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Technical Association of the European Gas Industry

SESSION FILE

EXECUTIVE BOARD MEETING

ONLINE, 13 SEPTEMBER 2023

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AGENDA OF THE EXECUTIVE BOARD MEETING

13 SEPTEMBER 2023

Start & end of the meeting: 9h30 – 12h00

Venue: Online via Teams

09h30 – 11h00

Item	Subject	Presenter
I.	Opening of the Session	President
1.	Quorum and approval of the agenda	
2.	Welcome to new attendants	
3.	Approval of the minutes of the meeting of 01/06/2023	
II.	Implementation of the decisions from the last Executive Board meeting	
III.	Status of Membership (Enagas, EDA Attikis/DEPA Infrast., Naftogaz)	
IV.	Organization of EGATEC 2024	Vice-President
V.	Status of the Work Programme 2023	Sec. General
VI.	Presentations of the Standing Committees	Chairs of SCs
1.	Standing Committee Sustainability (SCS) • Working Group Health and Labour Safety • Working Group Methane Emissions+ • Update of Projects	
2.	Standing Committee Gas Infrastructure (SCGI) • Update of the TF Hydrogen study (full document and 2 papers) • Situation of the WG LNG and WG Storage	

COFFEE BREAK (11h00 – 11h15)

11h15 – 12h00

Item	Subject	Presenter
3.	Standing Committee Gas Utilisation and New Gases (SCGU&H2+) • Status of “Space Heating” action plan of the European Commission • Situation of the WG Sector Integration and WG Gas Installations. • Project on “Provision of New Gases”	Chairs of SCs

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Status of budget of 2023</td><td rowspan="2">Sec. General</td></tr>
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I.3 Draft minutes of the last Executive Board meeting

Minutes of the Executive Board meeting

1st of June 2023

Start & end of the meeting: 09h00 – 12h30
Venue: Det Kgl. Bibliotek, Copenhagen, Denmark

Attendants: Liam Nolan (President), Alexander Schwanzer (Vice-President), Manuel Coxe (Secretary General), Stefano Cagnoli, Thierry Chapuis, Daniel Czeto (replacing Rastislav Nukovic), Anne-Sophie Decaux, Francisco de la Flor Garcia, Kris de Wit, Sylwia Gladysz, Alvaro Laranjo, Thea Larsen, Diego Modolell, Naiara Ortiz de Mendibil, Signe Sonne (replacing Aaron Petersen), Pawel Stanczak, Jose Miguel Tudela Olivares, Steven Van Caekenberghe and Uwe Wetzel.

Apologized: Frank Graf, Mattias Hanson, Stanislav Kazda, Arto Korpela, Dimitrios Kourkouraidis, Ion Manescu, Agnieszka Ozga, Lenka Strakova, Ioannis Tsiblakis, Steven Vallender and Jeroen Zanting.

Invited: Georg Florian Kircher and Virginia Sanchez.

1. Opening of the Session

The President welcomed the Members and opened the meeting.

1.1. Quorum and approval of the agenda

The quorum was reached as 14 Executive Board Members out of 21 were present or represented. The proposed agenda was approved without modification.

1.2. Welcome to new attendants

The President welcomed Signe Sonne as representative of Energinet in replacement of Aaron Petersen.
The President thanked Francisco De La Flor for his contribution in MARCOGAZ as it was his last Executive Board meeting due to a change of position and invited him to address a few words.
Francisco De La Flor thanked the Members for the very constructive work done together over the past years and ensured that ENAGAS will continue to be represented in the meetings of the Executive Board and General Assembly by Abel Enriquez.

1.3. Approval of the Minutes of 16/03/2023

The Minutes of the Executive Board Meeting of 16/03/2023 were approved without modification.

2. Implementation of the decisions from the last Executive Board meeting

The President informed the Members of the Executive Board that the candidature of DVGW, together with Gasunie and DGC, to host the EGATEC 2024 in Hamburg was approved by both MARCOGAZ and GERG and that DVGW Kongress will start the preparation of the event jointly with the two associations and the hosting Members. The Members were also informed that the document *"A Methane Target for Midstream Gas Industry"* was published on the website and promoted through communications channels.
The President notified the Executive Board that David A. Merbecks who was appointed as Secretary of the Standing Committee Sustainability has started his duties.
The President let the Executive Board Members know that two fixed deposit bank accounts (3 months

maturity and 11 months maturity) were created for MARCOGAZ, with respectively 250 (000) € and 1.000 (000) € as it was agreed during the last Executive Board meeting in March.
At last, the President reported to the Executive Board on the conclusions of the 37th Gas Regulatory Forum (Madrid Forum) that took place on 11-12 May 2023 and to which MARCOGAZ President and Secretary General participated. The President debriefed the Members about the discussions and outcomes of the Madrid Forum.

3. Preparation for the General Assembly: Accounts, Audit and Budget

3.1. Accounts and Audit for Financial Year 2022

3.1.1. Accounts for the Financial Year 2022

The Secretary General informed the Members about the budgeted vs actual costs in 2022 compared to the costs in 2021. The actual costs were 48 (000) € less than the budgeted costs while an increase of 8 (000) € of costs was verified if compared to 2021.

More details are shown in the table below:

COSTS				
Nr.	**Description**	**2022**		**2021**
		Budgeted (€)	Actual (€)	Actual (€)
1	Cost of payroll staff	385 (000)	373 (000)	398 (000)
2	Office rent, logistic & reception	45 (000)	49 (000)	48 (000)
3	Office operation	90 (000)	88 (000)	64 (000)
4	Services and membership	70 (000)	40 (000)	38 (000)
5	Communication and events	15 (000)	7 (000)	1 (000)
	Total costs	**605 (000)**	**557 (000)**	**549 (000)**

The Secretary General also presented the Financial Accounts for 2022. The current assets were **1.476 (000) €,** same as liabilities, with a net total profit of **23.821€.** The profit was achieved despite the reduction in revenues of 48 (000) € due to the wind up of membership fees of the two Members from Ukraine.
More details are shown in the documents from the accountants Amaris, provided to the Members, and here below summarized:

2022 Balance Sheet (Simplified) [€]	
Assets (Current)	**1.476.665**
Fixed Assets	22.465
Accounts Receivable	27.767
Cash at Bank as of 31/12/2022	1.426.433
Liabilities	**1.476.665**
Capital & Reserves	1.418.865
Current Liabilities	57.800

2022 Profit and Loss Statement (Simplified) [€]		2022 Budgeted [€]
Revenues (Membership)	580.890	605.450
Operation Expenses	557.069	-605.202
Net Profit	**+23.821**	**248**
Capital & Reserves 2021	1.395.044	
Capital & Reserves 2022	1.418.865	

DECISION 2023/04: The Executive Board approved the statements of the accounts for 2022 and recommended its submission to the General Assembly of the Members taking place on the 1st of June 2023 at 14h00 in Copenhagen – Denmark, for final approval.

3.1.2. Audit of the Financial Accounts for the Year 2022

The Secretary General presented the result of the audit performed by Deloitte and mentioned that the signed document was not available yet but would be distributed via email as soon as received.

DECISION 2023/05: The Executive Board agreed to recommend to the General Assembly of the Members taking place on the 1st of June 2023 at 14h00 in Copenhagen – Denmark the approval of the Audit report by email.

3.2. Budget for 2024

3.2.1. Presentation of proposal of the membership contribution in 2024

The Secretary General also informed the Members of the Board that although inflation has been very high (>10%), the proposal for the membership fee in 2024 is to keep the same amount as the one agreed for 2023. The estimation of revenues coming from the membership fees is expected to be at 628 (000) €, the bank interests on fixed deposit is expected at 20 000€ This leaves a total revenue of 648 (000) €.
Therefore, the following proposition was presented:

- The membership fee for Charter Members would remain at 35,700 € (no change).
- The membership fee for Corporate Members would remain at 12 210 € (no change).
- The membership fee for Associate Members would remain at 6 410 € (no change).
- The membership fee for RGC and UA TSO (Ukraine) would remain null (no change).

Following a brief discussion, the following was concluded:

DECISION 2023/06: For the year 2024, the Executive Board approved to maintain the membership fee of the Charter Members at 35.700€ (no change from 2023), Corporate Members at 12.210€ (no change from 2023), and Associate Members at 6.410€ (no change from 2023) and recommended its submission to the General Assembly of the Members taking place on the 1st of June 2023 at 14h00 in Copenhagen – Denmark, for final approval.

DECISION 2023/07: The Executive Board approved to maintain the exemption of membership fees in 2024 for the two Members from Ukraine due to the war and recommended its submission to the General Assembly of the Members taking place on the 1st of June 2023 at 14h00 in Copenhagen – Denmark, for final approval.

3.2.2. Income and cost estimation

The Secretary General first presented the Executive Board some relevant information on estimation of income in 2024.
On one hand, Membership fee for RGC and UA TSO (Ukraine) will be kept at 0 € which will mean a reduction of income of - 48 (000) €. There will also be a membership fee reduction from 18 (000) € to 12 (000) € for

two Charter Members due to the downgrading of their membership (from Charter to Corporate Membership) that will result in a reduction of income of - 11 (000) €. There is uncertainty about the continuation of Membership of one Corporate Member due to the restructuring of the company that would mean a reduction of income of -12 (000) €.
On the other hand, there was a Membership fee increase of 50% for three Charter Members (one in 2022 and two in 2023) which will mean an increase of income from 2023 to 2024 of +36 (000) €. Furthermore, the fixed bank deposit will lead to an increase in income of 20 000€ (after tax). So, the total balance for revenues is expected to decrease by -16 (000) €.

The Secretary General then exposed the estimation of costs in 2024. Regarding the costs of Payroll staff for 2024, they are estimated to be higher than for 2023 due to inflation adjustments.
Also, it was previously agreed to have 5 full time employees with the withdrawal of 74 (000) € of accumulated reserves per year. This strategy will be pursued by with reduced withdraw of accumulated reserved at 35 (000) € in 2024. The Secretary General also informed the Board that there is a vacant position of energy profile to deal with the Standing Committee Gas Utilisation & New Gases, CEN/ISO Standards, Regulation on Methane Emissions and Hydrogen and other energy related Regulations and Directives.
Regarding the office rent, logistics & reception, in 2023 the costs increased by 10% due to inflation (that was the practice in the properties market in Brussels). The contract for renting the office will expire in December 2023. The initial offer received for the renewal of the contract has a 46% increase from 2023 to 2024. The consideration is to reduce the surface rented – other options are also being analysed. A remote working scheme for all employees will ease the management of the reduced surface of the offices.
Regarding the office operation, the costs of daily operations, meetings and travel are expected to remain as for 2023. Costs of services and membership are also expected to remain as for 2023 while costs for communications and events are expected to decrease due to no planned big physical events.

More details are shown in the table below.

ESTIMATION OF COSTS			
Nr.	Description	2024 Budget (€)	2023 Budget (€)
1	Cost of payroll staff	498 (000)	470 (000)
2	Office rent, logistic & reception	50 (000)	48 (000)
3	Office operation	85 (000)	82 (000)
4	Services and membership	45 (000)	43 (000)
5	Communication and events	5 (000)	25 (000)
	Total costs	**683 (000)**	**668 (000)**

Finally, the Secretary General presented the budget for the Financial Year 2024 as depicted below:

Income		
Nr.	Description	Amount (EUR)
1	Membership Fees	628 (000)
2	Interests on Deposits	20 (000)
	Total Receivable	**648 (000)**
3	Withdraw of Reserves	35 (000)
	Total Available	**683 (000)**
	EXPECTED ANNUAL LOSS IN 2024	**- 35 (000)**

Costs		
Nr.	Description	Amount (EUR)
1	Cost of payroll staff (5 Full Time)	498 (000)
2	Office rent, logistic & reception	50 (000)
3	Operations	85 (000)
4	Services and membership	45 (000)
5	Communication and events	5 (000)
	Total Costs (2,25% increase from 2023)	**683 (000)**

DECISION 2023/08: The Executive Board Members approved the budget of 2024, comprising a total cost of 683 (000) € and withdrawal of 35 (000) € from the accumulated reserves and recommended its submission to the General Assembly of the Members taking place on the 1st of June 2023 at 14h00 in Copenhagen – Denmark, for final approval.

3.3. State of Budget in 2023

The Secretary General informed the Executive Board on the state of the budget of 2023 as of 15 May 2023. The approved budget in December 2022 expected a total income of 594 (000) € with expenses of 668.000€, meaning a total loss of -74 (000) € (this amount was agreed to be withdrawn from the accumulated reserves). The amount received is 580 (000) €, expecting other 54 (000) € that would lead to a total of 634 (000) €; the total expense as of 15 May 2023 was of 180 (000) €, expecting other 476 (000) € by the end of the year, that would lead to a total expense of 656 (000) €, reflecting on a final loss of -22.000€ (expected to be 52 (000) less loss than budgeted).

More details are shown in the table below:

	Approved Budget (15/12/2022)	Received / Paid (as of 15/05/2023)	Expected (16/05 to 31/12/2023)	TOTAL Projection
INCOME	€ 594 (000)	€ 580 (000)	€ 54 (000)	€ 634 (000)
EXPENSES	€ - 668 (000)	€ - 180 (000)	€ - 476 (000)	€ - 656 (000)
TOTAL PROFIT/LOSS	€ - 74 (000)	€ 400 (000)	€ - 422 (000)	€ - 22 (000)

The Secretary General also informed the Members that there is 1 802 (000) € available at the bank, comprising 236 (000) € in the current accounts, 315 (000) € at flexible deposit and 1 250 (000) € at fixed term deposit.

4. Organisation of EGATEC 2024 & 2026

The President informed the Members that the official call for hosting the event initiated in December 2022 and that MARCOGAZ received an expression of interest from Gas.be (Belgian gas Association) and official candidature from DVGW (with the possibility of organizing it together with Gasunie and DGC), to host the EGATEC 2024. The Members were notified that no expression of interest or candidates were registered from GERG Members.

MARCOGAZ and GERG Executive Boards jointly approved the organization of EGATEC 2024 by DVGW, jointly with Gasunie and DGC.
It was also addressed the fact that internal discussions with OVGW are being held to organise the EGATEC 2026 in Vienna, Austria (and possibly with MARCOGAZ Members from Austria's neighbouring countries).

DVGW Kongress, exposed to the Executive Board the milestones achieved on the organisation of EGATEC 2022 and presented the proposal of the organisation of EGATEC 2024. He also presented the 3 options for the event's venue, suggesting the preference of the Atlantic Hotel in Hamburg. The side events were also introduced: 11th GERG Young Researchers' Awards, the scientific poster exhibition and MARCOGAZ's Annual Ordinary General Assembly. Nonetheless, the Secretary General said that MARCOGAZ General Assembly would take place the day before the EGATEC 2024 event.
The representative of DVGW Kongress also proposed the event ticket prices for approval: 1700 € (excl. VAT) for the regular ticket, 1500 € for early bird ticket, 1400 € for Members in MARCOGAZ, GERG, DVGW, DGC and Gasunie, and 700 € for students and poster presenters.
Finally, the representative of DVGW Kongress presented to the Members the sponsoring possibilities: Diamond (30 000 €), Gold (10 000 €), Member Gold (5 000 €), Silver (4 000 €), Host of Evening event (30 000 €), Host of Bar Reception (15 000 €), Breakfast Reception Host (8 000 €) and Video Sponsor (3 000 €).

The President suggested that Alexander Schwanzer, Vice-president of MARCOGAZ, represents the Association in the Programme Committee of the event. Nonetheless, the Vice-President asked for time for reflection.

DECISION 2023/09: The Executive Board approved the dates (18 and 19 of June 2024) and the Atlantic Hotel in Hamburg as the venue for EGATEC 2024 following the proposal of DVGW Kongress.

DECISION 2023/10: The Executive Board approved the ticket prices and sponsorship prices proposed by DVGW Kongress.

5. Presentations from Standing Committees

5.1. Standing Committee Gas Utilisation and New Gases (SCGU&H2+)

The Chair referred that the report "Exposing the Hidden Health Impact of Cooking with Gas" of NGO CLASP was addressed, and it was agreed that the position of MARCOGAZ, should not directly point to the CLASP report nor the electric cooking.

During the meeting there was also an exchange on National/Regional situations regarding heating and cooling of buildings, a template will be drafted to facilitate collection of information. The topic of hybrid heat pump as a solution for collective heating systems was also covered.

The Chair referred to the fact that the **WG Gas Quality** is following closely the activities at CEN/TC234/WG11 and CEN/TC408 level. The position paper *"Harmonization of gas quality on Wobbe Index restriction in product standards"* (internal publication) was shared with ENTSOG.

Following up of the standard *EN16726:2015 Gas quality H-gas*, it was referred that CEN SFGas GQS WG proposed the inclusion of class system, nevertheless TSOs do not see feasible to implement deviation treatment and some regulatory framework would be needed. It was referred that Madrid Forum supports an amendment of INT NC for considering WI (Wobbe Index) class system.

It was referred that the 2nd meeting of the **WG Energy Efficiency** took place on 20th of April and following that an ad hoc meeting was held on the 12th of May to discuss the position paper on revision of Ecodesign for central heating appliances and water heaters. The WG drafted a MARCOGAZ position paper in response to the European Commission's call for contributions following the 27th of April Consultative Forum.

It was said that the last **WG Gas Installations** meeting took place on 15th of March and the following will be on 5th of October. The WG GI is addressing data collection for EGAS-C study, maintenance of appliances, blending of natural gas with H2 and H2 issues, the CLASP report on cooking appliances.

The 1st meeting of the **WG Sector Integration** was held on the 21st of April with only 4 participants (BE, ES, IE and CH). It was reported the need to have more participants involved in the group.

The next duties of the WG SI would identify topics related to geological H2 storage at different scales, study the role of pipelines compared to electricity cables in transporting energy from offshore wind plants to onshore distribution and usage points, analyze sector coupling of natural gas and electricity through H2, understanding the interplay between energy efficiency measures and sector coupling to mitigate costs.

The Chair referred to the kickoff meeting of the **WG H2, bioCH4 & SNG** that was held on the 25th of May, with the scope being a study on technological and gas infrastructure related aspects as well as the climate impact of new gases. The foreseen next steps of the WG will be to analyse existing studies on new gases (e.g., IRENA), define topics for detailed examination and to elaborate and coordinate MARCOGAZ related work items with experts from different WGs. The gases and derivatives that will be under the scope of the WG are hydrogen, biomethane and SNG, hydrogen derivatives (NH_3, Mohede, LOHC), CO_2 provision for SNG and H_2 derivatives.

5.2. Standing Committee Sustainability (SCS)

The Chair referred about the project "EU Taxonomy for Sustainable Activities" that is directly addressed at SCS level to align positions of different TSO's in the reporting. PSG launched an initiative to distribute a questionnaire specific to DSOs in the WG Distribution and SCS, to try pave the way for involvement of DSOs in this project.

The Chair of SCS referred to the work of the **WG HLS**, presented the technical note on "*Black Powder and Mine Dust*" that was addressed during the 8th of May SCS meeting and proposed its approval for publication.

It was also notified on the ongoing discussions on Contractor Safety Management in the 3 phases of pre-qualification. The WG will also be addressing the topic of education and training of the workforce especially related to the handling of H2.
Likewise, the topics of Gas cooking appliances impact on health (CLASP report) and organisation of HSE in companies were being addressed.

The Chair gave an update on the topics being addressed by the **WG Methane Emissions+**, including the follow up with CEN/TC234/WG14, CEN/TC264/WG38 and ISO/TC197/SC1. The Chair referred that the expert group of 5 Associations (MARCOGAZ, GERG, ENTSOG, GIE and EUROGAS) is working on a 1–2-page document to support the discussion during the Trialogue whose intention would be to have a shared position paper from the midstream and downstream of the gas system.
A new topic on IED (Industrial Emissions Directive) was covered in an ad hoc meeting (25th of May). The revised IED is expected to have a Trialogue discussion starting soon, with the final text expected for early 2024. It was referred that the revised Directive could have a large impact on emissions of Large Combustion Plants (LCP). The intention of the group was to start building a common position to influence the upcoming Trialogue process.
The Correlation Factors project, aiming to propose arguments for the revision of standard EN15446, so far has collected unsatisfactory data both in terms of number of datasets received (11 companies) and in terms of the amount of data points within the datasets. The Chair invited the Executive Board Members to reinforce the relevance of sending the data for this important initiative within their companies.
The Chair referred that the BATs on venting and flaring were finalized and approved, with only the introductory document missing, for which delivery is expected before the next Executive Board meeting on 13th of September.

