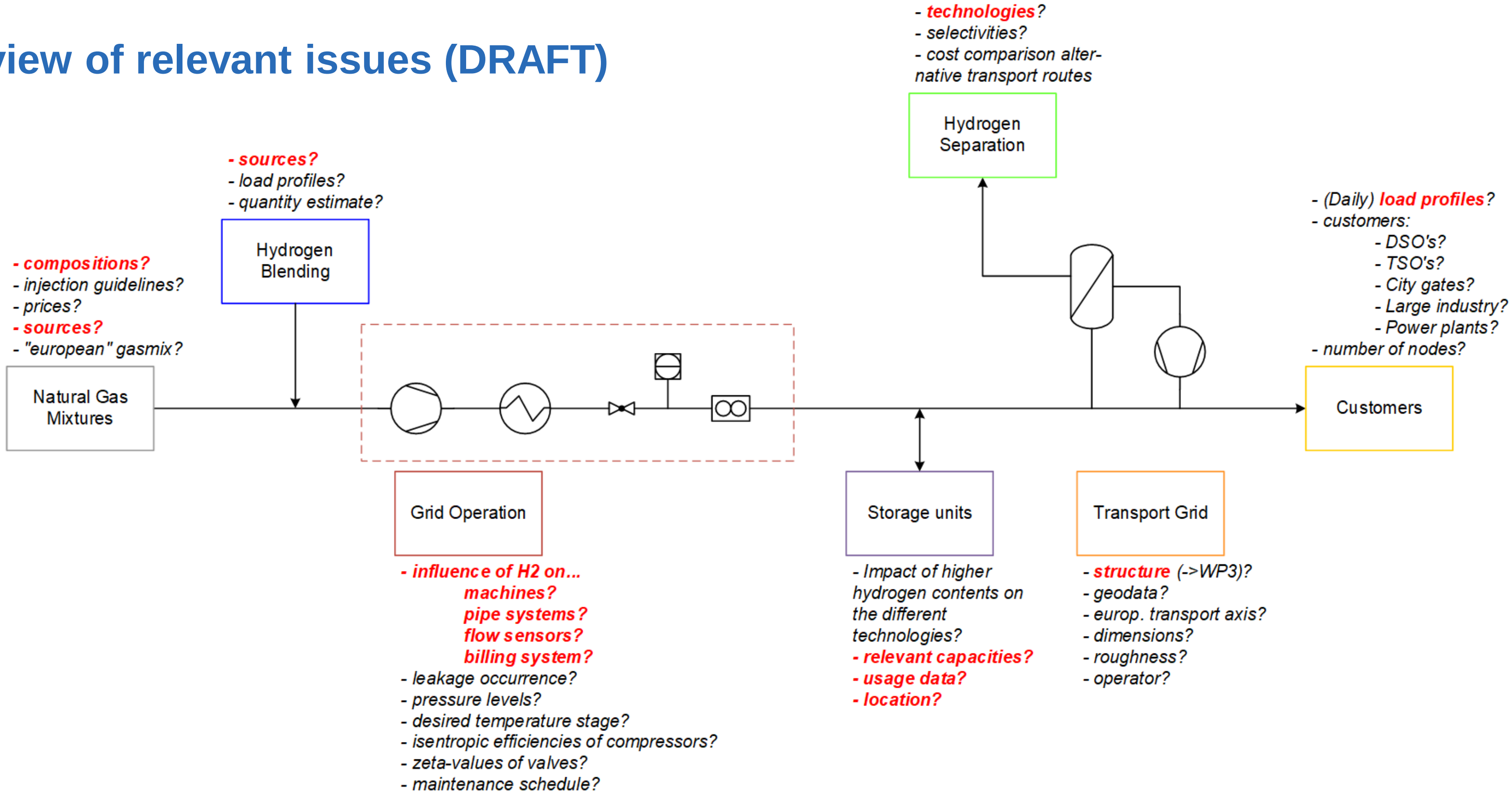
Work Package 5 – Mindmap

Overview of relevant issues (DRAFT)



Work Package 5 – Mindmap

Overview of relevant issues (DRAFT)