The Chair reported that the project on Scope 3 emissions will have its kick-off in the second half of the year, and a call for participants will be made in June.

5.3. Standing Committee Gas Infrastructure (SCGI)

The last meeting of the SGGI was held on the 19th of April where an update on the work done on repurposing UGS to hydrogen and on methane emissions under CEN/TC 234 was given. The Chair reminded that Chairmanships positions for the WG LNG and WG Storage are still vacant and Executive Board Members were encouraged to propose candidates.

Regarding **TF H2**, the Chair referred that the power point summarizing the report "Cost Estimation of Hydrogen Admission into Existing Natural Gas Infrastructure and End Use" was presented, covering the goals of the study and its scope, the methodology applied, the draft results and key finding and conclusions. It was also reported that the infographic published in 2019 was updated with new findings and information.

The last meeting of the **WG Distribution** was held on 8th of March. The Chair mentioned that the WG Distribution agreed to merge the EGAS-B and KPI reports in a single report on safety and for that a call to gather data was launched through MARCOSTAT (CALL#4).

The **WG Transmission Pipelines** has recently addressed the "Corporate Sustainability Reporting Directive" and plans to address the topic of CO2 transmission. The Chair informed that the document "Gas Transmission Pipeline Safety" was published on the MARCOGAZ website.

The **WG Odorization** has revised the document *"Natural Gas Odorization Practices in Europe"*, with it now being ready for publication. The WG is also working on the document *"Odorization of Natural Gas/Hydrogen Mixtures and Pure Hydrogen"* although the countries odorizing hydrogen are not yet known. A document for internal use was shared on fuel cells and impurities from odorants.

The **WG Gas Metering** is gathering information through a questionnaire on measurement of non-conventional gases and is working on the meter's life service.

DECISION 2023/11: The Executive Board approved the document "Mine Dust and Black Powder" and recommended its publication.

DECISION 2023/12: The Executive Board approved the publication of the position paper "Pan-European 'boiler ban' in 2029 - another way is possible and preferable and recommended its publication."

6. Communications & Liaisons

6.1. Communications

The Secretary General informed the Members that the technical document *"A Methane Target for Midstream Gas Industry"* was published and disseminated through social media. Also, the internal library in the Intranet was updated with new documents.

The Association keeps on conducting activities related to the 55th MARCOGAZ Anniversary Conference & Gala Dinner. It was also mentioned that MARCOGAZ has partnered and participated in numerous relevant energy related events addressing technical topics on renewable and low-carbon gases and continues to organize the Monthly Methane Mondays, together with GIE and the Energy Community Secretariat.

Finally, it was informed that other communication activities are coordinated with other associations (EBA, Eurogas, Ready4H2, etc). Likewise, the Secretariat will closely support the activities of DVGW Congress for the organization of EGATEC 2024.

6.2. Liaisons

The Secretary General informed the Members of the Executive Board that MARCOGAZ's mandate in the Clean Hydrogen Alliance Transmission and Distribution Roundtable has been recently renewed for other two years. MARCOGAZ continues to be part of ENTSOG's Advisory Panel.
The Secretary General let the Executive Board know that meetings with OIML and WELMEC were carried out and that there was an exchange with EURAMET on the availability of MARCOGAZ to be part of the Advisory Panel. There was also an exchange with the Canadian Gas Association to partner on the promotion of both MARCOGAZ organised events and CGA events, such as the International Gas Research Conference 2024.
At last, the Secretary General informed the Members of the Executive Board that there was an expression of interest from ICGB (the gas interconnector Greece-Bulgaria) to become Member in MARCOGAZ and the Secretariat held a meeting with its representatives.

7. Administration and Secretariat

The Secretary General informed the Executive Board Members that a new colleague, Friso Resink, seconded by Gasunie, joined the Secretariat for 8 months traineeship and will be supporting the technical activities.

8. 55th Anniversary event

The Secretary General informed the Members of the Executive Board about the general and specific communications being carried out for the 55th MARCOGAZ Anniversary event, that included openness of registrations to the public (with a symbolic cost of 140 €) due to the limited registrations verified from the Members.

9. Dates of the next meetings

The following dates summarize MARCOGAZ's next meetings:

- 22/06/2023: 55th Anniversary of MARCOGAZ (Brussels).
- 13/09/2023: Executive Board Meeting – Virtual meeting on Teams.
- 13/12/2023: Executive Board Meeting – Zurich, Switzerland.
  Welcome dinner the night before (12 Dec. 2023).
- 13/03/2024: Executive Board Meeting – Dublin, Ireland.
  Welcome dinner the night before (12 Mar. 2023).
- 17/06/2024: Executive Board Meeting and General Assembly – Hamburg, Germany.
- 18-19/06/2024: EGATEC 2024

10. Any other business

Nothing relevant to report.

II. Implementation of the decisions from the last Executive Board meeting

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Item II: Implementation of the decisions from the last Executive Board meeting

Liam NOLAN, President of MARCOGAZ

MARCOGAZ Executive Board Meeting- 13 September 2023

Update on decisions of the last Executive Board meeting (1/2)

- The Executive Board approved the statements of the financial accounts for 2022 and were submitted to the General Assembly of the Members (1st June 2023).
- The Executive Board approved the membership fee for 2024, including the exemption of membership fees in 2024 for the two Members from Ukraine due to the war situation, approved the budget for 2024 and were submitted to the General Assembly of the Members (1st June 2023).
- The General Assembly of the Members approved the financial accounts for 2022, the Audit Report performed by Deloitte, the membership fee for 2024 and the budget for 2024 as suggested by the Executive Board.

Update on decisions of the last Executive Board meeting (2/2)

- The Executive Board approved the dates (18 and 19 of June 2024) and the Atlantic Hotel in Hamburg as the venue for EGATEC 2024 following the proposal of DVGW Kongress. The EB also approved the ticket prices and sponsorship prices proposed by DVGW Kongress .
  - More details are provided at Item IV. of the Agenda.

- The document “Mine Dust and Black Powder” and the position paper “Pan-European ‘boiler ban’ in 2029 - another way is possible and” were approved by the Executive and subsequently published and disseminated.

III. Status of Membership (Enagas, EDA Attikis/DEPA Infrast., Naftogaz)

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Item III: Status of Membership

Liam NOLAN, President of MARCOGAZ

MARCOGAZ Executive Board Meeting- 13 September 2023

Status of Membership

- Enagas decided to terminate its membership at the end of the year 2023 (according to Article 3.4 of the statutes) due to recent internal changes and reorientation of priorities and resources (official Termination Letter attached).
- Enagas will continue contributing to MARCOGAZ's activities via the Spanish national gas association Sedigas.
- EDA Attikis was acquired by DEPA Commercial S.A., which decided to evaluate Membership in all national, European and International associations. Consequently, EDA Attikis will transit its MARCOGAZ Membership at the end of 2023 to DEPA Commercial S.A. that will become a new Member in MARCOGAZ in 2024. DEPA is still to address the formality of the transition.
- MARCOGAZ Secretariat met with NAFTOGAZ (Ukrtransgaz) – the gas underground storage company in Ukraine – and they expressed interest to become a new Member. Currently they are preparing the formal request for Corporate Membership.

IV. Organization of EGATEC 2024

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Item IV: Organisation of EGATEC 2024

Alexander SCHWANZER, Vice-President of MARCOGAZ

MARCOGAZ Executive Board Meeting- 13 September 2023

Organisation of EGATEC 2024

- The event venue, previously approved by MARCOGAZ Executive Board, is confirmed and booked by DVGW Kongress at Atlantic Hotel Hamburg, Germany.
- DVGW Kongress drafted the Conference Agenda, to be now discussed with the Programme Commitee for revision, adjustment and approval (attached hereinafter).
- The proposed schedules for the expected milestones both from the Programme Committee and the Paper Selection Committee can be found attached hereinafter.
- EGATEC 2024 slogan:

EGATEC 2024

Hosted by Denmark, Germany and The Netherlands – Connecting the North Sea Powerhouse

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Organisation of EGATEC 2024

- EGATEC 2024 Committee Members :

EGATEC COMMITTEES 2024

THE PROGRAMME COMMITTEE

	Complete Name	Title	Name	First Name	Function	Organization
1	**Alexander Schwanzer**		**Schwanzer**	**Alexander**	**MARCOGAZ Vice-President**	**MARCOGAZ**
2	Manuel Coxe		Coxe	Manuel	Secretary General	MARCOGAZ
3	Dr Robert Judd	Dr	Judd	Robert	Secretary General	GERG
4	Alexandra Kostereva		Kostereva	Alexandra	Consultant	GERG
5	Torben Kvist		Kvist	Torben	VP Projects	Danish Gas Technology Centre (DGC)
6	Frank Gröschl		Frank	Gröschl	Head of Technology and Innovation Management	DVGW
7	Leen Pronk		Pronk	Leen	Asset Management	Gasunie

THE PAPER SELECTION COMMITTEE

	Complete Name	Title	Name	First Name	Function	Organization
1	**Dr Murès Zarea**	**Dr**	**Zarea**	**Murès**	**President**	**GERG**
2	Dr Frank Graf	Dr	Graf	Frank	Co-Chair of Standing Committee and Board Member	MARCOGAZ
3						external academic / scientific expert
4						external academic / scientific expert

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Rough Conference Agenda (1/2) – to be discussed with Programme Commitee

DAY 1: 18 June 2024

9.15 am **Conference Opening by MARCOGAZ and GERG Presidents & Hosts**

9.25 am
TOPIC 1: The Boom – Hydrogen Everywhere
Industry, Heating with H2, Mobility, Power Production and Combined Heat and Power, Local Solutions Based on Hydrogen

11:00 am **Coffee Break**

11.30 am
TOPIC 2: Hy-Neighbours – Energy Hub North Sea
EU Hydrogen Strategy, H2 Global vs IRA, Green Deal (?), Alignment of Political Instruments

POSTER EXHIBITION
1.00 pm Lunch Break with GERG Young Researchers' Poster Presentations

2.00 pm
TOPIC 3: Hydrogen Readiness of the Gas Grid
Status of the European Hydrogen Backbone, H2 Starter Grid (Core Network) Germany, H2 Readiness

INNOVATION PITCHES – YOUNG RESEARCHERS
3.15 pm 10 Selected Research Pitches (Award Finalists)

Being revised

EVENING EVENT
6.30 pm Evening Speech by host or sponsor
Appetizers & Starters

6.45 pm **GERG YOUNG Researcher's Award**

7.15 pm Dinner & Music

Rough Conference Agenda (2/2) – to be discussed with Programme Commitee

DAY 2: 19 June 2024

9.00 am Poster Breakfast with Presentations & Discussion

10.00 am
TOPIC 4: H2 Supply Europe
Import Vectors (Pipeline, LH2, NH3, LOHC), Power to X projects: Ammonia, Fuels etc.

11.30 am
TOPIC 5: CO2
Carbon Capture (Example Cement), CO2 Transport (Pipeline, Ship, etc.) e.g. Captrans Project DBI, Carbon Storage (e.g. Greensands Denmark)

12.45 pm **Lunch Break**

1.45 pm
TOPIC 6: Biogas
Biogas as Basis for a Green Transition, Biogas to H2, SNG (Thermochemically from Biomass and/or via PtG with CO2 Methanation); Use of the Existing LNG Infrastructure, the Role of Biomethane in European Gas System

3.00 pm Summary and Conference End

Being revised

SCHEDULE: THE PROGRAMME COMMITTEE

Kick-off meeting	Personal introduction, EGATEC ‘24 concept, discussion of schedule and annual appointments, first ideas & tasks, Q&A	**End of Aug 2023**
Call to action	Please select interested external invited scientific/academic expertsto become committee members for THE POSTER SELECTION COMMITTEE	**11 Sept 2023**
Landing page	Deadline for short CV, photo and 1-3 sentences “Teaser / Expectations EGATEC ’24” for the landing page	**Mid of Sept 2023**
Conceptual meeting	Conference motto 2024 / leading theme and focus topics → important for Save the Date, Call for Posters & landing page	**Mid of Sept 2023**
Deadline 1st programme draft	Final definition of speakers → condition to start with speaker invitations	**Start of Oct 2023**
Acquisition of speakers	DVGW Kongress	**Start/mid of Oct 2023**
Final programme release	Starting with promotion of EGATEC (in meetings, social media, invitation of VIPs / guests)	**End of Jan 2024**
EGATEC	Participation at conference	**18-19 June 2024**

green = tasks

SCHEDULE: THE PAPER SELECTION COMMITTEE

Kick-off meeting	Personal introduction, EGATEC ‘24 concept, discussion of schedule and annual appointments, first ideas & tasks, Q&A	**End of Sept 2023**
Landing page	Deadline for short CV, photo and 1-3 sentences “Teaser / Expectations EGATEC ’24” for the landing page	**End of Sept 2023**
Call for Poster Abstracts	Invitation campaign by DVGW Kongress, additional promotion by Paper Selection Committee	**Mid of Oct 2023**
Deadline paper and poster submissions		**1 March 2024**
Selection papers & posters	by Paper Selection Committee. Papers and posters will be preselected and prepared for evaluations by DVGW Kongress (completeness of texts / information, quality / promotional character etc.)	**10 March – 7 Apr 2024**
Conceptual Meeting	Discussion about submissions, if desired	**before 7 Apr 2024**
Response to submitters	Confirmation or refusal of submissions & offers to transform papers to posters, if desired	**8 Apr 2024**
Deadline for printable poster documents	Printed by DVGW Kongress	**31 May 2024**
Final programme release	Starting with promotion of EGATEC (in meetings, social media, invitation of VIPs / guests)	**End of Jan 2024**
EGATEC	Participation at conference	**18-19 June 2024**

green = tasks

V. Status of the Work Programme 2023

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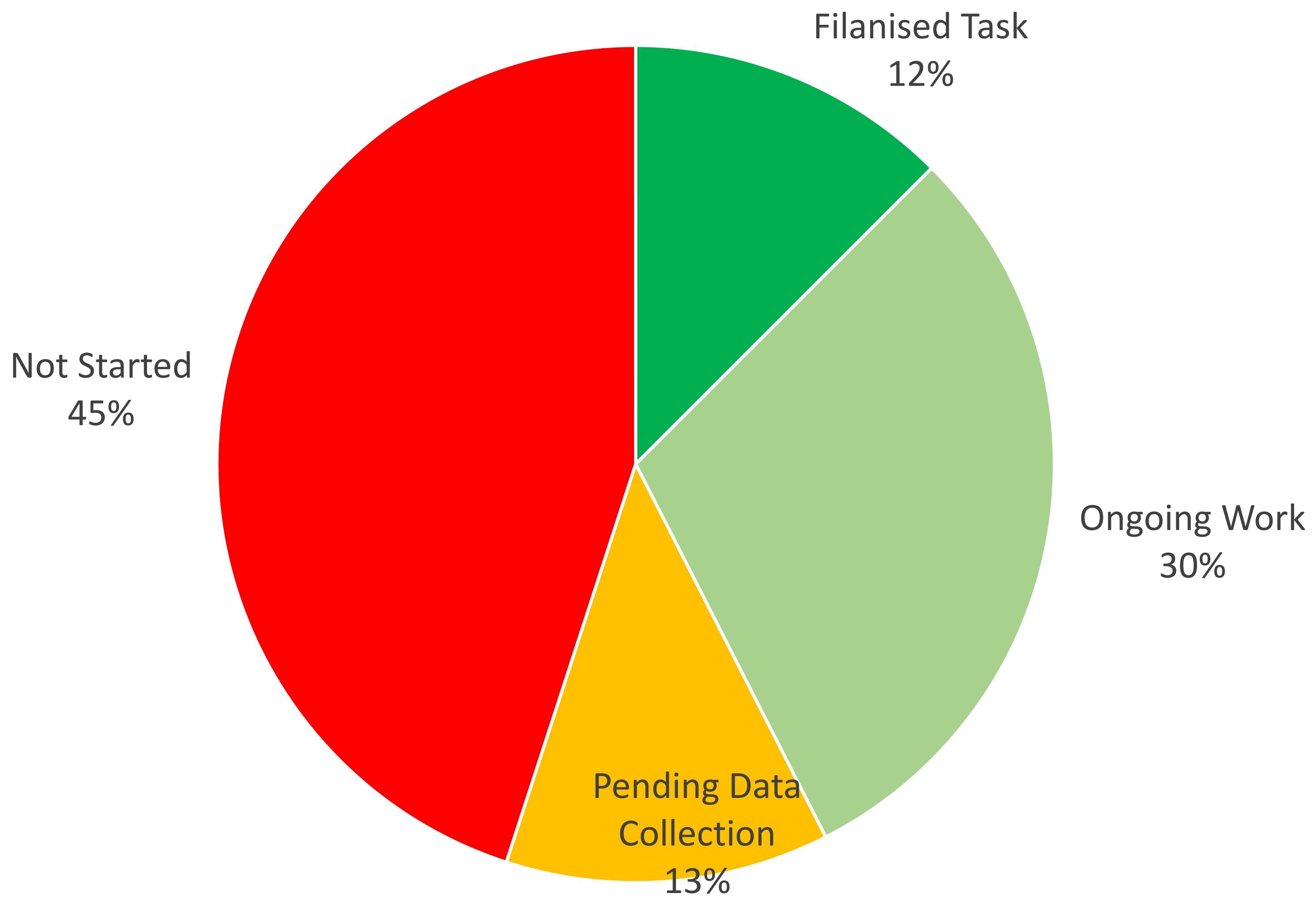
Technical Association of the European Gas Industry

Implementation of Annual Work Program

Manuel Coxe – Secretary General

MARCOGAZ – Executive Board – 13 September 2023

Annual Work Program 2023



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Annual Work Program – inputs for implementation 2/3

- CALL#2: Natural Gas Odorization Practices In Europe

Countries/Members that provided Data	Countries/Members that did NOT Contribute
Austria, Belgium, Czech Republic, Denmark, France, Germany, Italy, Ireland, The Netherlands, Poland, Portugal, Slovakia, Spain, Sweden, United Kingdom	Finland, Greece, Romania, Switzerland, Ukraine

- CALL#3: Occupational Health and Safety Performance of the European Gas Industry

Countries/Members that provided Data	Countries/Members that did NOT Contribute
Belgium, France, Portugal, Slovakia, Spain	Austria, Czech Republic, Denmark, Finland, Germany, Greece, Ireland, Italy, The Netherlands, Poland, Romania, Sweden, Switzerland, Ukraine, United Kingdom

Annual Work Program – inputs for implementation 1/3

- CALL#4 – EGAS-B new report on Gas Distribution safety

Countries/Members that provided Data	Countries/Members that did NOT Contribute
Austria, Belgium, Czech Republic, France, Germany, Greece, Italy, The Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden (no data available)	Denmark, Finland, Ireland, Switzerland, Ukraine, United Kingdom

- CALL#5 – EGAS-C report on Gas installations safety (was launched in the beginning of September with deadline end of September).

- Questionnaire on "EU Taxonomy for sustainable activities" for WG Distribution members to pave DSOs involvement in the activity (WG-DIS-275), deadline set for mid-October, no answers received so far.

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Annual Work Program – inputs for implementation 2/3

- Strengthen participation/nominations to WG Sector Integration and WG Gas Installations.
- WG LNG resuming shortly, ensure your representation is updated.
- Encourage to use with stakeholders the position paper on methane emissions (not public, ongoing discussion in the group).
- Encourage to use with stakeholders the position paper to answer the EC Public Consultation on heat pumps roll out.

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Detailed Work Plan update (as of 05 September 2023)

1) **Technical note on black powder and mine dust – WG HLS**
The document was published and is available on the MARCOGAZ website

2) **Health effects of H2 and NG – WG HLS**
The activity is currently hybernated, a draft document is available it needs finalization and approval. It refers to the ECHA (European Chemicals Agency) table containing the harmonised classification and labelling of hazardous substances, which are available in Table 3 of Annex VI to the CLP Regulation.
The conclusions of the MARCOGAZ's technical note is that both hydrogen and methane are not classified as health hazardous, moreover health hazards of hydrogen and natural gas are comparable.