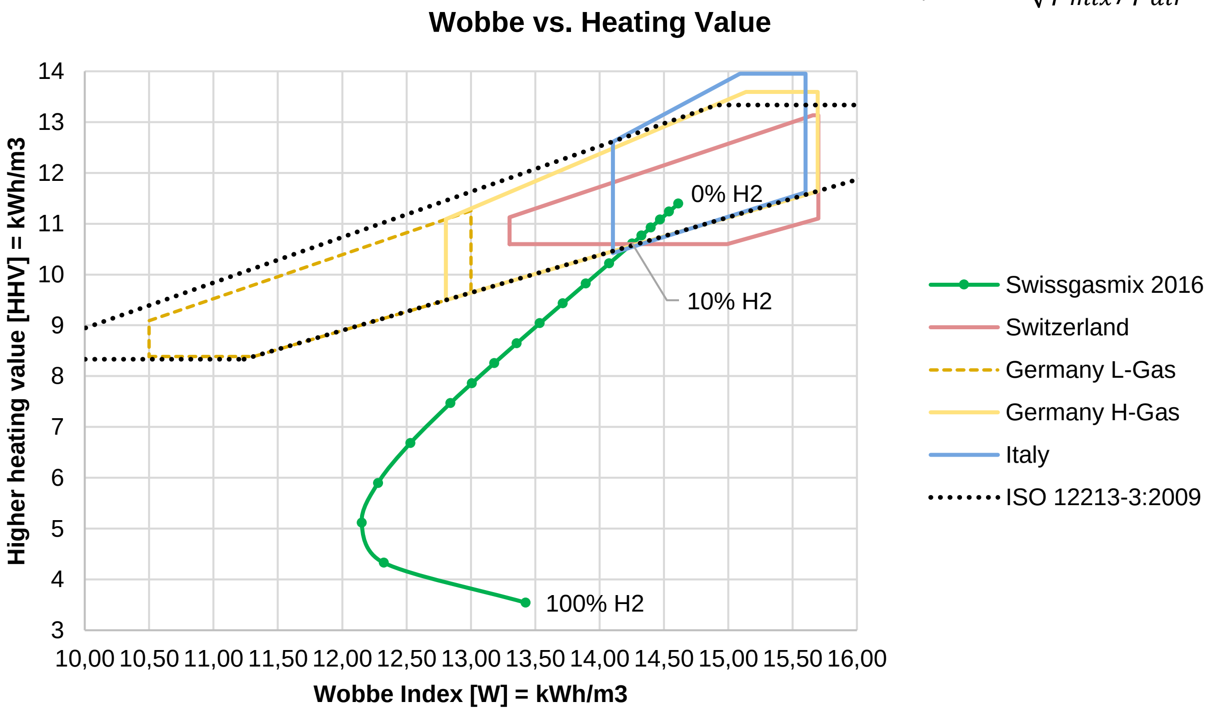


Work Package 5 – Gas Composition

Technical specifications for gas injection in different countries

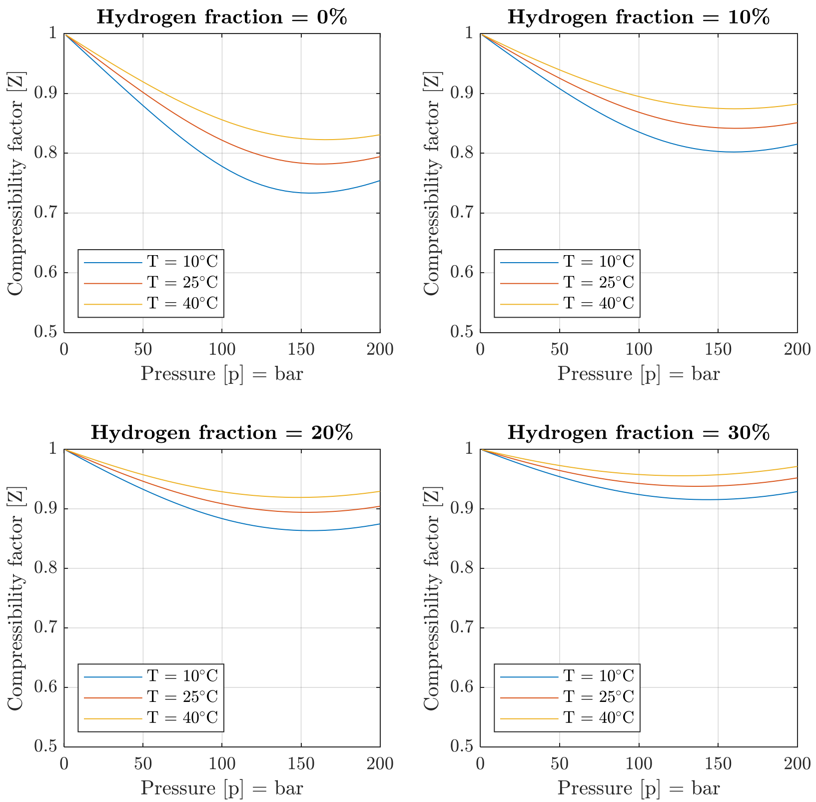
$$W_s = \frac{H_s}{\sqrt{\rho_{rel}}} = \frac{H_s}{\sqrt{\rho_{mix}/\rho_{air}}}$$

- Example Swissgasmix 2016:
  - Methane: 91.61%
  - Ethane: 4.80%
  - Propane: 0.74%
  - Butane: 0.30%
  - Carbon dioxide: 1.32%
  - Nitrogen: 1.23%
- Gas mix blended with different fractions of Hydrogen. Density calculated with REFPROP and derived Wobbe and HHV.
- The relative density as a fixed boundary condition, is directly related to the wobbe and calorific value (see Equation).