3) **Occupation health and safety performance of the European gas Industry 2019 to 2022 data – WG HLS**
Marcostat CALL#3 was launched, at the moment only 5 countries answered. There is the need to reiterate the call to have more participation.

4) **Optical and electronical radiation – phase 2 – WG HLS**
The activity is currently hybernated. The objective is to updated an old document dated 2014 with latest findings and information available.

5) **Naturally occurring radioactive materials (NORM) – WG HLS**
The activity is currently hybernated.

6) **Contractors Safety Management – WG HLS**
Activity is currently hybernated. Exchange of best practices between the members to prevent accidents and increase safety performances. Discussion on KPIs in the different phases: Pre-qualification, tender and execution.

7) **Update of good practices on health and safety in the gas industry – WG HLS**
Activity is currently hybernated.

8) **Follow up of CEN work on draft TS on quantification – WG ME+**
It is related to the MARCOGAZ project methane emissions assessment (link). (also OGMP refers to the project).
MARCOGAZ liasion officer with CEN is ensuring communication flow. The TS is expected to be published at the end of 2023, there is an ongoing discussion about including materiality in it, with the EC reported to be reluctant to see it included in the standard since it is expected to be referred to in Delegated Acts.

9) **Project Correlation Factors (from ppm to g/h) – WG ME+**
Call for data ended in mid-June, 11 datasets were received, they were considered not satisfactory for the moment. Project leader is Per Kristensen. Call for data was also circulated to the 5 Associations CH4 group. The project aims to define correlation factors more suited to the mid and downstream industry since it is perceived that currently they tend to overestimate our industry emissions. The output of the study would support in providing technical evidences to revise EN15446.
The status of the project will be rediscussed in the next WG meeting planned for the 11th of September

10) **BATs on venting and flaring – WG ME+**
BATs are finalized at WGs level, only an introductory document is missing, status of the project will be addressed in the next WG meeting (11th of September)
The documents can be used once published to help in discussion with CEN TC 234 and CEN TC 264.

11) **"A methane target setting for midstream industry (2 parts) - SCS**
First part was published and available on MARCOGAZ website (2nd part would aim to extend the scope also to distribution operators and to update the targets over time)

12) **Project top-down challenge for reconciliation (GERG) – WG ME+**
Follow up of the GERG project. Additional information on the status of the project are expected in next WG meeting of 11th September.

13) **Project hydrogen emissions and climate impact (differences with methane emissions) – WG ME+**
The WG is drafting a paper to describe the main differences between hydrogen and methane emissions. Additional information on the status of the project are expected in next WG meeting of 11th September

14) **Project SCOPE 3 emissions (reporting framework for DSOs and TSOs) - SCS**
The SCS is expected to launch a call for participants to the project shortly and draft a document describing the objectives and the boundaries of the project more in detail.

15) **EU Taxonomy for sustainable activities - SCS**
Led by SCS, recently involvement of WG Distribution with a questionnaire from PSG. Deadline for WG Distribution members to answer the questionnaire was fixed for mid-October 2023.

16) **Addition to best practices on methane emissions to answer new regulation (related to BAT in WG Methane Emissions+)**
No update, was mentioned as topic of interest from SCGI.

17) **Policy on leakages in hydrogen infrastructure (new or repurposed)**
No developments, was mentioned by SCGI as topic of interest.

18) **Monitor LCP Best Available Techniques related to last reference document revision (BREF) – WG ME+**
WG ME+ is following the related IED revision, the aim is to produce a deliverable to influence upcoming Trilogue (expected to start in September). WG Transmission Pipelines was also informed from Chair of WG ME+ about developments on the topic to ensure alignment.

19) **Information on standardization works and their impact – All WGs and SCs**
Ongoing activity, common to all WGs/SCs

20) **Update of "Natural gas odorisation practices in Europe" – WG OD**
Document is being reviewed and is expected to be finalized in Q4-2023

21) **Odorisation of natural gas/hydrogen mixture and pure hydrogen – WG OD**
Document is being reviewed and is expected to be finalised in Q4-2023

22) **LNG contractors/operators/drivers qualification – WG LNG**
New Chair was recently nominated. WG LNG will resume its activities after summer and the topic will be rediscussed. Chair of the WG and Secretariat met early September to discuss next steps.

23) **Report on safety of distribution grids (EGAS-B report with additional KPIs) – WG DIS**
MARCOSTAT CALL#4. End of data collection set for end of September (so far 13 countries). Further discussion to understand the added value the report can bring to the industry is expected. The external report will not show companies data but only countries aggregated figures, nevertheless more detailed information will be shared internally for learning from most efficient companies/countries.

24) **Monitoring the decreasing level of turbine emissions for existing turbines - WG ME+**
Not addressed by the WG yet. During next meeting it will be proposed to insert it as an agenda point for WG ME+.

25) **CO2 transport and measurement (gaseous, liquid) – WG TP**
Presentation from OGE at WG TP (main concerns are harmonization of CO2 quality and phase to be chosen accordingly to situation, topic is also addressed at WG GM)

26) **Experiences in different countries with the measurement of non-conventional gases – WG GM**
Questionnaire on injection plants (type of gas, measurement technology,service and type of energy determination) was circulated. Its results were also shared in a WELMEC meeting.

27) **List all the initiatives and reasearch projects on impact of non conventional gases (National,EU,International) – WG GM**
NewGasMet porject is being monitored, as well as hydrogen distribution project in Lochem (12 houses heated with h2). DVGW infomred of a research project on domestic gas meters in combiantion with pressure regulators when using h2-admixtures.
Follow up of MetHyInfra project wehre aim is to improve the metrology infrastrcuture for high pressure gas and liquified h2 flows. Also follow up of THOTH2 project about measurement of ng/h2 blends up to 100% h2. Recently MARCOGAZ Secretariat shared a questionnaire about the THOTH2 project to MARCOGAZ members of WGs Gas Metering, Transmission,Distribution and Gas Quality.

28) **Benchmark on SEVESO III Directive – WG Storage**
It was published in MARCOGAZ Intranet for internal use only.

29) **Follow up on adaptation costs from TF H2 study**
The full report is being currently updated with feedback collected until 11th of August. It will be discussed together with ENTSOG statement (with the last two pages taken out) in the next SCGI meeting (25th September).
In parallel, the Secretariat produced a methodology document and an updated document of the infographic, with these having approval processes independent from the full report

30) **H2 quality specifications in rededicated natural gas pipelines – WG GQ**
Follow up of work done at CEN TC 234 WG 11 level, (AWI). Draft TS17977 was agreed by WG 11 on January 2023 and was sent for voting to NSB on 4th of May, with 3 months for voting and only editorial comments allowed.

31) **EGAS-C report (data 2020 to 2022) MARCOSTAT CALL#5 – WG GI**
Secretariat launched a call for participation to EB members to invite them to appoint representatives in the Group.
The documents for the EGAS C were circulated at the beginning of September to the MARCOSTAT representatives. Envisaged deadline for data collection will be end of September.
CALL's project leader is Marc Berger.

32) **Methane leakage during commissioning, periodic maintenance and appliances replacement – WG GI**
The study aims to gather data and knowledge on the topic even though the Comission is not currently looking into that specifically. A questionnaire needs to be recirculated.

33) **H2 (NG) impact on end-use Gas Installations – WG GI**
It was referred that, more specifically, the impact of H2 on existing installations with respect to safety issues and the approach of different EU countries were of interest (national strategies, developments for new installations, pure H2 and/or blends).
Follow up of publications and study addressing the compatibility of gas appliances with H2 (CEN works and especially CEN/TC234, THyGA, etc.)

34) **Follow up of the Revision of EN16726 – WG GQ**
Final working draft expected in August 2023. Publication of revised standard is expected for April 2025. Main topics addressed are effect on h2 admixtures/relative density, sulphur, oxygen and CO2 content, wobbe index and calorific value, methane number.

35) **Safety data comparison between different energy vectors – WG GI**
Questionnaire to be recirculated

36) **Gas Installations Regulations in force in different countries – WG GI**
The WG intends to gather information on specific National laws regulating gas installations.

37) **Project "Provision of new gases technologies, integration in the gas systems and climate impact**
Second meeting was held on the 19th of July, presentation on H2 import options, Dutch hydrogen specifications and renewable and low carbon gases were given.
Next meeting will take place on the 29th of September.

The outline of the project is the following:

Task 1 - Analysis of existing studies on new gases
Task 2 - Definition of topics for detailed examination
Task 3 - Elaborating of MARCOGAZ related work items with experts from different WGs

38) **Position Paper on ECO-design draft revision – WG EE and SCGU&H2+**
Paper was published and its content was shared at EC CF on Ecodesign of 12th June. It was also sent to DG, and Philippe riviere.

39) LNG Database – WG GQ

The aim of the study is to provide gas network operators and users in Europe with information about the gas quality that they can expect from LNG supplies.

The data will be the LNG composition of each individual LNG cargo downloaded in an LNG regasification terminal and origin, not the quality of the gas injected into the grid from the LNG terminal.

Inquiry from the Secretariat was launched to understand how many answers can be expected and then to plan accordingly (deadline end of July), results and next steps will be discussed in the next WG meeting (26th of September)

40) Quality values required by legislation in EU countries for biomethane injection into NG network – WG GQ

The information was updated in 2018/2019 and some changes has been made in regulation in several European countries. So it was proposed to update the document. Comments to be received within end of July, results and next steps will be discussed in the next WG meeting (26th of September)

41) List of EN standards for use in industrial gas installations (update of old document) – WG GI and SCGU&H2+

MARCOGAZ publication of 2009 to be updated. In particular technical input to integrate the document with standards covered in the following Directives is required:

- Machinery Directive 98/37/EEC or the new one (the last version of the document is 2006)
- ATEX Directive 94/9/EC (or the new one)
- Public procurement Directive 93/38/EEC
- Low Voltage Directive (73/23/EEC)
- Boiler Efficiency Directive 92/42

Document was sent for collecting feedback to WG GI (no feedback received), it was sent for SCGU&H2+ revision with deadline 19th of July (feedback from Denmark-DGC received), results and next steps will be discussed in the next SCGU&H2+ meeting (9th of October)

42) EC Public Consultation on heat pumps roll out – SCGU&H2+

SC responded to the EC questionnaire with an accompanying position paper, also available publicly on MARCOGAZ website.

VI. Presentations of the Standing Committees SCS

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Technical Association of the European Gas Industry

Standing Committee Sustainability Report to the Executive Board

13th of September 2023

José TUDELA, SCS Chairman

Executive Board meeting – 13/09/2023

WG Health & Labour Safety Activity

Activity

Expected Delivery Time

Outputs

- 2023: Finalization of technical note on "Black Powder, Mine Dust" ✓ — Q1/Q2
- 2023: "Health effects of hydrogen and natural gas" (concept ready) — QX
- 2023: "Optical and Electronical Radiation - Phase 2" — QX
- 2023: "Benchmark report on safety" (report on safety statistical indicators, 2022 data) — Q3

Topics in meetings

- Hydrogen
- Contractor Safety Management (CSM)
- Incidents/accidents and evaluation of effectiveness of measures.

No activity since last Board Meeting – No Significant Change in Outputs

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Activity

Outputs

- Document on:

  "Mine dust and black powder" [New Publication in Marcogaz Knowledge Hub]

KNOWLEDGE HUB

back

Mine Dust and Black Powder

12 June 2023

Mine dust and black powder are contaminants which can occur in natural gas transport pipelines. Mine dust occurs in pipelines dating back from the time when coke oven gas was transported. Mine dust contains amongst others toxic cyanides and thiocyanates, as well as rust, sand and clay.

Black powder is a mixture of corrosion products resulting from the interaction of iron with sulphur and/or oxygen (iron sulphides and rust). Black powder can also contain sand, clay and elemental sulfur. Black powder is also sometimes referred to as black dust.

This MARCOGAZ technical note describes risks and mitigating measures regarding Mine Dust and Black Powder.

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Activity

Outputs

- **Document "Health effects of hydrogen and natural gas".** Draft of a new version is in progress (WG-HLS-296)
- **Document "Optical and electronical radiation in the gas industry-phase 2".** Currently analyzing the previous edit in order to propose a new updated version (link).
- **Benchmarking safety figures from 2019 to 2022. Call #3 in MARCOSTAT** for data for the "Occupational health and safety performance of the European gas industry" study was circulated. The final expected outcome will be a deliverable showing safety commitment of the gas industry

We reiterate the need for data in this Project and in Other similar ones (ME-"Correlation Factors Project")

Some decisions taken in the Coordination Group meeting in order to improve this recurrent issue:

- Schedule two Follow up - Meetings / year with the MARCOSTAT SPOCS of the different countries
- Increase Transparency in the Board Meetings of the status of information per country.

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Activity

Topics in meetings

- **Hydrogen:** Sharing information on e-learning and training of the workforce on Hydrogen handling and the differences between Natural Gas and Hydrogen.
- **Contractor Safety Management (CSM).** Starting analysis of KPIs in the scope of CSM in the 3 phases (pre-qualification, tender and execution)
- **Incidents/accidents and evaluation of effectiveness of measures.** Starting preparation of a template to gather information from members in the scope of compliance with ISO 45001 in order to evaluate effectiveness of measures taken to prevent accidents/incidents
- **Gas cooking appliances impact on health:** Discussion on the CLASP report "Exposing the hidden health impacts of cooking with gas" published in January 2023 (WG-HLS-318)
- **Organisation of HSE in companies.** subject of interest to address in next meetings

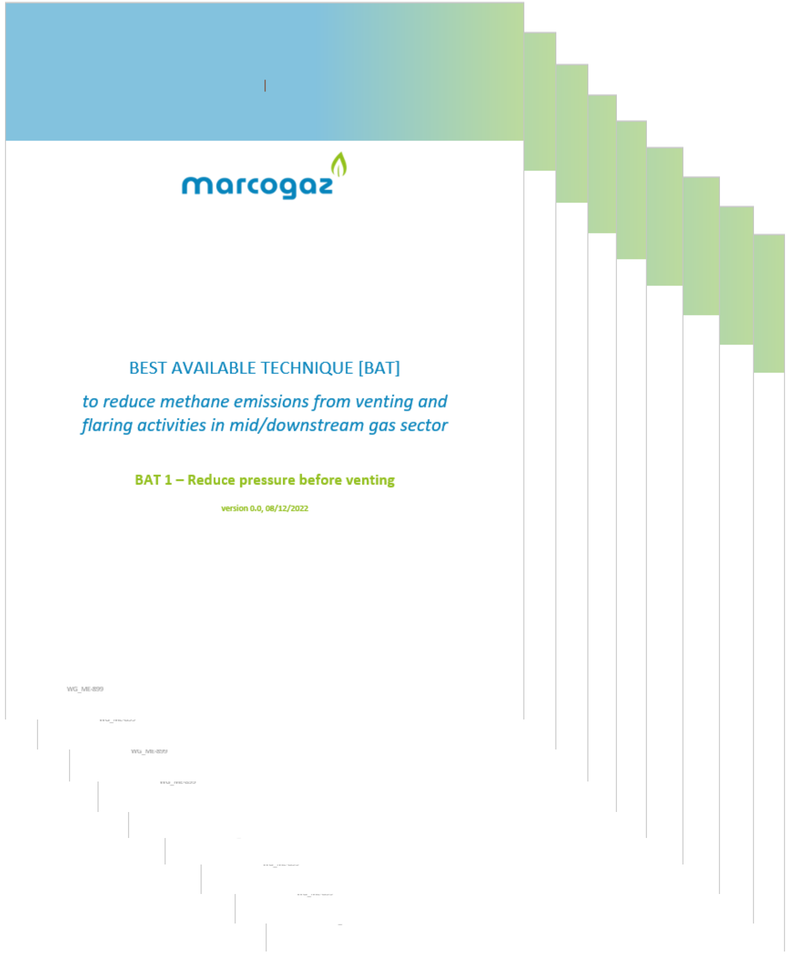
WG Methane Emissions+ Activity

ON GOING KEY TOPICS

Methane Emissions+

Best Practices

- BAT ON VENTING AND FLARING



- ALL BATs already finished (9 documents):

• BAT 1 – Reduce pressure before venting	WG-ME-899
• BAT 2 – Mobile recompression	WG-ME-900
• BAT 3 – Stationary recompression	WG-ME-901
• BAT 4 – Flaring as replacement of venting	WG-ME-902
• BAT 5 – High bleed continuous pneumatics mitigation	WG-ME-903
• BAT 6 – Electrical or pneumatic air starters	WG-ME-904
• BAT 7 – Use of nitrogen to purge LNG pipes	WG-ME-905
• BAT 8 – LNG truck loading – dry coupling connectors	WG-ME-906
• BAT 9 – Excess flow valves in new service lines	WG-ME-907

The documents are presented for the approval of the Board.

- An introductory document for the BATs will be elaborated and circulated afterwards for board approval and publication.

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Methane Emissions+

ON GOING KEY TOPICS

Standardization & Reporting

- CEN STANDARDISATION

CEN/TC 234/WG 14 Gas Infrastructure - Assessment of ME for gas transmission and distribution systems

- CEN delegated act document (assessment, LDAR, venting and flaring)
- Publication of the official document expected for the end of the year.

CEN/TC 264/WG 38 Determination of fugitive VOC emissions

- Two texts are still in the drafting phase.

- ISO STANDARDISATION

ISO/TC 197/ SC 1/ WG 1 "Hydrogen Technologies"

- WG Methane Emissions+ is following closely the preparation of a WD on "Methodology for Determining the Greenhouse Gas Emissions Associated with the Production, Conditioning and Transport of Hydrogen to Consumption Gate"
- 2ND Draft Circulated WG-ME-955

GHG Supply Chain Emissions Measurement, Monitoring, Reporting and Verification (MMRV) - Initiative

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Methane Emissions+

ON GOING KEY TOPICS

- EUROPEAN INSTITUTIONS

Document on Methane Emissions Regulation for the EU Presidency/Policy Makers

- The expert group of 5 Associations (MARCOGAZ, ENTSOG, GIE, GERG and Eurogas) prepared a document to support discussion during the Trilogue -it was approved by the Board (22nd of August)
- It was sent out to relevant policy makers. (23rd August)

Industrial Emissions Directive (IED)

- Finalization of IED revision is expected by early 2024.
- Proposal for an action plan has been developed in the WG including the involvement of GIE & Eurogas.

- METHANE EMISSIONS ASSESSMENT

New MARCOGAZ analysis of the emissions data (year 2022)

- Ask the OGMP members to forward us a copy of the data they provided to OGMP.

- CORRELATION FACTORS

- No satisfactory data so far – New actions agreed to make data capture more agile (see page 5)

ON GOING KEY TOPICS

Methane Emissions+

- SCOPE 3 EMISSIONS
  - **Call for participants** already sent with the scope of the project.
  - Doodle will be sent to the participants in order to schedule the **kick-off meeting.**
- EU METHANE TARGET SETTING
  - **Phase 1 finished with the Publication of the final document in Marcogaz Knowledge Hub:** Link to Publication
  - Phase 2 to be started in the following years with the following considerations:
    - Extend the scope of the analysis to Downstream activities.
    - Improve the reliability of 2030 targets.
    - Review the structure of the questionnaire (implement improvements).
- HYDROGEN EMISSIONS
  - A **White paper on differences** to methane emissions to be drafted.

Other SCS Projects Activities

Other SCS Projects

Activities

- EU taxonomy for sustainable activities
  - Before the summer break the project leader tried again to organize a meeting with DG ener with no success.
  - It is planned to restart the meetings with the group in September, with a benchmark of all the report published in this spring/summer, and decide the next steps.

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Technical Association of the European Gas Industry

Thank you!

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VI. Presentations of the Standing Committees
SCGI

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Technical Association of the European Gas Industry

SCGI report to the Executive Board

13/09/2023

Anne-Sophie DECAUX, SCGI Chairwoman

Executive Board meeting – 13/09/2023

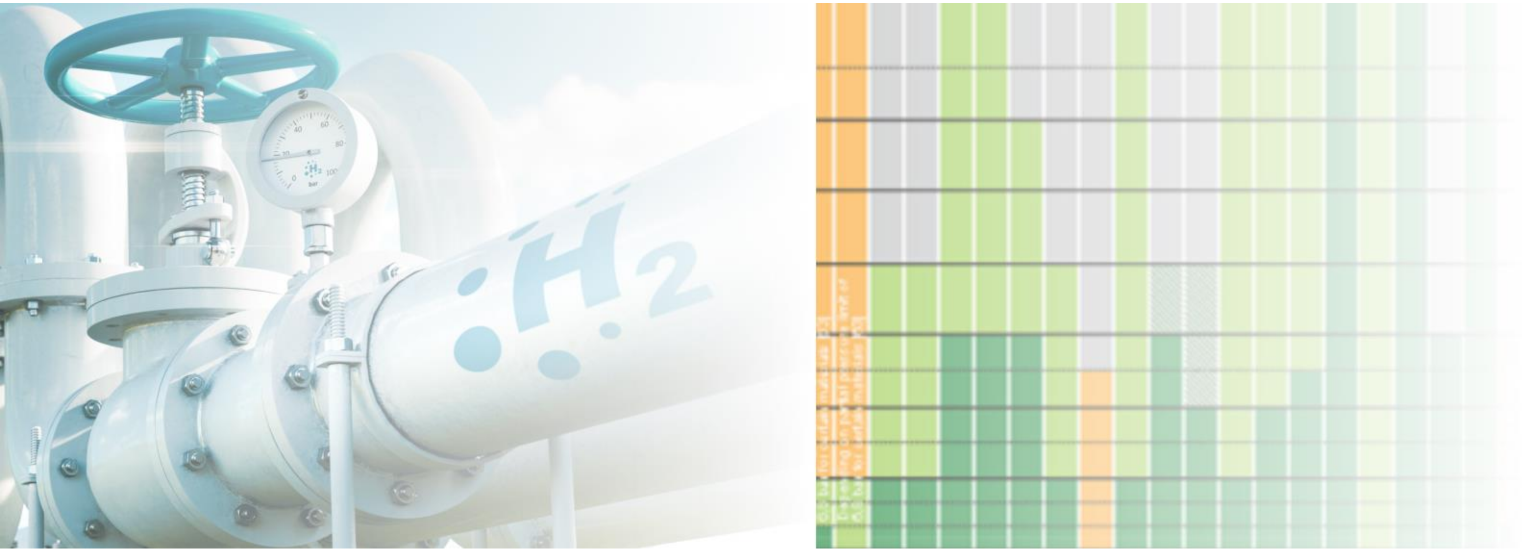
SCGI update

- Last meeting 19th April 2023 (Brussels+Teams with 22 participants from 9 countries)
  - Document “Gas transmission pipeline safety” published

- Next meeting 25th Sept 2023 (Teams)
  - Discussion on Madrid Forum topic « phase out of natural gas and decommissioning of infrastructure »

Update on WGs

- TF H2: Study "COST ESTIMATION OF HYDROGEN ADMISSION INTO EXISTING NATURAL GAS INFRASTRUCTURE AND END USE"
  - General conclusions with presentation for Madrid Forum approved by SCGI in April
  - Last comments addressed and report finalized for approval during next SCGI (25/09/23)
  - 2 high level documents prepared: Infographic and methodology
  - Approval of these 2 documents asked to EB for presentation during Webinar of Nov
- WG LNG
  - New topic: adaptation of LNG terminals for ammonia import?



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Overview of available test results* and regulatory limits for hydrogen admission into existing natural gas infrastructure and end use

Infographic

Version 2023 (Revised)

*According to the list of references.

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ABOUT MARCOGAZ

Founded in 1968, MARCOGAZ represents 29 member organisations from 20 countries. Its mission encompasses monitoring and policy advisory activities related to the European technical regulation, standardisation and certification with respect to safety and integrity of gas systems and equipment, rational use of energy as well as environment, health and safety issues. It is registered in Brussels under number BE0877 785 464.

DISCLAIMER

ACKNOWLEDGEMENTS

MARCOGAZ would like to express sincere gratitude to the organizations and individuals who have directly or indirectly made significant contributions to the development and success of this revision of the H_2-infographic. First and foremost, MARCOGAZ extends heartfelt appreciation to the experts from various technical groups in MARCOGAZ. Their profound knowledge, insights, and dedication have greatly enriched the content of this paper, ensuring its technical accuracy and relevance.

Furthermore, MARCOGAZ would like to acknowledge the experts from stakeholder organizations of the gas industry. Their collaboration, expertise, and industry perspectives have played a crucial role in guiding the direction of this paper, aligning it with the current needs and challenges of the gas industry.

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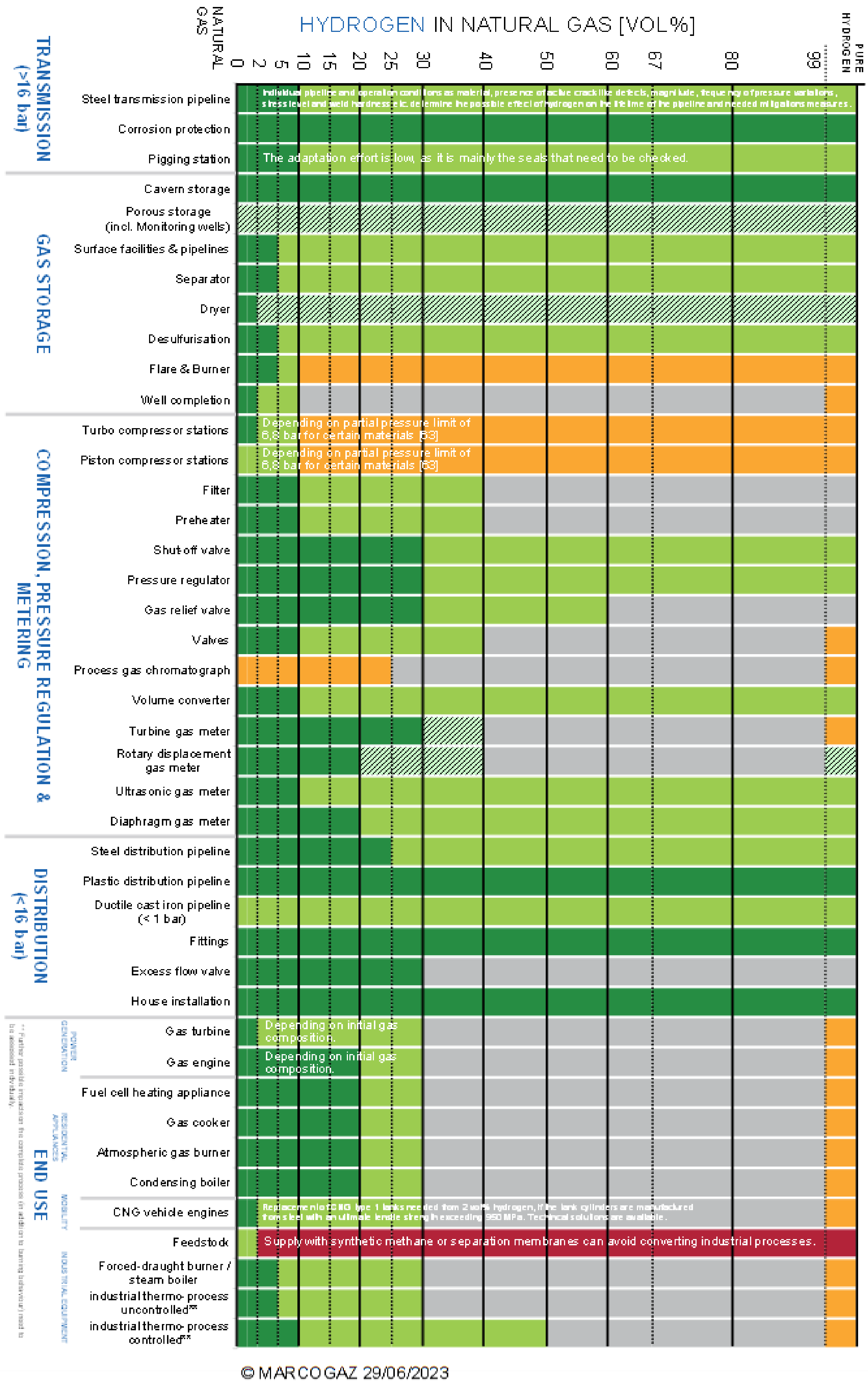

Figure 1: Overview of available test results and regulatory limits for hydrogen admission into the existing natural gas infrastructure and end use. Version 2023.

1. BACKGROUND AND THE PURPOSE OF INFOGRAPHIC

In October 2019, MARCOGAZ published its first version of the infographic (see Annex I) to provide an overview of the technical readiness of the gas infrastructure and end-use equipment to handle hydrogen-natural gas (H_2-NG) mixtures at each stage of the gas midstream and downstream value chain. Since the properties of mixtures of H_2-NG are different from those of pure hydrogen (H_2) or natural gas (NG), questions arose about the suitability of the existing natural gas infrastructure and end uses equipment for utilizing such mixtures.

Following the release of the first version of the infographic, H_2-NG mixtures (up to 30 vol.-% H_2) and pure H_2 have received more attention and research on this topic has increased both in the gas industry and academia. Therefore, MARCOGAZ has been following the H_2 development trends and revised the infographic with the current state of knowledge of NG transmission and distribution systems, including underground storage, gas pressure regulation and metering and end use, drawing on the wide expertise and experience of operators and experts.

The level of knowledge and available sources on H_2 tolerance may vary by infrastructure sector. In rare cases, this leads to differences in the listed H_2 tolerances for assets represented in different areas of the gas infrastructure. The infographic takes this into account as best as possible.

The infographic aims to:

- Provide an overview of the technical readiness of the gas infrastructure and end uses equipment to handle H_2-NG mixtures at each stage of the gas midstream and downstream value chain. The infographic currently focuses on material aspects and functional principles. It does not consider the effect of increasing levels of H_2 on performance, efficiency and output.

- Identify gaps in knowledge and areas where R&D is required to remove barriers that limit H_2 uptake in the supply chain and enable new applications for H_2 and H_2-NG mixtures.

- Collect and assess the most up-to-date knowledge on the use of H_2 and H_2-NG mixtures based on evidence and experience from gas network and storage operators and end use experts.

- Collect and appraise the current state of knowledge of transmission, storage, distribution and end-use of H_2-NG mixtures and H_2, drawing on the wide expertise and experience of network operators, storage operators and end use experts.

- Assist with the investigation into the opportunities with the existing gas infrastructure to achieve the best benefits and contribute to reaching climate goals.

2. SUMMARY

MARCOGAZ members with experience in operating gas infrastructure or involved in pertinent R&D activities have reviewed over 80 references on the H_2 tolerance of the existing gas infrastructure and end use applications and collected extensive data from the industry. In general, based on the throughout assessment conducted, it can be presumed that major elements of the gas infrastructure and end use equipment are expected to be able to handle H_2-NG mixtures in the range of 0-10 vol.-% H_2 without modifications[1]. With measures and replacement, most elements of the gas infrastructure and end use are expected to be able to accept concentrations of up to 30 vol.-% H_2. No conclusions could be drawn for the H_2-NG mixtures in the range between (but excluding) 30-100 vol.-% H_2 given that this was out of the scope of the study.

The main outcomes per infrastructure category are given below:

Transmission (> 16 bar):

- The main elements in the transmission infrastructure are expected to be able to accept H_2-NG mixtures in the range of 0-10 vol.-% H_2 without modification. With modification, concentrations up to pure H_2 are expected to be accepted.
- Individual pipeline and operation conditions determine the specific mitigation measure for steel pipelines to accept more than 10 vol.-% H_2 concentrations in a H_2-NG mixture.
- Some networks and residential appliances are already being operated with H_2-NG mixtures in the range of 0-20 vol.-% H_2 [62].

Storage:

- Major elements in the gas storage infrastructure are able to handle H_2-NG mixtures in the range of 0-5 vol.-% H_2 without modifications. With modification, most gas storage components are able to handle concentrations up to pure H_2.
- Above 10 vol.-% H_2, flare & burner components need significant modifications or replacement. Suitability of higher concentrations will require further R&D to determine the readiness when complete information is gathered.
- Porous gas storage and dryer installations require more R&D to clarify their suitability for H_2 mixtures.

Compression, Pressure Regulation and Metering:

- Most elements of compression, pressure regulation and metering are able to handle H_2-NG mixtures in the range of 0-10 vol.-% H_2 without mitigation measures.
- Turbo and Piston compressors are a limiting factor and are able to reach 10 vol.-% H_2 in H_2-NG mixtures with minor modifications. With higher concentration, signification mitigation measures or replacement are expected, depending on the partial pressure limit of certain materials.
- Process gas chromatographs are unlikely expected to be able to handle any H_2 mixtures. Nonetheless, with significant modifications, H_2-NG mixtures in the range of 0-25 vol.-% H_2 can be reached.

[1] Modifications refer to the relevant changes mentioned in the studies listed in the References accordingly.

Distribution (<16 bar):

- Major elements in the gas distribution infrastructure are able to handle H_2-NG mixtures in the range of 0-30 vol.-% H_2.
- With modifications, almost all components are expected to be able to handle H_2-NG mixture in the range of 0-100 vol.-% H_2. More R&D should be done on the readiness of excess flow valves with higher concentrations.

End Use Equipment:

- Residential appliances are expected to be able to handle H_2-NG mixtures in the range of 0-20 vol.-% H_2 without any modification and are expected to reach 30 vol.-% H_2 acceptance with minor modifications.
- Many industrial processes (except feedstock) are expected to be able to handle H_2-NG mixtures in the range of 0-5 vol.-% H_2 without modification.
- Current power plant gas turbines, industries using natural gas as feedstock and also CNG steel tanks are assessed to be sensitive to even small quantities of H_2 and need further R&D/mitigation measures when planning to convey higher H_2 concentrations.
- Higher concentrations (> 30 vol.-% H_2) for end use equipment requires R&D and can possibly be reached by mitigation measures or replacement.

3. MAIN UPDATES TO THE INFOGRAPHIC

The large number of new experiences and research results within the last few years make it necessary to update the infographic. Therefore, new components have been added and, information on existing components has been updated.

3.1 The following components were ***added*** to the infographic:

For compressor stations:

- The original compressor component was divided into two types: turbo compressor stations and piston compressor stations. The assessment was carried out based on the References "Consequences of H_2 in NG infrastructure" of CEN/TC 234 [65] and "Conversion of compression station for H_2 – Cost study" of MARCOGAZ [66].

For underground gas storage:

- The valves, piping and pipelines on the surface facility of an underground gas storage were grouped together as the "Surface facilities and pipelines" component [67-72].
- Desulphurisation for gas treatment after underground gas storage withdrawal was included [67-72].
- In addition, the combustion of gases in connection with underground gas storage facilities is summarised in the two components "Flare & Burner" [67-72].

3.2 The following components were significantly ***updated***:

- **Pigging station:** In analogy to the (pipeline) steels typically used, it can be assumed that the material is suitable for H_2. From H_2-NG mixtures of 10 vol.-% H_2, only the seals must be tested for suitability and adapted if necessary.
- **Shut off valve and gas relief valve:** These are suitable for H_2-NG mixtures in the range of 0-30 vol.-% H_2. The basic physical principle for activating the valves remains unchanged. In addition, standard natural gas components were installed in a pressure station as part of the "H2-Netz" project [73] and as part of a DBI project [74] for industrial thermoprocessing plants and operated with 100 vol.-% H_2 . The long-term tests have so far resulted in no functional restrictions as well as effects on seals.
- **Volume converter:** For H_2 admixtures greater than 10 vol.-% H_2, it must be examined whether a changeover to one of the two calculation methods (SGERG-mod-H2 or AGA8-92DC) can be made. These are applicable for all H_2 contents in NG according to DVGW G 685-6 "Gasbilling – Natural Gas Compressibility Factor" [75]. According to ISO 20765-2, the equation of state GERG-2008 can be used up to 40 vol.-% hydrogen [76].

- **Turbine and ultrasonic gas meter:** According to the results of the project DNV JIP "Suitability of Flow Meters for Renewable Gases" [77], flowmeters normally used in transmission grids (turbine and ultrasonic gas meters) can be operated with H_2-NG mixtures in the range of 0-30 vol.-% H_2 with an uncertainty in the measurement inside the requirement of the reference normative (OIML).
    - Although the JIP test results show measurement errors inside the acceptable range defined by standards for 30 vol.-% H_2 for ultrasonic meters, the bias in some specific meter types could be significant for fiscal measurement purposes carried out on large metering stations, for which high quality (very low uncertainty) measurement is required. For this reason, some manufacturers ask their costumers to contact them before using existing gas meters for applications with H_2-NG mixtures above 10 vol.-% H_2. Nonetheless, some new gas meters have already obtained their metrological certification for applications with H_2-NG mixtures in the range of 0-30 vol.-% H_2.
- **Diaphragm gas meter:** In the DVGW research project G 202010 "H2 measurement accuracy" [78], the measurement deviations of bellows gas meters with different gases (methane, 20, 30 and 100 vol.-% H_2) were investigated. A suitability for all gases could be proven. A custody transfer measurement is not yet possible due to the lack of a separate approval for H_2 contents in H_2-NG mixtures greater than 20 vol.-% H_2. The suitability for concentrations up to 20 vol.-% H2 has also been proven by further investigations [79].
- **Ductile cast iron:** In the project from Sedigas [80], ductile iron pipes were tested for their suitability for hydrogen. For this purpose, pipes were examined that had already been operated with town gas and those that had only been operated with NG. The latter were also exposed to different hydrogen concentrations (up to 100 vol.-% H_2). The mechanical parameters were all compliant with manufacturing standard (UNE-EN 969) and the brittle fracture surfaces also showed no abnormalities.
- **Fittings and house installation:** For house installation, it is assumed that all common materials are suitable. In addition, leak tests on the fittings have not revealed any abnormalities with H_2-NG mixtures up to 100 vol.-% H_2. The evidence was provided in the DVGW research project G 201615 "Influence of hydrogen components in natural gas on gas installation components" [81].
- **Gas engine, fuel cell heating appliance, gas cooker, atmospheric burner, condensing boiler:** According to the THyGA project [82], operation with H_2-NG mixtures in the range of 0-20 vol.-% H_2 is possible for these end use applications. Even H_2-NG mixtures up to 30 vol.-% H_2 can be ensured through minor adjustments.
- **Forced-draught burner /steam boiler, industrial thermo-process uncontrolled:** Through individual assessment and, if necessary, some adjustments, H_2-NG mixtures in the range up to 30 vol.-% H_2 suitability can be ensured [82].
- **Industrial thermo-process controlled:** There is suitability of operating H_2-NG mixtures in the range of 0-10 vol.-% H_2 [82].

4. NEXT STEPS

- To enable H_2 concentrations of 10 vol.-% H_2 in H_2-NG mixtures, R&D is recommended to understand the effect on compressor stations, gas turbines, process equipment in the chemical industry using NG feedstock and steel tanks for CNG vehicles.

- To exceed H_2 concentrations of 10 vol.-% H_2 in H_2-NG mixtures in addition to the topics mentioned before, special R&D focus is required on underground gas storage (including well completion, flare and burner equipment, dyer installations and the suitability of porous rock structures). Furthermore, compressor stations, metering devices and industrial gas use need to be addressed in more detail.

- R&D for residential appliances is especially recommended for H_2-NG mixtures with concentrations above 30 vol.-% H_2 as well as to understand the impact of varying H_2 concentrations in general. A few cases are expected where R&D will be recommended for H_2 concentrations as from above 20 vol.-% H_2.

- For pure H_2 usage (100 vol.-% H_2), research should focus on the readiness and mitigation measure for underground gas storage, compression, pressure regulation and measuring devices, and end use equipment.

- Further focus should be put on the development of retrofit solutions for existing installed appliances to allow them to handle H_2-NG mixture.