Scope of the standards in use

- The calculated accuracy of thermodynamic properties of natural gases is given up to an admixture of 10% hydrogen according to ISO 12213. Most feed-in guidelines are limited in this range as well due to allowable relative density of the gases.
- The influence of higher hydrogen admixtures is still missing in the literature. Experts in thermodynamics refer to an increasing "idealisation" of the gas at higher hydrogen contents and therefore the equations of state remain valid.
- On the right an example of the real gas factor for the Swissgasmix 2016 with different hydrogen contents is shown; the higher the proportion the more "ideal" the gas, i.e. the higher the compressibility factor. The calculation was carried out with FluidProp in Matlab.



Simulation Software

- Inquiries sent to various SW providers, covering:
  - Applications and references
  - Computational possibilities of Hydrogen as part of mixtures
  - Thermodynamic models and balance equations used for calculations
  - Network modeling possibilities
  - Time resolution of balance equations
  - Input data file formats, corresponding outputs and interfaces
  - Simulation of system components, e.g. compressors, valves, metering stations, storages, membranes, etc.
- All companies gave live demonstrations and presentations of their software online.
- Second questionnaire is in preparation

3.1.9 Overview / Comparison

	SmartSim	Simone	PSI Gas	Neplan	Synergi Gas	Irene Pro
Applications and references?	Gas Quality Tracking in order to ensure correct billing when different gases are injected into the grid. An additional module for grid planning is currently being developed.	Product for planning purposes. Integrated as state estimation and leak detection tool. Computing high- and low pressure networks as well as for transportation- and distribution structures.	Planning of new gas networks, entry and exit flows, new customer exits, transport of hydrogen or bio gas through networks	Stadtwerke und Planer	Recently awarded the contract to assess the feasibility of transporting Hydrogen in the Italian transmission system; Used in 90% of all gas distribution companies in the US, 100% in UK as a network design and planning tool and for optimization / forecasting.	Used to calculate the Dutch natural gas distribution networks since the seventies up to now and is used by most Dutch DSO's
H_2 computable as part of a mixture?	Yes, hydrogen can be tracked. Also any other components that may be expected in natural gas grid can be considered.	Can be used also for gases containing a considerable content of hydrogen…	Gas compositions are according AGA8-92DC (21 gas components including hydrogen)	Ja	Proven Hydrogen modelling capabilities and any gas using multiple gas compositions simultaneously allowing you to trace any component through the network	Following properties define the fluid: density, dyn. viscosity, calorific value, relative compressibility, these values must be given for the mixture.
Simulation: - Network modelling (i.e. GIS) - Thermodynamic model used? - **Time resolution of balance / DE?** - Input data to be generated or modified? - Corr. output? - Dynamic and steady-state? - Guidelines / Regulations?	Topology taken from GIS or other software for grid calculation. For conversion of data formats, interface that can be adjusted in a very flexible way. **Kernel** in-house development based on high accurate thermodynamic functions. Further reference (ISBN: 978-3-18-350507-4). The calculation is performed on an hourly basis. Higher time resolution would not increase accuracy of results. All common data interfaces like e. g. csv, txt, XML, MSCONS.	Due to the implementation of various state equations (**GERG2004, AGA8DC92, BWR**, etc.) It be can be used also for gases containing a considerable content of hydrogen. For hydrogen planned to extend the list of EOS with **GERG2008** by the end of 2020; Standard API which allows transferring data from and to SIMONE within a programming environment. Offered implementations for Java, JavaScript, LUA, C, C# and C++	GIS import not available. Networks edited via topography editor; Thermodynamics based on Helmholtz free energy. **SGERG-88** and **AGA892DC** for calculation of real gas deviation is available. **GERG 2008, SRK, PR, LKP and BWRS** addable; Solution of DE via implicit finite difference method. The time step range of 1 to 3600 s. No strong relation between time steps and space. Input in dialogs for entry and exit flows. Export and import possible via clipboard (to MS-Excel); Steady-state normally	No steady states;	Networks drawn freehand or from AutoCAD Import, Shape / Layer / Coverage files, Geodatabases or live SDE connection to GIS; Calculates gas characteristics from inbuilt code (GasVLE), including HHV, LHV, spec. gravity, viscosity, density etc.; Analysis of a 200,000 pipe network in 1 min. (steady state). Transient a lot longer depending on time period, step size and wave speed; Data can be im- and exported to text file, CSV, MS Excel & Access or spatially to Shape file;	Network can be drawn freely, but it is also possible to import existing GIS data via XML. Exchanging data with a GIS system is common; The gas properties are not calculated, but have to be defined by the user. We calculate pressure loss using the extended ideal gas law; For both input and output XML (GML based) is used - output data to Excel, ESRI-Shapefiles and DXF. Other options are: generating a report in PDF format or export views as image.