- Mitigation technologies, such as membranes and methanation, used to reduce the vol.-% H_2 concentration in gas grids exist. They are considered to be very important to protect sensitive equipment and processes and can be installed beforehand. Where required, further R&D[2] may be recommended.

[2] R&D does not mean that the equipment is not suitable for use with H_2-NG mixtures or that no modification measures are currently available. Rather, it reflects the need for innovation to develop new opportunities with the aim of obtaining the maximum benefit from the existing infrastructure.

5. ADDITIONAL REMARKS

- Equipment in the gas infrastructure, underground gas storages and end use are diverse and have different life/usage times. Nevertheless, all equipment needs to be renewed at the end of its useful economic life. This is a continuous process that naturally offers the opportunity to install optimised and more future-proof equipment. Hence, renewal cycles should be used to increase the tolerance of the gas infrastructure and end uses to higher H_2 concentrations.

- For many currently installed end use applications, the presence of H_2 in NG remains a relatively new topic. Given the wide variety of end uses across all sectors (residential, commercial, industry, power generation and mobility), R&D activities are required to investigate the impact of higher levels of H_2 and to develop technology solutions for "H_2 readiness". The aim is to maintain highest levels of performance in terms of efficiency, fitness for purpose, flexibility and low-pollutant emissions that these appliances and applications have achieved over the last decades.

- Sensitive end use equipment could require the use of digital reproduction systems, local gas quality measurement and appropriate control technology.

- As part of the Fit-for-55 package from the European Commission (EC) to reduce the use of fossil fuels, the EC has revised the Gas Package and proposed the acceptance of H_2 blends into natural gas networks at international connection in the regulation *on the internal markets for renewable and natural gases and for hydrogen* [83].

ANNEX I: H2-INFOGRAPHIC 2019 VERSION

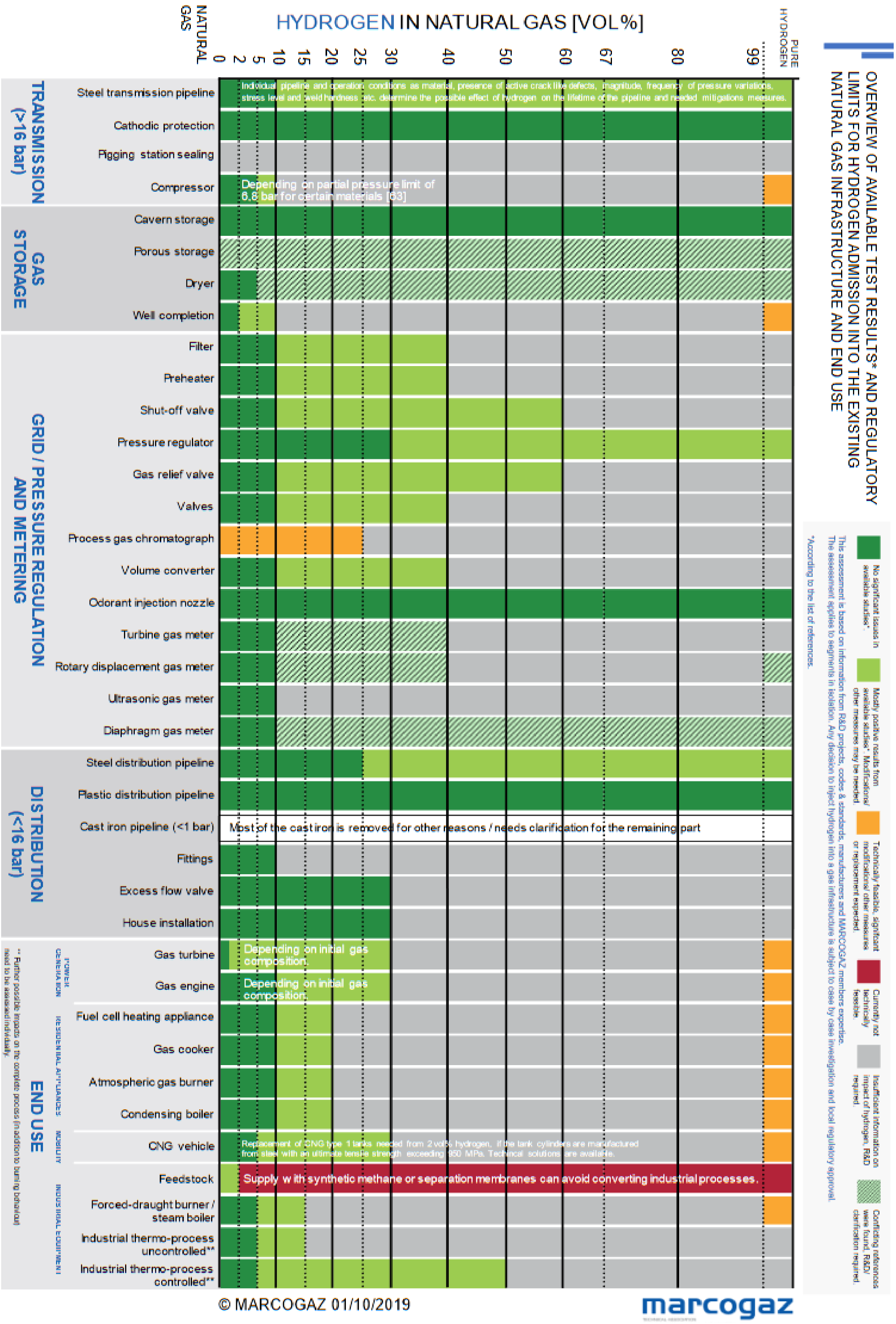

Figure 2: Overview of available test results and regulatory limits for hydrogen admission into the existing natural gas infrastructure and end use. Version 2019.

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This assessment is based on public and non-public information R&D projects, Codes & Standards as well as manufacturer and MARCOGAZ member expertise.

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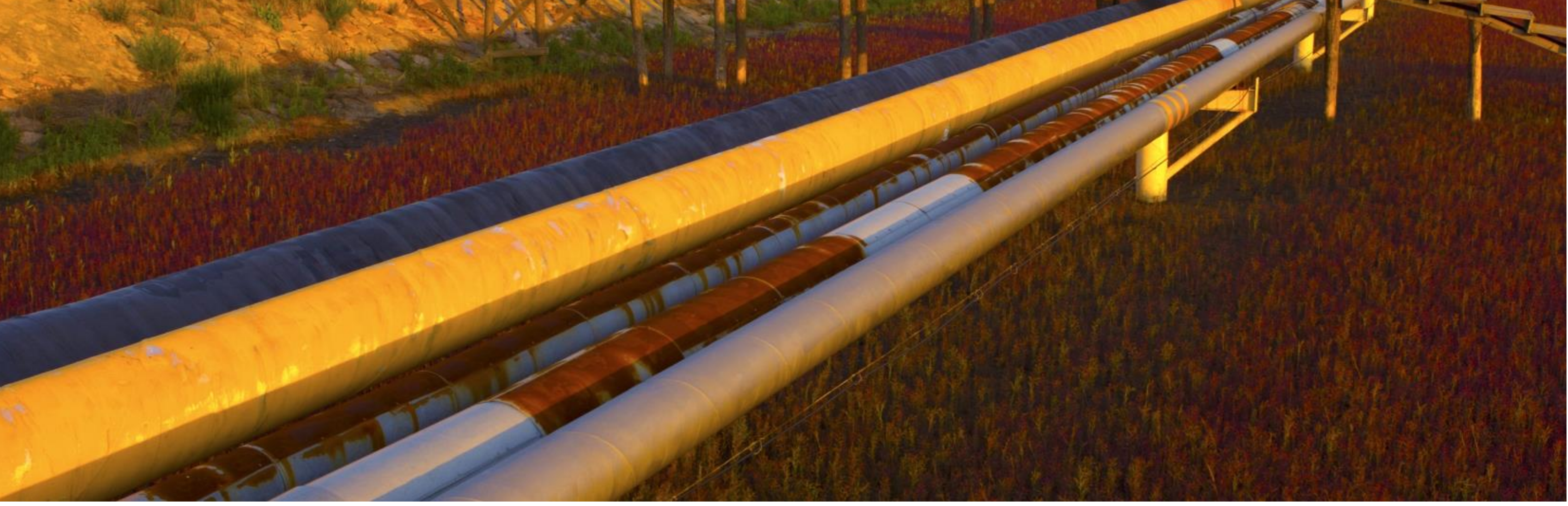

Methodology description for the cost estimation of hydrogen admission into existing natural gas infrastructure and end use

2023

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ABOUT MARCOGAZ

Founded in 1968, MARCOGAZ represents 29 member organisations from 20 countries. Its mission encompasses monitoring and policy advisory activities related to the European technical regulation, standardisation and certification with respect to safety and integrity of gas systems and equipment, rational use of energy as well as environment, health and safety issues. It is registered in Brussels under number BE0877 785 464.

DISCLAIMER

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1. INTRODUCTION

In order to achieve climate neutrality in Europe by 2050, the use of renewable gases, and especially hydrogen (H_2) in the gas industry is becoming a necessity. In the transition towards a net-zero energy system, many aspects need to be considered to find the most sustainable, economic, and implementable way of achieving this goal. MARCOGAZ aims to alleviate some of those concerns by bringing more clarity to the actual status of the European gas infrastructure regarding its hydrogen suitability.

With this report, MARCOGAZ provides a methodology to estimate the costs of hydrogen admission into existing natural gas infrastructure or end use equipment on a national or regional level. Besides the methodology description, also specific European averages values are given as reference to support stakeholders in case local data is lacking. The figures are based on experiences from several stakeholders in the gas industry and include expected technical suitability of components for the use with hydrogen. Nevertheless, as the existing situation on national or regional level might differ significantly from the European average, the European picture might not always hold on small scale. As the purpose of this document is on the methodology description, no cost estimations are included in this work. However, assumptions are given on the transformation within the borders of technical feasibility.

This methodology description starts by elaborating on the essential steps to determine the cost of repurposing the existing natural gas grid for hydrogen mixtures. For each of these steps, MARCOGAZ experts have selected five main categories regarding the use of hydrogen: transport, storage, local distribution, pressure regulation and metering, and end use. Beyond the methodology steps, this document identifies different asset types in the natural gas mid- and downstream infrastructure, with the specific asset volumes and the H_2 readiness of the assets. These values assist stakeholders in determining their total asset volumes and the required mitigation measure costs.

The structure of this report can be summarized in the following parts:

1. In the first part, chapter 2, a general methodology outline is given to set a framework to determine the cost estimation of hydrogen admission into existing natural gas infrastructure and end use
2. In the second part, chapters 3-7, the five categories are described individually in more detail. Here, assumptions are given for the quantification of the specific asset volumes of components that are operated in the European gas infrastructure and their respective hydrogen tolerance.
3. In the third part, chapter 8, a brief overview of the cost estimation for hydrogen admission into existing natural gas infrastructure and end use is given when the methodology is applied on an European level.
4. In the final part, chapter 9, a conclusion is presented which summarizes the main outcomes of the document.

The mitigation measures are in line with the updated version of H_2-infographic as published by MARCOGAZ in 2023 [1]. A more general comparison between various types of technology, concerning aspects like energy efficiency and energy availability, might require additional measures even for low hydrogen concentrations. These questions can only be answered on a case-by-case assessment by the operator, when deciding which technology is best suited for a specific task. These measures are therefore not considered in this publication.

2. METHODOLOGY

2.1 Scope of the methodology

In developing the methodology to determine the cost estimation of hydrogen admission into existing natural gas grids, MARCOGAZ experts worked closely together with the different European shareholders. The method, assumptions and data have been extensively discussed by MARCOGAZ experts. Following this discussion, five gas infrastructure categories are identified covering the mid- and downstream gas chain for which the cost analyses can be performed. These categories are:

- **Transmission and regional distribution:** All the gas systems operating with pressures higher than 25 bar. These systems are typically used to deliver gas over long distances through steel pipelines and operated by transmission system operators (TSOs).
- **Local distribution networks:** Systems operating with pressures below 25 bar, in most cases pressures up to 16 bar. This encompasses gas distribution networks on a more local scale. Note that there are some pipelines in distribution grids that are operated with pressures above 25 bars. These are covered within the first item.
- **Gas Storage facilities:** The surface- and subsurface facilities used to store gas in depleted reservoirs, aquifers, or salt caverns and their respective equipment.
- **Pressure regulating and metering stations:** Stations in both the gas transmission and distribution system for pressure control and gas metering.
- **End use:** Equipment related to the different specific usages of gas for residential and commercial appliances.

For these categories, the individual costs for hydrogen admission into existing gas infrastructure can be estimated using the methodology outlined below. Adding the costs of the individual categories will result in the estimation for the total costs of hydrogen admission in the mid- and downstream gas infrastructure. After this chapter, the individual categories are explained in more detail and assumptions on the specific assets volumes and mitigation measures are given.

2.2 General approach of the calculation

Using the general methodology, the reader can calculate the costs for the specific situation in their country or segment. The general approach to calculate the cost for hydrogen admission into existing gas infrastructure can be summarized by four steps:

1) *Quantification* of the volumes of all assets utilized in each operation category.
2) *Evaluation* of these assets regarding their hydrogen suitability for the key concentration: 2, 5, 10,15, 20, 25, 30 and 100 vol.-% H_2 and the corresponding adaptation measures.
3) Elaboration of the *specific costs* for the defined adaptation measures
4) Calculation of the *total costs* for the entire gas value chain for each specific hydrogen concentration

An overview of the steps can be found in Figure 1. Before applying these steps in detail to the different categories in the next chapters, a few general remarks can be made about the individual steps.

Quantification

As a first step, the quantification of the asset volumes has to be carried out for all the above-mentioned areas of interest. The quantification of a complete gas grid can be quite a challenging task, as it is not always possible to make an overall audit of all the necessary assets (valves, meters, pressure regulators, etc.). In these cases, more realistic and strategic approaches need to be implemented. This would entail using certain countries, which have this data readily available, as basis for this study to calculate a specific asset volume (weighted average e.g. on the basis of the corresponding pipeline length) for each area of interest. MARCOGAZ experts have analysed multiple data sets to provide European weighted average specific asset volumes (often per km). These numbers serve as reference or in case detailed data is lacking but the grid size is known. The assumptions for quantification and specific asset volumes are given in the chapters of the individual categories. From the specific asset volumes, the total asset volume can be calculated as in:

$$Total\ asset\ volume = specific\ asset\ volume \times grid\ size.$$

Evaluation

Once the quantification is done, the assets need to be evaluated in terms of their hydrogen suitability for the key concentration: 2, 5, 10,15, 20, 25, 30 and 100 vol.-% H_2. Following a hands-on oriented approach, only the technically most important hydrogen concentrations mentioned above are part of this investigation. This also means that no statements are given about hydrogen concentrations of 31 – 99 vol.-% in the gas blend. If higher concentrations would become of more interest to the industry, they could be investigated in more detail separately.

From the evaluation of H_2-readiness, mitigation measures are derived which describe in brief what action is needed to convey certain hydrogen concentrations in the existing gas infrastructure. The mitigation measures have been developed based on available literature, findings of research and demonstration projects, discussions, and consensual assumptions by MARCOGAZ expert groups. The identified mitigations measures underline the latest (2023) version of the H_2-Infographic as published by MARCOGAZ [1]. These mitigation measures apply to general asset groups in case the H_2-readiness of a specific asset model is not known. Similar as with the specific asset volumes, the expected mitigation measures for the different asset types are given in the chapters of the individual categories.

Specific costs

Next, to determine the specific costs for each asset, the expected mitigation measure per evaluated hydrogen concentration has to be translated to an estimated cost. It needs to be considered that calculating a specific price for renewal or retrofitting of a selected component is complex, especially because prices vary over Europe and depend on many variables. Therefore, prices assumptions are *not* included in this document and should be included by the expert performing the study.

Total costs

Finally, the previous steps for the different categories are consolidated to estimate the overall mitigation costs for the mid- and downstream gas value chain for a specific hydrogen concentration scenario. This can mathematically be represented by:

$$Total\ Cost\ (X\%\ H_2)[€] = C_{TP\ (X\%\ H_2)} + C_{DIS\ (X\%\ H_2)} + C_{PM\ (X\%\ H_2)} + C_{UGS\ (X\%\ H_2)} + C_{EU\ (X\%\ H_2)},$$

In which, $C_{(X\%\ H2)}$ is the cost for X vol.-% H_2 admission into the infrastructure category and the acronyms TP, DIS, PM, UGS and EU refer to the segments *Transmission Pipelines, Distribution, Pressure regulating and Metering stations, Underground gas storage and End use* respectively. A full spectrum can be derived by calculating the total costs for each vol.-% H_2 concentration.

To be able to perform the calculation above, first the cost per category per hydrogen concentration ($C_{(X\%\,H2)}$) has to be calculated as:

$$C_{(X\%\,H_2)} = A_i * C_{Ai\,(X\%\,H_2)} + A_j * C_{Aj\,(X\%\,H_2)} + \cdots,$$

In which A_i is the volume of an asset type i, possibly derived from a specific asset number per km pipeline multiplied by the length of the grid, and $C_{Ai\,(X\%\,H2)}$ is the specific cost for the mitigation measure to allow X vol.-% hydrogen admission into asset type Ai.

The acquired and aggregated data concerning the specific assets volumes, their hydrogen compatibility as well as required mitigation measures are presented in next chapters for each operating category.

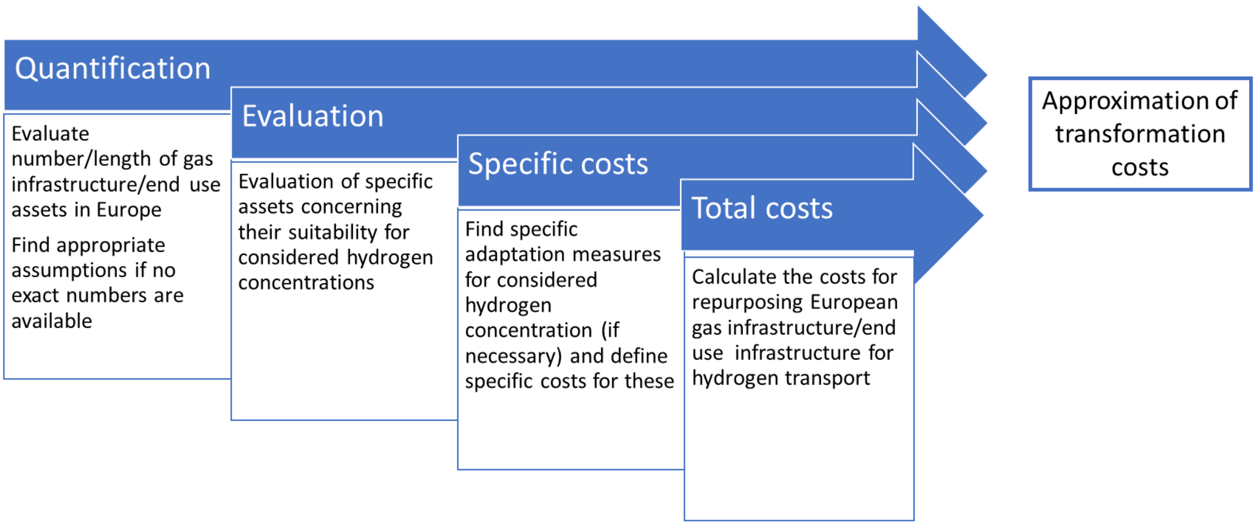

Figure 1: Four steps to calculate the transformation costs of hydrogen admission into existing natural gas infrastructure.

3. TRANSMISSION AND REGIONAL DISTRIBUTION

3.1 Introduction

In this chapter, the infrastructure category transmission and regional distribution is worked out in more detail. Firstly, the quantification of the assets within this category is evaluated and specific European average values, in unit per km, are given as a reference in case local data is lacking. In the second part of this chapter, the mitigation measures for the individual assets types in this category are outlined for the different hydrogen concentrations.

The following asset types are identified by MARCOGAZ experts in the transmission and regional distribution category: Piping, and Valves-, Pigging-, Metering- and Compressor stations. Depending on the local situation and the scope of the research, asset types might be left out or new types could be included in this category.