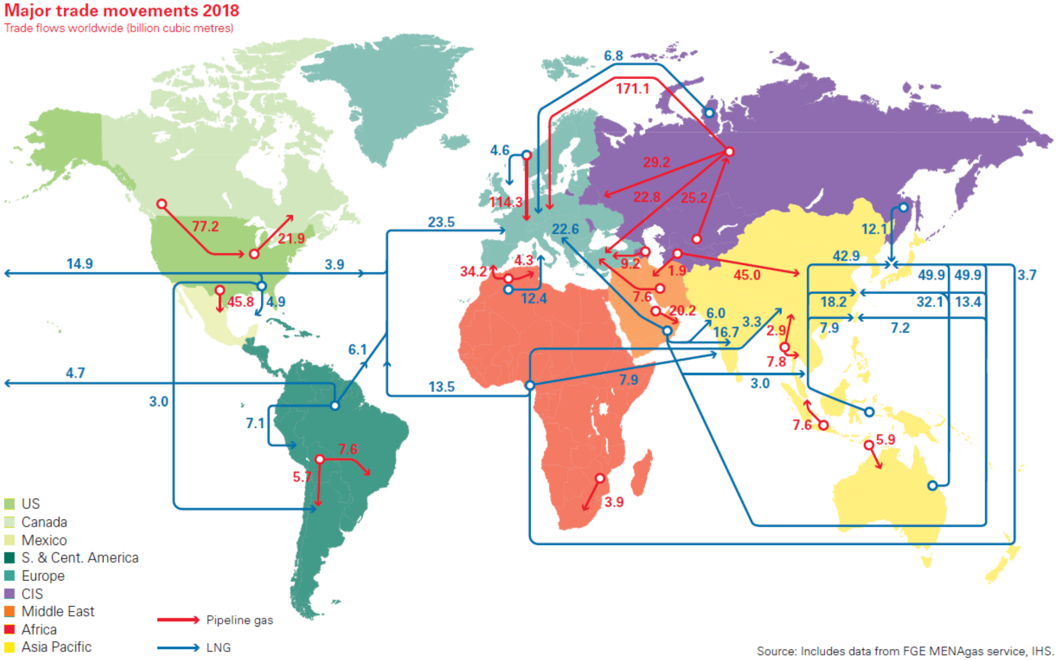
9

Work Package 5 – EU Gas Sources

Gas Imports of European Countries: 2018

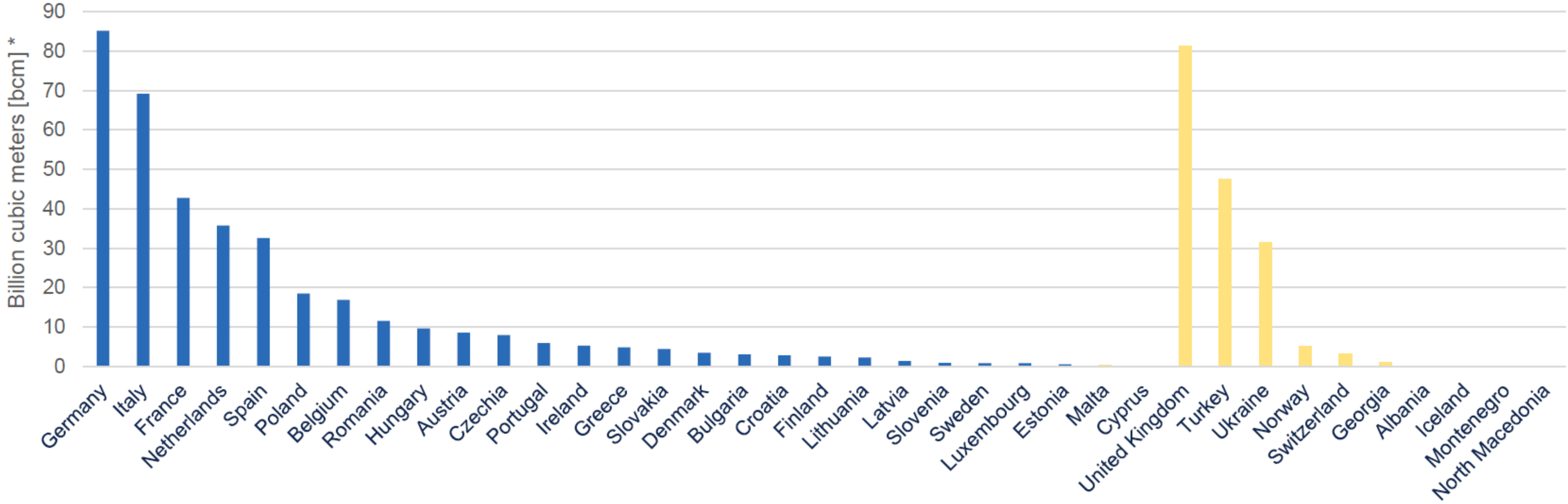
Trade movements (2018)

- Consumption: 549 bcm
- Production: 251 bcm
- Imports: 316 bcm
  - Pipelines: 244 bcm
  - LNG 72 bcm



Source: BP Statistical Review of World Energy (Natural Gas) 2019 | 68th edition

EU and non-EU countries in 2018

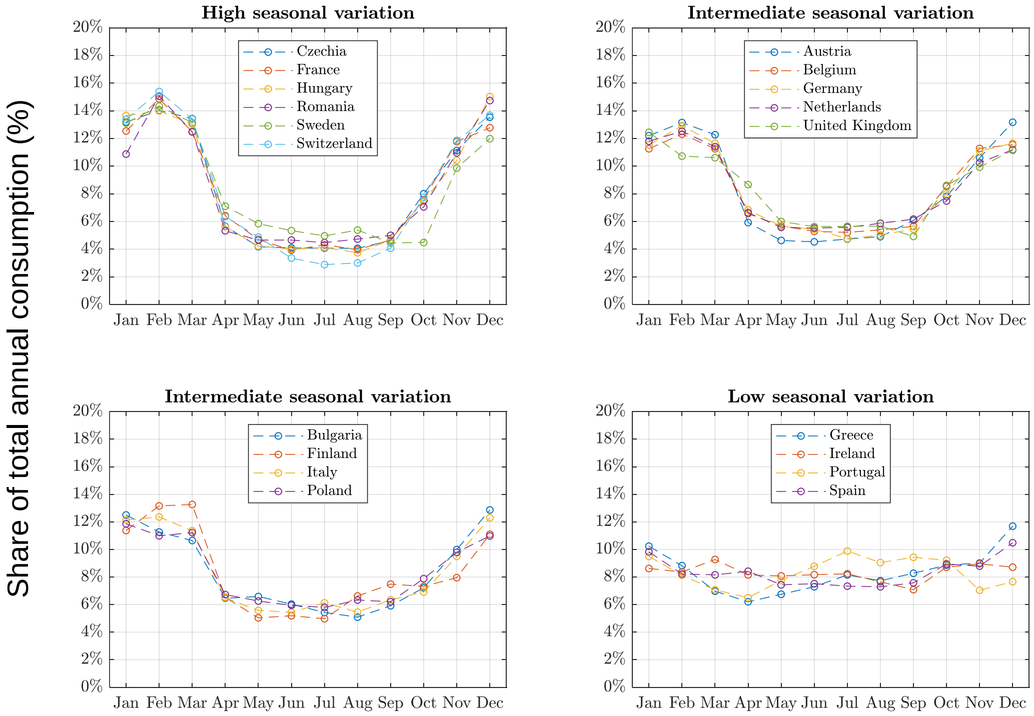


** cubic meters at 15ºC and 1013 mbar and standardized using a gross calorific value (GCV) of 40 MJ/m3*

Source: https0//ec.europa.eu/eurostat/web/energy/data & BP Statistical Review of World Energy (Natural Gas) 2019 | 68th edition