3.2 Quantification of specific asset volumes for transmission infrastructure

Sometimes it might be hard to quantify the assets in the category transmission and regional distribution. This subsection helps by evaluating and defining specific European average values in case national or regional data is not available.

- **Piping:** It is crucial to differentiate between older and newer steel pipelines as this determines the proposed mitigation actions and therefore adaptations costs. The motivation for the differentiation is that due to improved non-destructive testing technologies, the pipeline quality was improved during production and welding. This improved technical situation was included in the standards for pipeline production and installation in the mid 1980's, unfolding to an improved quality in the complete infrastructure that has been build afterwards. There are cases where those quality measures have been applied even earlier but this is not considered to be the typical case. Based on this background the following distinction has been made:

    - Older pipelines: commissioned before 1984 with a lower weld quality.
    - Newer pipelines: commissioned after 1984 EN12732 with an improved weld quality.

  The TYNDP and the 11th EGIG report have estimated for both groups the operated assets length in Europe [2, 3]. It was concluded that the total 225.000 km of gas transmission pipelines consist of 121.000 km (54%) older and 104.000 km (46%) younger pipelines.

- **Stations:** Station assets are defined as assets that have a character or a structure that is more complex than a single pipeline. In the following, the assumptions and estimated specific asset volumes are described by different types of stations:
    - Valve stations: Aiming to estimate a realistic amount of currently operated valve stations, codes and standards are considered that define the distance between valve stations. The regulations are varying across Europe between 10 and up to 90 km of pipeline length. A specific amount for valve stations was calculated based on the specific regulations and pipeline lengths of the countries; Belgium, France, Germany, Italy and The Netherlands. Based on this information a length-weighted average of 1 valve stations every 15 km in existing pipelines lines has been concluded.

      For conveying pure hydrogen, it is expected that all existing valve stations will be replaced by double block and bleed stations every 20 km on average in the European gas transmission system. This estimation is based on the currently discussed requirements. The expected regulation in the member states can vary significantly. It is expected that in the near future more certainty will be achieved concerning the requirements and regulations.

- Pigging stations: Data from France, Denmark en Italy is collected to determine the volume of pigging stations in the transmission network. Based on this information, a weighted average of 1 pigging station every 66 km of pipeline length has been set.

- Metering stations: The assumptions of metering stations (gas pressure regulation stations are covered separately) are derived of data from France, Germany, Italy, The Netherlands and United Kingdom. It is assumed that there are a total of 870 metering stations over the total European grid, resulting in a specific value of 0,0039 station per km. Each metering station is estimated to be equipped with three trains, two converters (one back up) and one process graph chromatograph (PGC). It should be noted that not all the measuring stations are equipped with a PGC. As in other parts of the grid some additional PGC are installed, it is assumed that one PGC per stations leads to a realistic total amount. Note that pressure regulation stations are considered in chapter 6.

- Compressor stations: The estimation of installed compressor power follows from data of Germany, Italy and France. Based on this information a specific weighted average of 0.042 MW installed compressor power per kilometre has been determined.

Overview of the considered asset volumes

An overview of the considered asset types and their specific asset volumes are given in Table 1.

Infrastructure item	Specific asset volume per km pipeline
Share of older pipe construction (before 1984 EN12732) [2,3]	54%
Younger pipe construction (after 1984 EN12732) [2,3]	46%
Valve stations (existing)	0,067 station / km
Valve stations (needed for pure hydrogen service)	0,05 station / km
Pigging stations	0,015 station / km
Metering stations	0,0039 station / km
Compressor station installed power incl. drive and auxiliaries combined	0,042 MW/ km

Table 1: Overview of the considered specific asset volumes.

3.3 Mitigation measures for transmission infrastructure with different H2 concentrations

This section elaborates on the estimated H_2-readiness and corresponding mitigation measures for assets in the category transmission and regional distribution. Beyond the mitigation measures described in the following subsections, further mitigation actions, including replacement of pipeline sections, could become necessary, especially if the same energy throughput as in the natural gas service needs to be maintained. These, non-operational required measures, could in some constellations become necessary even for low hydrogen concentrations and are not considered in this publication. This can only be provided based on an individual assessment by the operators itself.

- **Piping:** Steel pipelines that are operated statically are deemed to be suitable for hydrogen applications [4, 5]. Statical operation has been defined by pressure swings lower than 10% of pipeline design pressure. The following measures are recommended to assure a safe operation and are considered in the subsequent assessment:

    - For hydrogen concentrations up to 10 vol.-% in the gas mixture, a risk assessment is required considering the current condition of the pipeline. (Existing inline inspection (ILI), magnetic flux leakage and for smaller diameters DC voltage gradient, should be considered).

    - For higher hydrogen concentrations as of 10 vol.-%, inline inspection and subsequent repair are required if the pipelines are operated dynamically. Dynamic operation is considered for 5% of the pipeline length. This approach is considered to be conservative as pressure swings in the mentioned magnitude occur mainly in pipelines directly connected to UGS or LNG regasification plants [5].

    - It is expected that inline inspection with suitable technologies (e.g. EMAT) leads to the identification of cracks and crack like defects. It is assumed that defects for older pipelines are expected to be more frequent (0,1/km) than for younger pipelines (0,01/km) [5].

The mitigation measures are summarized in Table 2 below.

	Mitigation measures according to hydrogen concentration							
	2 vol.-%	**5 vol.-%**	**10 vol.-%**	**15 vol.-%**	**20 vol.-%**	**25 vol.-%**	**30 vol.-%**	**100 vol.-%**
Steel pipelines before 1984	risk assessment			ILI and subsequent repair for dynamically operated pipelines needed				
Steel pipelines after 1984	risk assessment			ILI and subsequent repair for dynamically operated pipelines needed				

Table 2: Mitigation measures for transmission pipelines.

- **Stations:** Station assets are complex concerning the number of components, technologies that are used, as well as their designed. The mitigation measures shown in this subsection summarise measures that apply for the majority of the assets in the field. However exceptions where more, less or different measures are needed are expected. For the different station types, the following measures are identified:

    - Valve Stations:
        - Require tightness checks due to the different nature of hydrogen molecules in respect to natural gas. Replacement can be mandatory depending on the country for mixtures above 10 vol.-% H_2 [6].
        - For mixtures between 10 and 30 vol.-% H_2, it is expected that 10 % of the valve stations has to be replaced [6].
        - For 100 vol.-% H_2, it is assumed is that all valve stations will be replaced by double block and bleed stations.

    - Pigging stations:
        - No modifications are foreseen as required for mixtures up to 10 vol.-% H_2 for piggings stations.
        - Above the limit of 10 vol.-% H_2, seal replacement is expected for pigging stations.

- Metering stations:
    - Above concentration of 2 vol.-% H_2, process gas chromatographs need to be replaced.
    - Concentrations above 10 and up to 30 vol.-% H_2, manufacturer approval of meters and converters is expected, and recalibration of us-meters might be needed [7].
    - For 100 vol.-% H_2 mixtures, replacement of meters and volume converters and further complex measures are expected to be necessary.

- Compressor stations: Compressor stations are complex and unique facilities, especially regarding the design and key technologies. Mitigation measure listed below are therefore of general nature and based on a case-by-case approach more/less measures could become necessary to achieve certain hydrogen concentrations.
    - For blends up to 2 vol.-% H_2, an additional control system is considered to be necessary. As the (volumetric) heating value of hydrogen is lower compared to natural gas, a higher flow rate is needed to provide the same amount of energy through the system. Furthermore, in some cases, a H_2 concentration monitoring system might be needed.
    - Above 2 and up to 10 vol.-% H_2 concentration, modifications of the following components are considered to be necessary in many cases [8]: control systems, fuel gas systems incl. filters, sealing systems (wet systems not suitable) and fire detections systems.
    - Mixtures with concentration between 10 and 20 vol.-% H_2, in addition to the previous listed measures, also complex modifications as retrofit of compressors, drives and possibly pressure reduction is required.
    - For concentrations above 20 vol.-% H_2, replacement of the compressors and drives and significant changes on the station are required. Providing the same pressure loss in the pipelines, the additional compression energy amounts to 13 % in comparison to natural gas. If the same energy flow needs to be maintained, the higher flow rate would amount to more than 50% additional compression energy in comparison to natural gas [9]. Therefore replacement of the compressor stations is considered when hydrogen concentrations of 20 vol.-% will be exceeded.

The mitigation measures for different station types are summarized in Table 3**Error! Reference source not found.** below.

	Mitigation measures according to hydrogen concentration							
	2 vol.-%	**5 vol.-%**	**10 vol.-%**	**15 vol.-%**	**20 vol.-%**	**25 vol.-%**	**30 vol.-%**	**100 vol.-%**
Valve stations	risk assessment	tightness check		tightness check, replacement in some countries may be mandatory				valve stations will be replaced by DBB stations every 20km on average
Pigging stations	no modification expected			Replacement of seals expected				
Compressor stations incl. drive and auxiliaries	Additional control system and H_2 concentration monitoring in some cases needed	Modifications are often needed regarding: Control System Fuel gas system Sealing systems Fire detections systems		complex modification as for 10 vol.-% plus retrofit of compressors, drives and possibly pressure reduction required		Replacement/measures that are of comparable effort needed		
Metering stations	PGC renewal			PGC renewal + volume converter calibration manufacturer approval for turbine meters, manufacturer approval and case depending on modification of us-meters			PGC & volume converter renewal Meter replacement	

Table 3: Mitigation measures for station assets.

4. UNDERGROUND GAS STORAGE

4.1 Introduction

Underground Gas Storage facilities (UGS) refer to the facilities used to store gas for future utilization, including all the equipment required for injection and gas treatment. Three main types of UGS facilities have been distinguished, namely salt caverns, depleted oil- and gas fields and aquifers.

UGS facilities vary significantly throughout Europe, not only in terms of type, but also regarding size and storage volume, as well as operating conditions. Accordingly, a wide variety of equipment is used, and currently in several cases no distinct proclamations on hydrogen suitability can be provided. However, currently there are a series of real projects in the field being carried out, and real practical experience will be gained in near future. These experiences are expected to improve the current knowledge of hydrogen suitability for several components.

Similar to the assessment of the transmission category, the existing UGS facilities in Europe have been analysed to determine the main parameters and specific asset amounts to come up with a so-called European generic UGS. Subsequently, the main components have been analysed for their H_2-tolerance and adoption measures.

4.2 Quantification of an European generic UGS

A total of 205 UGS facilities exist in Europe, distinguished into three main types (see Table 4), and all of them with unique parameters and different types and amounts of components installed. To be able to quantify a so-called generic UGS, a bottom-up approach was used, supplemented with more detailed information from reference projects. The workflow to determine the amounts and types of components are outlined below:

1. Analysis of the data base "Gas Storage Europe" [10]. Compilation of main parameters of *each* UGS, i.e. storage volumes and maximum withdraw and injection rates. Further, analysis of depths and number of wells, if there are secondary sources available. Mainly used here: IGU WGC 2018 [11].
2. Determination of main parameters for each UGS
3. Determination of amounts of main equipment for each UGS using the assumptions and approaches described in Table 6).
4. Determination of average values for each UGS-type, for both main parameters and amounts of equipment.
5. Determination of a weighted average value for all main parameters and equipment, using the average values for each UGS-type and the number of UGS facilities for each type.

Applying the workflow above, a so-called generic UGS was generated, covering cavern-UGS, depleted field-UGS and aquifer-UGS alike. This approach can be considered representative, since in the end all necessary main equipment and their overall shares and quantities are covered. However, this approach also has some limitations in that regard that it produces unrealistic combinations of equipment in a single UGS (e.g. different types of gas treatment and different types of compressor drives[1], whereas in reality only a single system would be used).

[1] Usage of different compressor types on the other hand is indeed common, there are several UGS facilities using both piston compressors and turbo compressors, e.g. Rehden in Germany.

4.2.1 Main parameters of UGS

In this sub-chapter, the main parameters of the European UGS facilities are determined. These values are important to determine the amounts of the main component of the UGS facilities (as in Table 6). Starting point for the analysis was the data base "Gas Storage Europe" [10]. First of all, Table 4 summarizes the number of considered UGS facilities:

Type	Salt Cavern	Aquifers	Depleted Fields	Total
Number	68	36	101	**205**

Table 4: Summary of UGS facilities according to type.

In the next step, the main characteristics/parameters for each UGS were assessed and subsequently, average values for each type calculated. Then, a weighted average value for a standard representative European UGS facility was formed, using the number of each type in relation to the total existing UGS facilities. The parameters considered are:

- Depths are used to determine the length of the tubing and LCCS,
- Working gas volume is required to determine the number of wells
- Maximum withdraw rate is required to stipulate the amount of components on the withdrawal side of the UGS
- Maximum injection rate is required to stipulate the amount of components on the injection side of the UGS, mainly number and type of compressors.
- Max. Pressure at the LCCS is important for calculation of power consumption of a compressor.

Parameter	Unit	Cavern-UGS	Aquifer-UGS	Depleted Field UGS	Weighted Average
Depth Top	m	1,040.30		1,244.51	958.22
Depth Bottom	m	1,324.13	706.43	1,427.67	1,266.67
WGV	Mio. Nm^3	220.56	150.98	529.88	360.74
TGV	Mio. Nm^3	662.13	368.13	1160.52	856.05
Max. Withdrawal Rate	1000 Nm^3/h	516.03	325.25	654.76	550.88
Max. Injection Rate	1000 Nm^3/h	263.02	192.40	476.92	356.00
Max. Pressure at LCCS	bar	185.00	78.79	149.03	148.63
Min. Pressure at LCCS[2]	bar	60.00			19.90
Temperature	°C	47.50	27.17	54.91	47.58
No. Wells	-	9	31	28	22

Table 5: Summary of main parameters of UGS facilities according to type.

[2] For cavern-UGS, a regular value fitting for the cavern depth had been applied by DBI, for the other types no minimum pressures could be determined from GSE. Thus, the weighted average value automatically gets very low. However, this value has no impact on the subsequent cost assessment.

4.2.2 Analysis of UGS facilities: specific asset volume of main components

As a next step, the main components for gas operation were assessed according to the facilities' main parameters. For several components a distinction into two cases needed to be made regarding their H_2-suiability.

A few remarks on the assumptions to derive a reference-UGS:

- For some components like gas chromatographs, fixed values are assumed.
- For components like amounts of compressors and gas treatment units, assumptions for calculations are made, e.g. amount of compressors is determined according to maximum injection capacity:
  - Maximum injection rate of an UGS facility:
    - Above 200,000 Nm3/h max. injection capacity:
      - Maximum injection capacity divided by 150,000 Nm3/h leads to the amount of turbo compressors. Value rounded.
    - Below 200,000 Nm3/h max. injection capacity:
      - Maximum injection capacity divided by 50,000 Nm3/h leads to the amount of piston compressors. Value rounded.
    - Above 200,000 Nm3/h max. injection capacity:
      - Maximum injection capacity divided by 150,000 Nm3/h leads to the amount of turbo compressors. Value rounded.
    - Below 200,000 Nm3/h max. injection capacity:
      - Maximum injection capacity divided by 50,000 Nm3/h leads to the amount of piston compressors. Value rounded.
    - 1 compressor for redundancy has been added of each.
  - The above calculation was done for each UGS facility in Europe, using the general information from GIE.
  - Then the weighted average amount of compressors was, using the calculated amount of each UGs-type in Europe.
- For components with differing types, such as varying gas treatment units, it was important to determine not only the overall amount of the component itself, but also the share of certain types (e.g. TEG drying and adsorption drying) [11, 12].
- For a number of components like subsurface tubings, there could no funded determination be found about the degree of H_2-tolerance, since this is unknown for the API grades typically used for subsurface equipment. Future and currently ongoing research projects / results might change this assessment.
- However, there are some practical experiences in the field, showing that regular API-steels can be used under certain conditions and / or up to limited shares of hydrogen blended into natural gas [13].
- Some API-steels are reported to be H_2-suitable, such as e.g. X-52. However, they are rather untypical.

For several components such as pipelines in the surface facility (SF) components a distinction into two cases needed to be made:

- H_2-suitable
- Not H_2-suitable

Reason is that for these components varying types and materials are available at the market, and a survey among UGS-operators in Germany [12] concluded that partially H_2-suitable material is used and partially not H_2-suitable material. The respective shares had been extrapolated to the European UGS facilities.

The following, Table 6, summarizes the main components and the assumptions with respect to the calculation principles for the specific number of a representative type-UGS.

Main Component and Type	**Calculation / Assumption**	**Amount for representative type-UGS**
Compressors • **Turbo Compressors** • **Piston Compressors**	• Calculated according to max. injection rate of UGS facility. Turbo-comp. with 150,000 Nm/h and Piston comp. with 50,000 Nm^3/h. 1 compressor in addition for redundancy. Calculated for each European UGS facility. • Above 200,000 Nm^3/h max. injection capacity utilization of Turbo-compressors, otherwise Piston. • 2-stages compression	• 4 turbo • 4 piston
Drive engine • **Electric engine** • **Gas engine** • **Gas turbine**	• One drive engine per compressor. • Numbers for different drive engines were applied from a reference project and extrapolated to the European UGS infrastructure [12].	• 3 electrical engines • 4 gas engines • 1 gas turbine
Cooler	• One per compression stage, i.e. two per compressor.	• 16
Separator	• Calculated according to max. withdrawal rate (3 separators for 1,500,000 Nm^3/h; rule of three[3]) + 1 for redundancy	• 2
Gas Dryer • **Absorption** • **Adsorption** • **JT-Dryer**	• Calculation of total number of dryers according to max. withdrawal rate (3 units for 1,500,000 Nm^3/h; rule of three[3]) + 1 for redundancy; • Analysis of shares of absorption drying, adsorption drying and JT-drying according to IGU WGC 2018 data base and type of UGS • Calculation of amount of units per UGS according to type and shares; formation of an average value for all European UGS facilities.	• 5 absorption • 1 adsorption • 1 JT

Pressure and flow regulations	• Analogy from a reference project:
	  ○ Cavern-UGS: 1 per every 2.25 wells
	  ○ Aquifer-UGS: 1 per every 6.2 wells
	  ○ Depleted Field UGS: 1 per every 1.56 wells
	• Final values are rounded up, and then the weighted average value is generated.
		• 11

Turbine gas meter	• Calculation of total number of flow meter as follows:
	  ○ 2 per well, i.e. 44
	  ○ 1 per compressor, i.e. 8
	  ○ 1 per cooler, i.e. 16
		• 77

[3] The assumption that 3 separators are used in a UGS facility with an overall maximum withdraw capacity of 1,500,000 Nm^3/h is directly applied from a reference project.

Main Component and Type	Calculation / Assumption	Amount for representative type-UGS
	○ 1 per separator, i.e. 2 ○ 1 per gas drying unit, i.e. 7 ○ 1 per field pipeline, multiplied with 1.5[4], i.e. 33 ○ 1 per desulphurization unit, i.e. 2 ○ 1 per flare, i.e. 4 • 2/3 of all normal gas meters are Turbine type. Analogy from a reference project.	
Coriolis gas meter	• 1/3 of all normal gas meters are Coriolis type. Analogy from a reference project.	• 39
Ultrasonic gas meter	• Calculated according to max. withdrawal rate (3 ultra-sonic meters for 1,500,000 Nm^3/h; rule of three[3]) + 1 for redundancy, used for fiscal measurement	• 2
Diaphragm gas meter	• Set to 0.	• 0
Process gas chromatograph	• 2 per UGS facility	• 2
Piping Surface Facility, lenght	• Analogy from a reference project [12]: ○ Cavern-UGS: 645 m 100% H_2-suitable pipes; 1,257 m not H_2-suitable pipes ○ Aquifer-UGS: 0 m 100% H_2-suitable pipes; 1,799 m not H_2-suitable pipes ○ Depleted Field UGS: 0 m 100% H_2-suitable pipes; 6,311 m not H_2-suitable pipes	• 214 m H_2-suitable • 3,842 m not H_2-suitable • Above numbers are the weighted average from the values different UGS-types.
Fittings Surface Facility, amount	• Analogy from a reference project: ○ Cavern-UGS: 67 100% H_2-suitable; 145 not H_2-suitable ○ Aquifer-UGS: 7 100% H_2-suitable; 112 not H_2-suitable ○ Depleted Field UGS: 25 100% H_2-suitable; 391 not H_2-suitable	• 36 H_2-suitable • 260 not H_2-suitable • Above numbers are the weighted average from the values different UGS-types.
Field pipelines (surface facilities - wells), length	• Analogy from a reference project: ○ Cavern-UGS: 4,245 m 100% H_2-suitable pipes; 14,415 m not H_2-suitable pipes ○ Aquifer-UGS: 0 m 100% H_2-suitable pipes; 4,678 m not H_2-suitable pipes ○ Depleted Field UGS: 0 m 100% H_2-suitable pipes; 4,225 m not H_2-suitable pipes	• 1,408 m H_2-suitable • 7,685 m not H_2-suitable • Above numbers are the weighted average from the values different UGS-types.
Glykol vessels: fresh, comdensate, old	• Each type 3 times, i.e. 3 x 3 = 9 [11]	• 9
Desulphurization	• Assumption that 1/3 of the UGS facilities need a desulphurization.	• 2

[4] For every well, there is a field pipeline. Some might directly go into the surface facility, but others might be preliminary combined to a larger common field pipeline first. Factor 1.5 is DBI's own assumption.

Main Component and Type	Calculation / Assumption	Amount for representative type-UGS
	• Amount determined as 1/3 of total number of gas dryers, value rounded.	
Flare	• Fixed value for each UGS type according to average Withdraw capacity: 4 for caverns, 2 for aquifers, 4 for depleted fields. • Calculation of weighted average amount	• 4
Burners	• 2	• 2
No. Wells	• Determined according to UGS type, reference project and WGV, in case no values in [11] are given; o Cavern-UGS: 9 o Aquifer-UGS: 31 o Depleted Field UGS: 28 • Calculation of weighted average value	• 22
Cumulative LCCS length	• Calculated as number of wells x depth bottom	• 21,081 m
Packer	• 1 per well	• 22
Tubing length	• Calculated as number of wells x depth bottom • Assumption that no tubing is H_2-suitable	• 21,081 m
Sand filter (in case porous UGS)	• Cavern-UGS: 0 • Aquifers and depleted Filed UGS: 1 per well	• 29
Wellhead	• 1 per well • Assumption that no WH is H_2-suitable	• 22
SSV	• 1 per well	• 22

Table 6: Summary of assumptions and calculation principles for assessment of number of main components.

4.3 Mitigation measures for UGS facilities with different H2 concentrations

The next step for the category UGS facilities is determining the H2-readiness of the identified components. Table 7 summarizes the actual H2-tolerances of each main component in more detail and gives the necessary adoption measures to reach higher H2-tolerance. Annex I, Table 17, gives a more detailed description of the identified mitigation measures.

<table>
<tr><th>Main Component</th><th>H_2-Tolerance vol.-%</th><th colspan="9">Specific Adoption Measures to reach levels of H_2-tolerance</th></tr>
<tr><th></th><th></th><th>0 %</th><th>2 vol.-%</th><th>5 vol.-%</th><th>10 vol.-%</th><th>15 vol.-%</th><th>20 vol.-%</th><th>25 vol.-%</th><th>30 vol.-%</th><th>100 %</th></tr>
<tr><td>Turbo compressor</td><td>10</td><td colspan="4">No Adoption required.</td><td colspan="2">Adjustments required, a detailed evaluation of the respective component must be carried out, taking into account the individual conditions / modes of operation</td><td colspan="2">Adjustments required, a detailed evaluation of the respective component must be carried out, taking into account the individual conditions / modes of operation</td><td>Replacement required.</td></tr>
<tr><td>Piston compressor</td><td>5</td><td colspan="4">No Adoption required.</td><td colspan="5">Check for material compatibility, adjust lubricant and pressure if necessary.</td></tr>
<tr><td>Electric engine</td><td>100</td><td colspan="9">No Adoption required.</td></tr>
<tr><td>Gas engine</td><td>10</td><td colspan="4">No Adoption required.</td><td colspan="5">Check for material compatibility, Check for required gas demand for fuelling, if is not given.</td></tr>
<tr><td>Gas turbine</td><td>2</td><td colspan="2">No Adoption required.</td><td colspan="6">Modification on the gas turbines are required.</td><td>Replacement required.</td></tr>
<tr><td>Cooler</td><td>20</td><td colspan="6">No Adoption required.</td><td>Adaptation is required. Check for material compatibility</td><td colspan="2">Adaptation or complete replacement is required.</td></tr>
<tr><td>Separator</td><td>5</td><td colspan="3">No Adoption required.</td><td>Check for material compatibility, eventually adaptation.</td><td colspan="5">Absorption Gas Dryer</td></tr>
<tr><td>Absorption & adsorption Gas Dryer</td><td>5</td><td colspan="2">No Adoption required.</td><td colspan="7">Check for material compatibility, eventually adaptation.</td></tr>
<tr><td>JT Gas Dryer</td><td>N/A</td><td colspan="9">N/A</td></tr>
<tr><td>Pressure regulator</td><td>30</td><td colspan="8">No Adoption required.</td><td>Testing of material compatibility and functionality / (capacity test) is required.</td></tr>
<tr><td>Turbine gas meter</td><td>30</td><td colspan="8">No Adoption required.</td><td>Replacement required.</td></tr>
<tr><td>Coriolis gas meter</td><td>5</td><td colspan="3">No Adoption required.</td><td colspan="6">Individual evaluation of the measuring range and material compatibility is required.</td></tr>
</table>

Main Component	H_2-Tolerance vol.-%	Specific Adoption Measures to reach levels of H_2-tolerance 0 %	2 vol.-%	5 vol.-%	10 vol.-%	15 vol.-%	20 vol.-%	25 vol.-%	30 vol.-%	100 %
Ultrasonic gas meter	10	No Adoption required.		Individual evaluation of the measuring range and material compatibility is required.	Replacement required.					
Diaphragm gas meter	N/A	N/A								
Process gas chromatograph	0.2	No Adoption required.	Replacement required.							
Piping, 100 % H_2-compatible	100	No Adoption required.								
Piping, not H_2-compatible	5	No Adoption required.			Piping, not H_2-compatible					
Fittings, H_2-compatible	100	No Adoption required.								
Fittings, not H_2-compatible	5	No Adoption required.			Fittings, not H_2-compatible					
Field pipeline, H_2-compatible	100	No Adoption required.								
Field pipeline, not H_2-compatible	5	No Adoption required.			Field pipeline, not H_2-compatible					
Glykol vessels	5	No Adoption required.			Check for material compatibility or use recommendation of the NACE and EIGA Standard.					
Flare	5	No Adoption required.			Check for material compatibility, define or adjust Ex-Zones	Check for material compatibility, define or adjust Ex-Zones, new flare to be installed.				
Burners	5	No Adoption required.			Burners must be adapted / check for material	Burners must be adapted / replaced, fuel gas demand increased according to calorific value, Ex-areas to be re-assessed.				

Main Component	H_2-Tolerance vol.-%	Specific Adoption Measures to reach levels of H_2-tolerance								
		0 %	2 vol.-%	5 vol.-%	10 vol.-%	15 vol.-%	20 vol.-%	25 vol.-%	30 vol.-%	100 %
					compatibility, Ex-areas to be re-assessed					
Desulfurization	**5**	**No Adoption required.**			**Check for material compatibility, eventually adaptation**	**Desulfurization**				
LCCS	**100**	**No Adoption required.**								
Packer	**2**	**No Adoption required.**		**Check material for long-term degradation safety, check Elastomer compatibility and eventually replacement.**				**Replacement is required[5].**		
Tubing - H_2-compatible	**100**	**No Adoption required.**								
Tubing - not H_2-compatible	**2**	**No Adoption required.**		**Check material for long-term degradation safety, eventually replacement.**				**Replacement is required.**		
New inner Liner as secondary barrier for protection of Casing	**100**	**No adaption required, new installation which must be H_2-compatible.**								
Sand filter (for porous UGS)	**100**	**No Adoption required.**								
Wellhead, H_2-compatible	**100**	**No Adoption required.**								
Wellhead, not H_2-compatible	**2**	**No Adoption required.**		**Proof of suitability/monitoring required. Eventually replacement.**				**Replacement is required.**		
SSV	**2**	**No Adoption required.**		**Check material for long-term degradation safety, eventually replacement.**				**Replacement is required.**		

Table 7: Summary of H2-tolerances of main components and adoption measures.

[5] Currently, no H_2-suitability for any packer is guaranteed by any supplier. Thus, conservatively a required replacement is stipulated. Some actual research projects are dealing with aspects of this and future results might result in a given packer suitability for certain types and H_2-concentrations. Here, the evaluation of the to-be replaced amount of packers might be updated.

5. DISTRIBUTION

5.1 Introduction

Gas distribution systems are defined as systems operating below 25 bars within the scope of this report. It is worth pointing out that the pressure ranges for these specific systems differ depending on the country, but they generally do not exceed 16 bars.

Following the procedure described in chapter 2, for the first two steps, concerning the quantification and evaluation, an online survey was implemented where stakeholders of the gas distribution systems were asked to share relevant data with MARCOGAZ.

Similar to the quantification step in the transmission category, the number of specific assets are calculated from the data of the asset volumes and corresponding grid length of the grid operators. In this way, a specific number of each component could be calculated per kilometre grid length to serve as a reference for the researcher.

Next, the answers about the evaluations of the components coming from the different stakeholders were compared to ensure consensus on the required mitigation measures, which was then presented to and confirmed by MARCOGAZ experts.

5.2 Quantification of specific asset volumes for distribution infrastructure

Based on the survey and the following studies; *MARCOSTAT Report on European Gas Safety Gas Distribution (EGAS B) 2018, MARCOSTAT Report on European Gas Safety Gas Distribution (EGAS B) 2019* [14], and *the Marcogaz survey on Methane Emissions 2017* [15], an overview of the European gas distribution grid was collected. For countries where specific data was lacking, an averaged benchmark calculation was used. From these results, the ratio of piping materials (steel, plastic, cast iron, other) was derived as giving in Table 8**Error! Reference source not found.**.

COUNTRY EU 28 + Ukraine	Total (km)	Total Plastic (%)	Total Steel (%)	Cast Iron (%)	Others (%)
TOTAL	2245993	54%	43%	2%	1%

Table 8: Share of piping materials for gas distribution grids in Europe.

The approximated specific number of valves in lines, diaphragm gas meters and house pressure regulators are shown in Table 9, including the number of data points, each result is based on. The number of house pressure regulators was calculated with the data gained from the survey on the one hand and data given in a report of the German federal environmental agency on the other hand [16].

Asset type	Specific amount (units / km)	Data points
Valves in Lines	0.89	7
Diaphragm gas meters	54	8 [16]
House pressure regulators	9	6

Table 9: Specific asset volumes for distribution (excluding pipelines).

Some remarks have to made about the asset types in the distribution category. First of all, components overlap with the Gas Pressure Reduction and Metering Stations category and are only listed in the next chapter to avoid repetition. Examples of such components are different types of valves, meters, filters, process gas chromatographs, volume converters and pressure regulators. Furthermore, also assumptions are made in the case data is lacking (excess flow valves) or for simplification reasons if the impact of the component is not expected to be significant (house entry combinations).

5.3 Mitigation measures for distribution infrastructure with different H_2 concentrations

5.31 Piping assets

Regarding the piping assets for distribution, some assumptions had to be taken, so that calculations were possible based on a slightly simplified approach. These assumptions are as follows:

- **Steel distribution pipelines:** Only a small part of the grid is used at pressures above 16 bar and an even smaller part is operated with regular pressure swings, so that the pressure dependency can be neglected. Damage of the pipelines because of hydrogen embrittlement is not expected because of the low pressure and the lack of cyclic loading. Furthermore, parts of the gas distribution grid are old and in sensitive condition, so that local replacement of the piping assets is necessary anyway. Regarding the use of hydrogen, it is assumed that for pure hydrogen 10% of the steel distribution pipelines need to be replaced due to risk assessments.
- **Cast iron distribution pipelines:** Cast iron pipelines can be either made of ductile cast iron or grey cast iron. Preliminary research results and the use for conveying town gas in this material underline the assumption that cast iron can be safely used with hydrogen. This is also supported by research results (e.g. from Sedigas 2023 [17]). Nevertheless, Grey cast iron is subject to renewal as it is prone to brittle fraction under certain conditions. Therefore, it is recommended in several countries to replace this material anyway and it is open to debate if this should be related to the introduction of hydrogen. The estimated percentage of grey cast iron in the European distribution gas grid is less than 5%.
- **Service lines:** According to the German rule G600 [18], no mitigation measures are necessary up to 20 vol.-% H_2 in the gas blend. At higher concentrations, replacement of the diaphragm gas meters becomes necessary.

An overview about the necessary mitigation measures for distribution piping assets is provided in Table 10.

	Hydrogen concentration / vol.-%							
	2	5	10	15	20	25	30	100
Steel distribution pipelines	No adaptation required							Replacement of pipelines can be necessary depending on the specific conditions.
Plastic distribution pipelines	No adaptation required							
Cast iron distribution pipelines	Replacement of grey cast iron pipelines as action independent of hydrogen injection							
Service lines	No adaptation required					Replacement of diaphragm gas meters		

Table 10: Mitigation measures for distribution piping assets.

5.32 Valves, meters and house pressure regulators.

Again, some assumption are made to process the available data for the valves, meters and house pressure regulators. First of all, some components are considered and judged on their hydrogen readiness, although dedicated investigation and testing is not completely finalised yet. So beyond that this makes it is difficult to assess the H2-readiness, it is also difficult to determine till what extend the introduction of hydrogen is responsible for the mitigation action in comparison to the continuous renewal of the infrastructure. The renewal process is expected to be intensified before hydrogen is injected as experiences with hydrogen in the system are rare and safety is at the first place. The following remarks can be made on the identified asset types:

- **Valves in lines:** Based on demonstration projects [19], where natural gas components are operated continuously and tested with pure hydrogen[6], it is expected that valves specified for natural gas are also suitable for H_2. However, risk assessments could lead to the situation that valve assets that are close to the end of their lifetime will be replaced if hydrogen is injected even though they are considered to be in at least temporary acceptable condition for natural gas. The corresponding measures can therefore not fully be considered to be initiated by hydrogen injection only. Therefore, it is assumed that at mixtures of 25 vol.-% H_2 and higher, 7.5% of the valves in lines will be replaced.
- **Diaphragm gas meters:** Diaphragm gas meters are considered to be suitable up to 20 vol.-% H_2[7] [20].
- **House pressure regulators:** It is assumed that house pressure regulators have to be replaced above 25 vol.-% H_2. However, research shows that these components can most likely be used at higher concentrations as well. Therefore, replacement above 25 vol.-% H_2 is considered for 7.5% of the installed house pressure regulators as e.g. receiving manufacturer approval especially for older types could be a difficult task in comparison to replacement.

An overview of the mitigation measures is given in Table 11.

	Hydrogen concentration / vol.-%							
	2	5	10	15	20	25	30	100
Valves in lines	No adaptation required					Partial replacement		
Diaphragm gas meters	No adaptation required					Individual assessment/ replacement		
House pressure regulators	No adaptation required						7,5% replacement	

Table 11: Mitigation measures for valves, meters and house pressure regulators.

[6] Preliminary findings of currently running testing at DBI laboratory.

[7] Marcogaz survey results show suitability of minimum 15 vol.% as expert guess, manufacturer information consider 25 vol.-%% as limit for accurate measurement.

6. PRESSURE REGULATION AND METERING STATIONS

6.1 Introduction

Gas pressure regulating and metering stations (GPRMS) are an essential part of gas transport systems as they allow network operators to keep track of, manage, and account for the natural gas moving through their networks. A gas metering station's primary function is to measure the flow of gas so that gas sellers may distribute and charge for consumption and distribution firms can manage the network.

6.2 Quantification of specific asset volumes for pressure regulation and metering stations

The GPRMS have been divided into four categories according to the pressure regime they are operated at. Each category contains a set of components that was specified by stakeholder and MARCOGAZ experts. Table 12 shows the calculated number of GPRMS for each pressure stage as well as the number of data points it is derived from. The volumes for GPRMS up to 40 bars have been derived from the survey of the distribution category. GPRMS with pressures up to 100 bars are more common in the gas transmission. It is worth mentioning that this pressure division is not strictly applicable to all European countries, but it is considered a feasible approach to distinguish between facilities with different complexity.

Pressure regime	Specific number (units / km)	Data points
GRRMS p <= 5 bar	0.0658	8+1
GRRMS 5 bar < p < 16 bar	0.0243	6+1
GRRMS 16 bar < p < 40 bar	0.0356	6+1
GRRMS 40 bar < p < 100 bar	0.029	5

Table 12: Specific volumes of GPRMS per pressure group.

Within the four pressure groups, the asset volumes have been identified as given in Table 13.

GPRMS group:	p <= 5 bar	5 < p < 16 bar	16 < p < 40 bar	40 < p < 100 bar*
Number of filters	2	2	2	x
Number of pressure regulator (incl. shut-off valve)	2	2	2 (shut-off valve separately)	x (shut-off valve separately)
Number of meters	1	1	2	x
Number of converters	1	1	2	x
Number of preheaters	-	-	2	x
Number of water safety shut-off valves	-	-	4	x
Number of separate safety shut-off valves	-	-	4	x
Number of process graph chromatographs (PGC)	-	-	0.1 (one per ten stations)	1

Table 13: Volumes of assets per GPRMS pressure group.

*These are complex plants with several outlets and/or consumers with various pressure and volume parameters. As a rule, all the above-mentioned fittings and devices are included in this system and sometimes multiplied many times over in their total according to the number of different outlets.

6.3 Mitigation measures

For each of the pressure groups, mitigation measures for the GPRMS are again identified depending on the hydrogen concentration. The results are shown in Table 14**Error! Reference source not found.**. A few remarks can be made on the identified measures:

- From H_2 admission of 2 vol.-% and more, PGC removal is needed if a PGC is installed.
- For concentrations up to 10 vol.-% H_2, it is assumed that no adoption is necessary unless a PGC is installed. This assumption is based on the fact that the changes to the physical properties of the gas mixture are minor and that the volume flow increase is minor, if the same energy through put is maintained.
- For concentration above 10 and up to 30 vol.-% H_2, the expected activities are focusing on approval and in some cases modification/recalibration of the metering devices. The capacity throughput of the regulators is about 94% and filter load about 130 % in comparison to natural gas at H_2 admission of 25 vol.-% [21]. These results consider an energy flow equal to pure natural gas service. As demand is expected to decrease over time, and as the effects are considered to be moderate, no explicit need for modification of the facilities is expected. This may be different for individual cases and can lead to additional costs.
  For stations above 16 bar, which are of more complex nature, some modification next to PGC and metering/converters are expected also for concentrations above 10 and up to 30 vol.-% H_2.
- Depending on the composition of other component in a natural gas – H_2 mixture with a H_2 concentration between 25 and 30 vol.-%, the explosion protection group is changing from IIa to IIb. It is assumed that by implementing further organizational measures, the potentially occurring risks can be minimized to such an extent that the replacement of the electrical equipment is not necessary.
- For 100 vol.-% H_2 mixtures; the renewal of filters, meters and possibly safety devices such as shut off valves are needed especially if the same energy throughput is envisaged leading to significant higher volume flows.
  For stations above 16 bar, additional measures are expected such as the removal of preheating systems, adoption of measuring lines due to a higher throughput and the installation of longer inlet section before metering systems.
  Finally for pure hydrogen, the explosion protection group IIc needs to be applied. It is assumed that by implementing further organizational measures, the potentially occurring risks can be minimized to such an extent that the replacement of the electrical equipment is not necessary. If this is not possible, technical changes are required concerning the selection/replacement of electrical equipment. Also, the adjustment of blow-out lines and other measures might be additionally needed. It is therefore an important task to develop organizational measures that avoid a change of the electrical equipment.

Table 14 summarizes the adjustments that may become necessary in relation to the different conversion variants.