Work Package 5 – Seasonality

Seasonal variations of monthly domestic gas delivery 2018

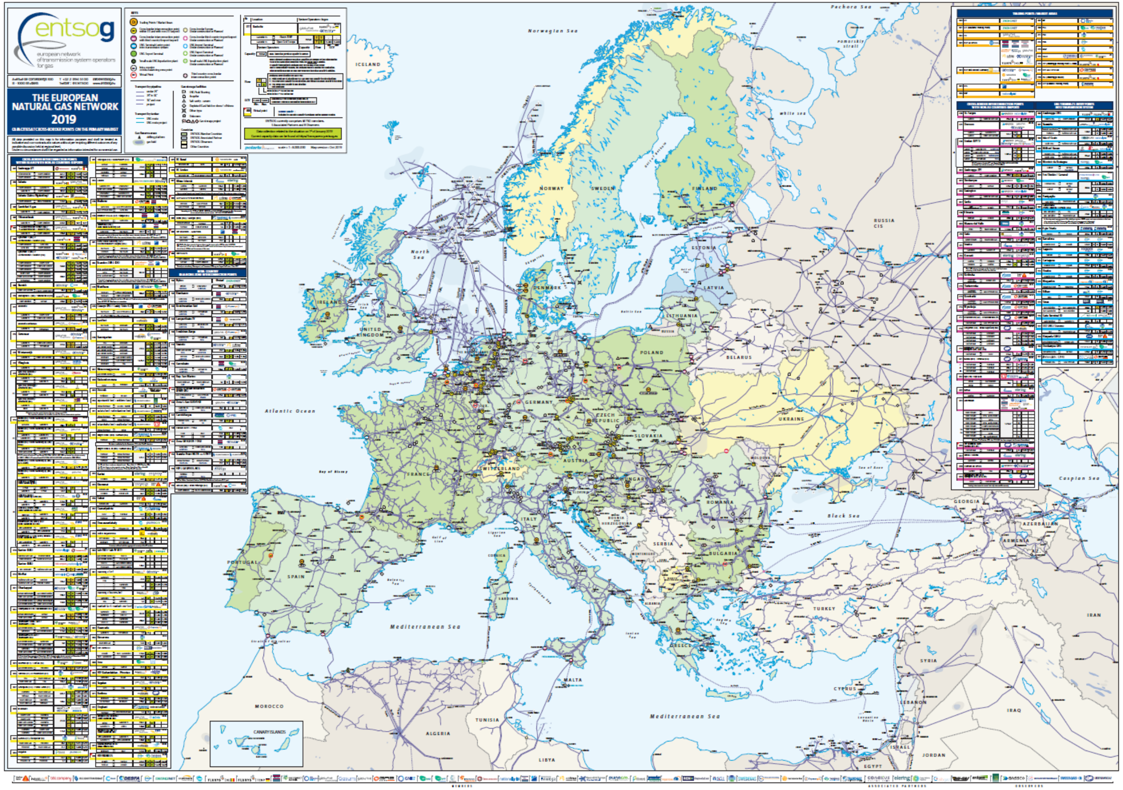


Work Package 5 – Transport Network and Storage data

HIGGS Hydrogen in Gas Grids

European Gas Network

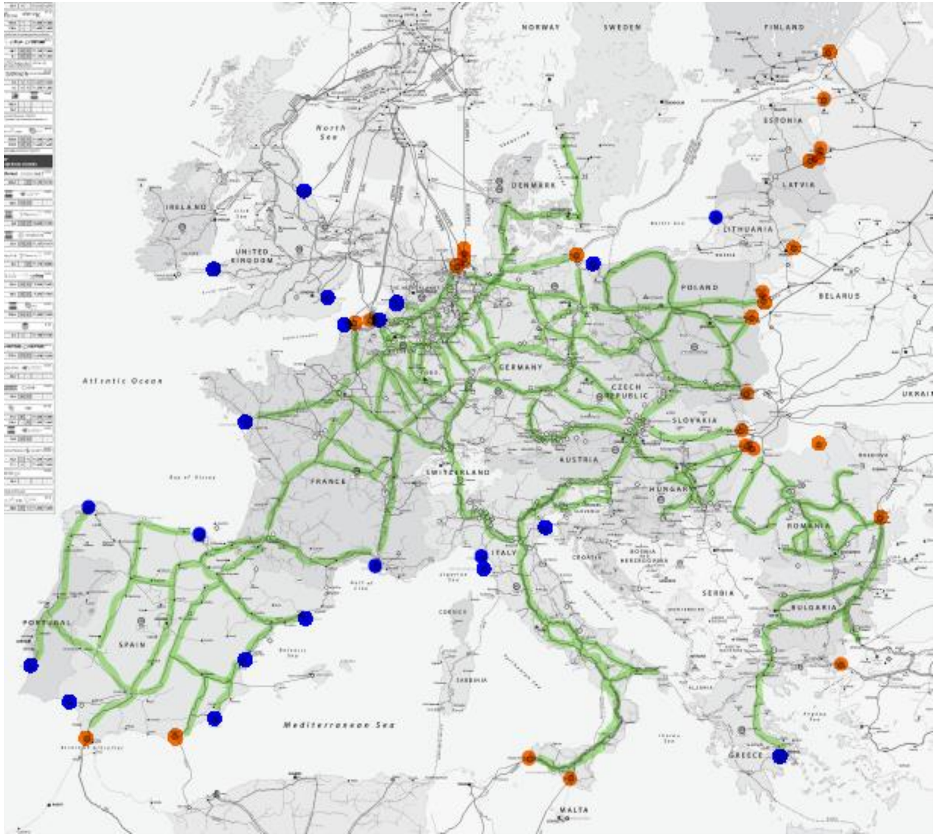
- ENTSOG Map 2019
  https://www.entsog.eu/maps#transmission-capacity-map-2019
- GIE Storage Map 2018
  https://www.gie.eu/index.php/gie-publications/maps-data/gse-storage-map
- GIE Database
  https://www.gie.eu/index.php/gie-publications/databases/storage-database



Work Package 5 – Interconnections of EU Transport Network

European Gas Network

- ~200'000 km Transmission Pipelines
- 21 LNG Terminals
- 26 Pipeline interconnection points with third countries
- > 120 Storage facilities
- Daily data on LNG terminals and storage units available on the transparency platform of GIE



Work Package 5 – Closing words

Key Challenges

- Network structure data missing (WP2)
- How to deal with the network's complexity
- Scenarios for hydrogen injection
  - Where from?
  - How fast?
- Gas consumption data/profiles
  - Essential for simulation

Next Steps

- Second round questionnaires to Simulation SW providers
- Propose and validate H2 injection scenarios
- Elaborate simplified network models
- Elaborate the case studies / base case scenario

Work Package 6 – Description of pathway towards integrating H_2 in EU gas networks

HIGGS Online Event 27 October 2020

Dr.-Ing. Michael Walter – DVGW e.V.

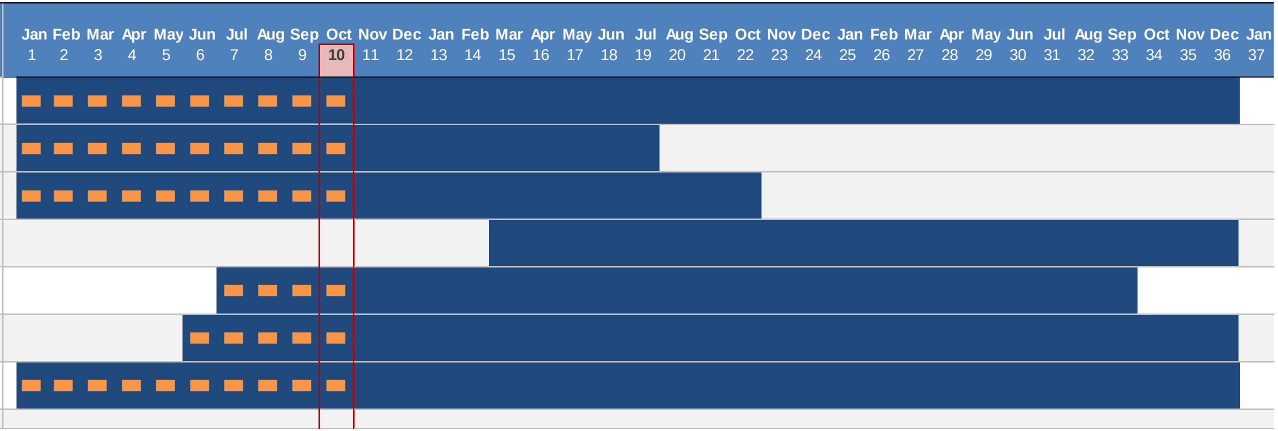
FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875091 'HIGGS'. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

HIGGS and WP6 schedule

Hydrogen In Gas GridS: a systematic validation appro

No.	Work Package/Task	Planned Start	Planned Finish
1	WP1 - Management and coordination	1	36
6	WP2 - Legal, regulatory and technical aspects: identification and follow-up	1	19
12	WP3 - Design, preparation and commissioning of testing facilities	1	22
22	WP4 - Systematic and experimental validation	15	36
29	WP5 - Techno-economic modelling and validation, enablers and interoperability	7	33
36	WP6 - Description of pathway towards integrating H2 in EU gas networks	6	36
43	WP7 - Communication, dissemination and exploitation	1	36
54			



Questions to be addressed

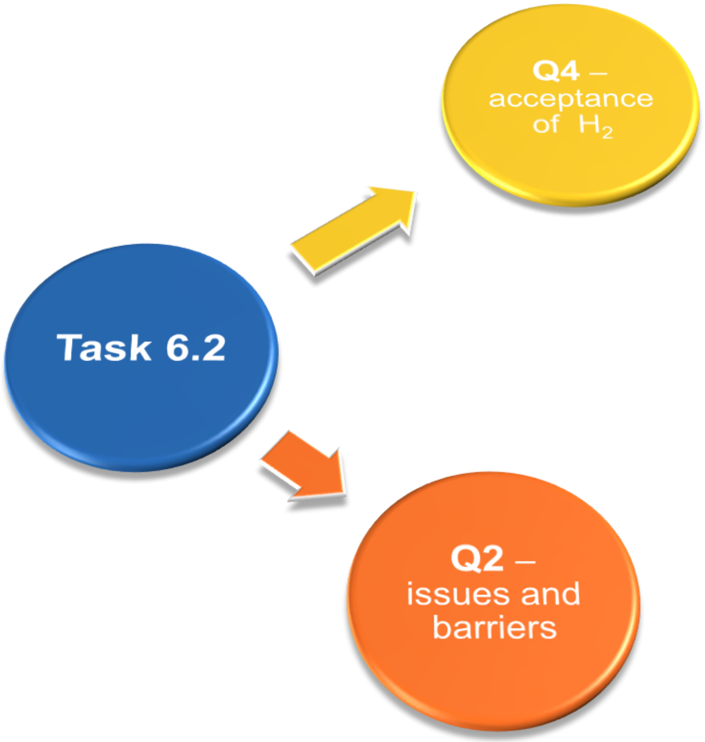
1. What are the potentials of hydrogen injection to decarbonize the EU gas network?
2. Are there
    a. *issues and barriers that hinder*
    b. *facilitators*

   the cross-border and interoperability of the gas grids when hydrogen is injected?
3. How could an optimal design for the hydrogen injection facilities look like?
4. What can be recommended towards regulations, codes and standards for
    a. *further development* ***and***
    b. *higher acceptance*

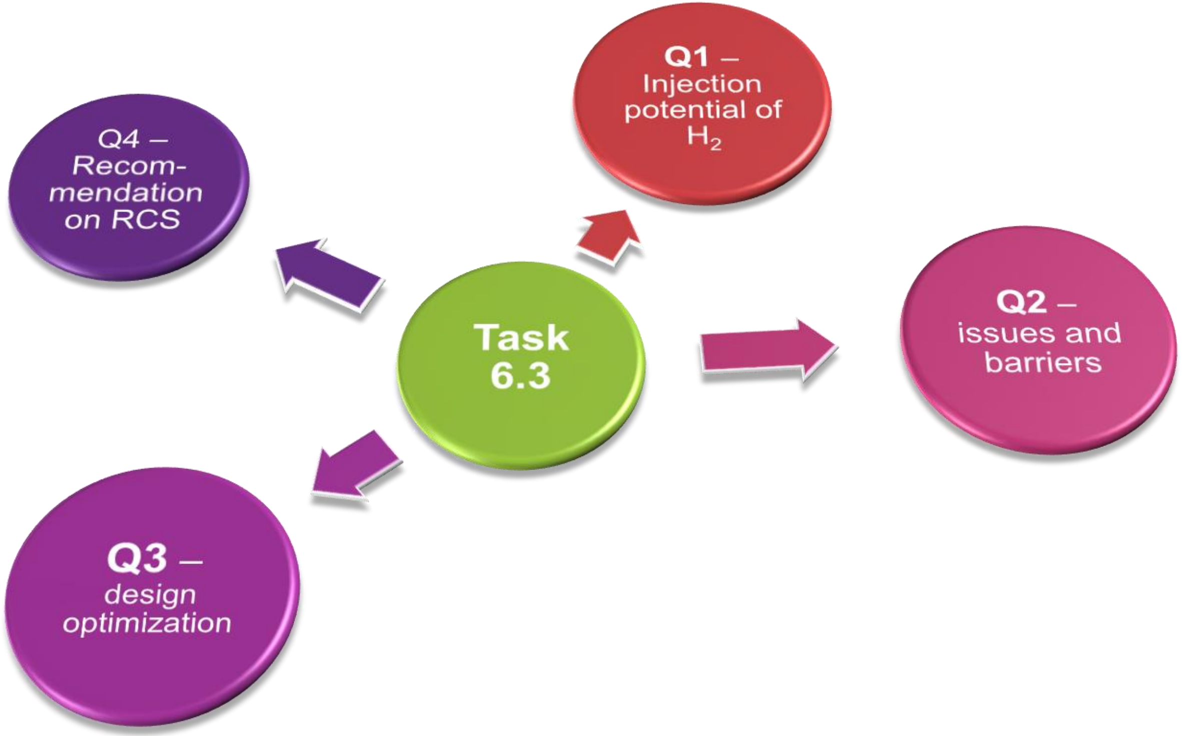
   of hydrogen in the European gas grid?

Task 6.1: Potential for H2 injection: alignment with EU policies (2030-2050)

Task 6.2: Interoperability, cross-border issues and gas market management and strategies



Task 6.3: Preparing a pathway and set recommendations towards a higher acceptance of H2 in EU gas grid network



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Any Questions left?

Hydrogen in Gas Grids

Thank your for your participation!

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