	Hydrogen concentration / vol.-%							
	2	5	10	15	20	25	30	100
GPRMS p <= 5 bar	No adaptation required			Manufacturer and metrological approval of meters needed.				Renewal of meters, filters, maybe safety devices
GPRMS 5 - 16bar	No adaptation required			Manufacturer and metrological approval of meters needed.				Renewal of meters, filters, maybe safety devices
GPRMS 16 - 40 bar	PGC renewal			PGC renewal, manufacturer and metrological approval of meters and volume converters, partly modification				renewal of: PGC, meters, volume converter, filters and preheater removal, further complex modifications incl. Safety expected
GPRMS 40 - 80 bar	PGC renewal			PGC renewal, manufacturer and metrological approval of meters and volume converters, partly modification				renewal of: PGC, meters, volume converter, filters and preheater removal, further complex modifications incl. Safety expected

Table 14: Mitigation measures for GPRMS.

7. END USE EQUIPMENT

7.1 Introduction

In this final chapter, end use equipment is assessed to set a reference for the asset volumes and required mitigation measures at different hydrogen concentrations. Due to the wide variety of end use equipment, this chapter is divided into two subsections which asses the asset volume and mitigation measures directly. The following two subcategories are identified:

- **Domestic and commercial end use:** This mainly covers space heating and cooking.
- **Industrial end use and power generation:** This refers to installations that are used to generate heat for steam generation or for product treatment (e.g. melting, drying, heat treatment) and installation which use gas mixtures as feed stock.

7.2 Quantification and mitigation measures for domestic and commercial end use

In order to determine the specific asset volume, the THyGA-research project [22] has be used to summarize the number of different end use categories for domestic and commercial purposes such as heating and cooking. Table 15 **Error! Reference source not found.**shows the accumulated results of research into hydrogen tolerances for domestic and commercial appliances. The specific asset volumes are found from dividing the total European amount by the total grid size (TSO (225,000 km) + DSO (2,245,993 km) grid = 2,470,993 km) [2, 3, 14, 15]. The assets are divided into four categories, namely:

- Atmospheric burners: mainly cooking appliances, gas fireplaces, barbecues
- Premixed/partially premixed burners: e.g. heating appliances
- Radiant burners: e.g. dark radiators for heating purposes
- Other: e.g. fuel cells

In general, it is expected that most appliances can cope with 20 vol.-% H_2 in natural gas. When further increasing the hydrogen concentration to 20-30 vol.-% H_2 range, the equipment is expected to stay operating, although a few premixed or atmospheric appliances may experience flashback problems. These appliances may therefore need to be adapted. For 100 vol.-% H_2, it is very likely that the existing appliances will require replacement. Therefore, new designs will be needed to replace current generations of appliances when operated with pure hydrogen.

			ADAPTATION MEASURES FOR DIFFERENT HYDROGEN SHARES [22]			
Type	**Volume per km [22]**	**Average Age**	**2 - 10 %**	**15 - 20 %**	**20 - 30 %**	**100 %**
Atmospheric (including all cookers)	37.72	20	No measures needed	No measures needed for most of installed appliances	Flash back risk increasing	New design needed
Premix / Partial premixed	54.52	20	No measures needed	No measures needed for most of installed appliances	Flash back risk increasing	New design needed
Radiant	0.81	20	Missing data/ not enough available knowledge			New design needed
Not burner based (eg. fuel cells heating appliances)	0.051					Varies from retrofit to new design

Table 15: Specific asset volume and adaptation measures for domestic and commercial appliances for different hydrogen levels.

7.3 Quantification and mitigation measures for industrial end use and power generation

Within the subcategory *industrial end use and power generation* there is a wide range of components, processes, products and performance levels, and a large number of small and medium-sized manufacturers as well as large corporations. Due to this large number of different plants and product types, with again a large diversity of plant layouts and process steps, it is currently not possible to oversee the necessary adaptations for industrial plants as a whole. Nevertheless, this subsection gives an overview of the most significant mitigation measures that could be identified by MARCOGAZ experts.

For lower hydrogen contents (up to 20 vol.-% H_2) in industry, it is expected that it is be possible to adapt or implement combustion control systems. It may also be necessary to adjust other factors of individual production steps. For higher hydrogen contents, it may be inevitable to retrofit the entire plant or even each individual production step [23].

For power generation equipment, the following statements refer to adaptability in general:

- Most gas turbines are adaptable to higher hydrogen blends. The percentages can vary between 5 and 20 vol.-% H_2, depending on age and manufacturer. Newer gas turbines are reported to be capable of up to 40% hydrogen with a combustion chamber upgrade [24].
- For 100 vol.-% H_2, it is expected that new gas turbines are required [24].
- Adaptation to gas engines for up to 20 vol.-% H_2 is easily possible for almost all manufacturers, mainly with software updates. In some cases retrofitting is necessary.
- Retrofitting gas engines to run on gas mixture up to 100 vol.-% H_2 is only possible in some cases. However, this requires the fuel injection system to be converted to direct injection without premix chambers [25, 26].
- Gas-fired boilers for steam or hot water production are mainly equipped with forced draught burners. These can in most cases be adapted to 20 vol.-% H_2, and sometimes even more. These typically require changes in combustion control and air/fuel ratios [23, 27].
- For 100% applications, new burner designs and changes in combustion and flame control are required [28].

8. COST ESTIMATION OF HYDROGEN ADMISSION APPLIED ON EUROPEAN LEVEL

In this chapter, a brief overview is given when the methodology is applied on European level. In doing so, the European averages values, as introduced in this document, are used and extrapolated with the size of the existing European gas infrastructure. Cost estimations for the mitigation measures are included for the key hydrogen concentration from which the total cost for hydrogen admission into existing natural gas infrastructure and end use could be derived. The results are compared (in %) to the estimated cost of constructing a new hydrogen gas grid in Europe. The outcomes are given in Table 16 and Figure 2.

	Adoption cost in % according to hydrogen concentration								
	2 vol.-%	**5 vol.-%**	**10 vol.-%**	**15 vol.-%**	**20 vol.-%**	**25 vol.-%**	**30 vol.-%**	**100 vol.-%**	**New build H_2 infrastructure**
Total adoption costs compared to new build H_2 IS in % without end use	0.3	0.7	1.1	2.0	2.1	8.0	8.0	19.0	100
Total adoption costs compared to new build H_2 IS in %	0.2	0.5	0.8	1.5	1.5	9.8	9.8	40.5	100

Table 16: Relative cost for hydrogen admission into existing natural gas infrastructure and end use on European level compared to construction of new build infrastructure.

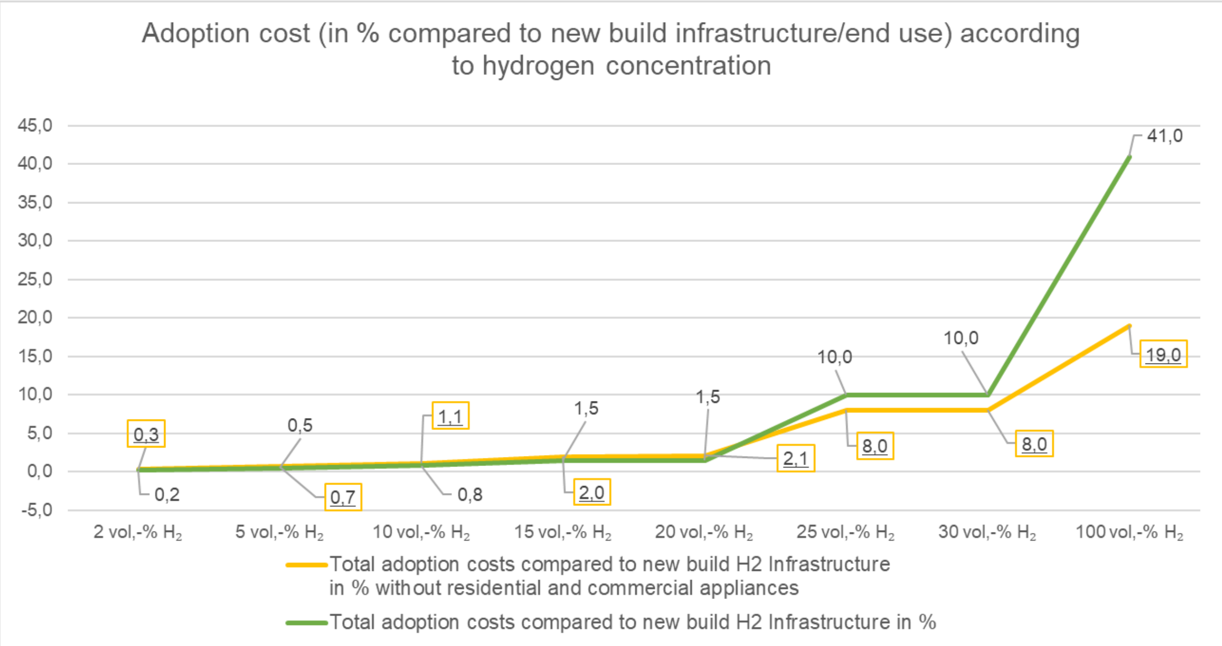

Figure 2: Relative cost for hydrogen admission into existing natural gas infrastructure and end use on European level compared to construction of new build infrastructure.

From the results, the following statements can be derived on the transformation cost for hydrogen admission into existing natural gas infrastructure and end use on European level:

- For the admission of gas mixtures up to 10 vol.-% H_2, the total transformation cost is less than 1% of CAPEX for a new build infrastructure.
- For the admission of gas mixtures up to 30 vol.-% H_2, the total transformation cost is less than 10% of CAPEX for a new build infrastructure.
- For the admission of pure H_2, the transformation cost is less than 20% of CAPEX for new build H_2 infrastructure when residential and commercial appliances are not included.

9. CONCLUSION

In this document, a methodology description has been given to estimate the cost of hydrogen admission into existing natural gas infrastructure and end use equipment. With this methodology, MARCOGAZ aims to support stakeholders in efforts of hydrogen admission into existing infrastructure, and thereby remove barriers for the introduction of a renewable energy carriers in Europe. To generate a clear picture, gas infrastructure and end use equipment were evaluated for their H_2-tolarence at the key concentration: 2, 5, 10,15, 20, 25, 30 and 100 vol.-% H_2 and the corresponding adaptation measures were given. The presented method and figures have been thoroughly discussed by industry stakeholders and MARCOGAZ experts.

A general approach was introduced, revealing four steps to determine the overall cost. The steps are given in logical order. Starting with the quantification of the asset volume, followed by the evaluation of the asset volume where the hydrogen readiness and required mitigation measures are identified for the different asset types. In the third step, the specific costs for the mitigation measures are determined and finally, the overall costs can be calculated in the fourth step from the previous three steps.

From this work, it follows that the segments in the mid- and downstream gas industry can be divided in five categories to determine the overall costs. The categories are: Transmission, Distribution, Underground Gas Storage Facility, Pressure Regulating and Metering Stations, and finally, End Use. The first two steps of the general approach, quantification and evaluation, are described in more detail in separate chapters of this document.

Although this work provides a strong framework and includes information on the size and readiness of gas infrastructure, the methodology description does not include any figures related to the costs of the introduction of hydrogen. The cost estimation is a complex process as prices depend on many variables and can vary largely within Europe. Therefore, no assumptions on costs are given in this specific work.

Nevertheless, in the final part of this work, the relative costs (in % compared to the cost of new construction) are briefly shown when the methodology is applied on European level. This revealed that the cost for hydrogen admission into existing natural gas infrastructure is depended on the vol.-% H_2 concentration and that even for pure H_2 admission, the cost are below 20% of the cost for the development of a new grid when end use equipment is not included. The results are based on values given in this work and an average cost approximation on European level is used. The situation in single countries might therefore be different. Beside that these results show the financial advantages of transforming the existing infrastructure, this will also lead to a faster establishing of a H_2 ready infrastructure with less negative effects on the environment and lower carbon footprint.

The transformation of the existing gas infrastructure is expected to be realized quickly. For the injection of low hydrogen concentrations as currently foreseen e.g. in the EASEE gas guidelines, no or only marginal adaptation measures are expected in the vast majority of gas infrastructure elements. In particular, hydrogen blending up to 10% by volume leads seems a realistic option from the limited required mitigation measures. Hydrogen blending is therefore a very attractive option to initiate an international H_2 trade and supports the required value chains.

As a final remark, an improvement of the data situation on gas asset volumes in Europe might contribute to more clarity on the readiness of the European gas grid for hydrogen admission . Nevertheless, the chosen methodology, assumptions and estimates by stakeholder and MARCOGAZ experts provide a solid basis for estimating the transformation costs of the gas infrastructure.

ANNEX I: DETAILLED MITIGATION MEASURES FOR UGS

Table 17 gives a more detailed overview of the identified mitigation measures for UGS asset.

Component	Comment / measures
Compressors	**Piston compressors**: need to be checked for material suitability, eventually change of lubricants. Function of piston compressors is not hindered by hydrogen (-blends). **Turbo compressors**: according to Adam et al. [28], operation for hydrogen blends up to 10 vol.-% is possible without any adjustments. Up to 40 vol.-% hydrogen blends require adjustments in the compressor, higher shares of hydrogen require a complete replacement. The power consumption of both, piston and turbo compressors increases significantly[8] when blending hydrogen to a degree of ca. 25 vol.-%, before it gradually decreases and reaches a lower level at 100 % hydrogen than with natural gas[9]. Material suitability a general pre-requisite for any compressor.
Compressor drives	**Gas engines**: suitability in analogy to piston compressors. **Gas turbines**: suitability in analogy to turbo compressors, but with a need for modification already at 5 vol.-% hydrogen blends. Reason here is the significantly increased power consumption of the compressor beyond 5 vol.-% hydrogen, that the engine must provide. **Electrical engines**: completely suitable, since this type of engines does not operate with the medium hydrogen itself. Power output might be a limiting factor, in particular at ca. 15 vol.-%, what can be mitigated by reduced rates (see also footnote 1).
Coolers	Generally suitable as long as the material is suitable. Up to a level of 25 vol.-% hydrogen blending, increased cooling power (at the same discharge and cooling temperatures) is expected. For 100 % hydrogen, power requirement is lower than for natural gas.
Separators	Generally suitable as long as the material is suitable. In analogy to pipeline materials, a share of up to 5 vol.-% hydrogen is considered not critical, up to 10 vol.-% material suitability needs to be examined in detail, and for higher H_2-concentrations adoptions are required (e.g. inner coating).
Gas Drying	Above 5 vol.-% of hydrogen blending, material suitability needs to be evaluated and adjustment measures might become necessary. The functionality of the dryers is not effected by the hydrogen concentration. Deciding point is the moisture: up to 40 mg/Nm^3 hydrogen, TEG (i.d. absorption drying) is suitable, beyond that only adsorption can be used [12].
Desulphurization	Material suitability must be granted; in terms of functionality, the amount of H_2S is deciding. Operating principle is the same as absorption drying.
Flow Metering	Flowmeters normally used in transmission grids (turbine and ultrasonic meters) can be operated with H_2 up to 30 vol.-%.

[8] It can be estimated that for the same inlet and discharge pressure and at the same volumetric flow rate, a ca. 50 % increased power consumption is required at ca. 25 Vol.-% hydrogen blending. This effect can be mitigated by reducing the volumetric flow rate. In contrast to grids, UGS compressors are not required to operate constantly / continuously throughout the year, but only temporarily until the UGS facility is fully filled with the storage medium. Thus, a reduced volumetric flow rate to decrease the power demand, does not result in malfunction of the compressor, but only in a prolonged injection time. DBI own assessment, for reference see our practical training program for underground hydrogen storage.

[9] It can be estimated that for the same inlet and discharge pressure and at the same volumetric flow rate, only 60 % of the compression power required for natural gas is required. DBI own assessment, for reference see the DBI practical training program for underground hydrogen storage.

Component	Comment / measures
	The bias in some specific meter types could be significant for fiscal measurement purposes carried out on large metering stations, for which high quality (very low uncertainty) measurement is required. For this reason, some manufacturers ask their costumers to contact them before using existing gas meters for applications with H_2 blends higher than 10 vol.-%. Anyway, some new gas meters have already obtained their metrological certification for applications up to 30 vol.-% H_2 [7].
Piping (SF and Field Pipelines) and Fittings	Here, distinction into H_2-suitable and not H_2-suitable is made. For not suitable material, a tolerance of 5 vol.-% hydrogen blending is made in analogy to the gas grids. Examples for 100 % hydrogen suitable materials are: P460 NL, P460 QH, L360 NB, L415 (ISO 3183) / X60 (API 5L) [12]. Besides the material itself, pressure levels and flow velocities must be considered. Both are adjustable via flow rate regulation.
Glykol vessels	Generally suitable as long as the material is suitable. In analogy to pipeline materials, a share of up to 5 vol.-% hydrogen is considered not critical, beyond that material suitability needs to be examined in detail, and adoptions are required (e.g. inner coating).
Flares and Burners	Up to 5 vol.-% of hydrogen blending, no adjustment is considered to be necessary. Beyond that, material suitability must be examined and Ex-zones re-calculated. Further, the fuel gas consumption for burners is increased according to calorific value.
Tubings, Packers, SSVs	Here, distinction into H_2-suitable and not H_2-suitable is. For not suitable material, a tolerance of 5 vol.-% hydrogen blending is made in analogy to the gas grids. A detailed examination might result in the proof of suitability for regular API grades and standard equipment, however currently no supplier grants such. Field experiences show however, that at least up to 20 vol.-% hydrogen blends, standard API materials (e.g. J55, K55) are suitable.
Wellhead	Here, distinction into H_2-suitable and not H_2-suitable is made. In case of wellheads the justifications for this distinction is that there are suppliers available at the market declaring their equipment H_2-suitable [29], however, such components are not installed at every UGS facility. A survey among UGS operators in Germany concluded that such H_2-suitable wellheads are not widely installed yet.

Table 17: Summary of adjustment measures for UGS components.

10. REFERENCES

This assessment is based on public and non-public information R&D projects, Codes & Standards as well as manufacturer and MARCOGAZ member expertise.

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[2]	ENTSOG: Ten-Year Network Development Plan (TYNDP) – Infrastructure Report, 2018.	Public (Freely available)	Report	EN
[3]	European Gas pipeline Incident data Group (EGIG): 11Th EGIG Report, December 2020.	Public (Freely available)	Report	EN
[4]	DVGW: Project SyWeSt H2: Investigation of Steel Materials for Gas Pipelines and Plans for Assessment of their Suitability with Hydrogen, 2023.	Public (Freely available)	Report	EN
[5]	Expert discussion Marcogaz TF H_2 2021-2023	Non-Public	Communication	EN
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[7]	H2GAR/ DNV, Paper 12 *JIP renewable gases; results on performance of turbine and ultrasonic flow meters up to 30% Hydrogen and 20% CO2*, Proceeding of the North Sea Flow Measurement Workshop, October 2021	Non-Public	Paper	EN
[8]	Fluxys: Conversion of compression station for hydrogen – Cost study, 2022.	Non-Public	Report	EN
[9]	Jens Mischner und Peter Schley: System- und netzplanerische Aspekte der Wasserstoffeinspeisung in Erdgasnetze – Teil 1, gwf-Gas|Erdgas, 1-2/2015.	Public (Purchasable)	Paper	DE
[10]	GIE: Storage Database, 2021.	Public (Freely available)	Database	EN
[11]	WOC 2 UGS Report SG 2.1: European UGS facilities in operation. Based on Presented at 27th IGU WGC 2018, Washington DC. Actuality: 2016/17.	Public (Purchasable)	Report	EN
[12]	Bültemeier et al. (DBI Gut, INES, BVEG, DVGW): Wasserstoff speichern – soviel ist sicher, 2022.	Public (Freely available)	Report	DE
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[15]	MARCOGAZ: Survey on Methane Emissions 2017	Non-Public	Report	EN
[16]	Umwelt Bundesamt: National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2020, 2020.	Public (Freely available)	Report	EN
[17]	Sedigas: Study of the possible effect of the joint conduction of natural gas/hydrogen on the mechanical resistance of gas pipelines made of ductile cast iron, UPC, 2022.	Public (Freely available)	Report	ES

	Reference	Accessibility	Source Type	Lang.
[18]	DVGW: Technische Regel für Gasinstallation(TRGI)-G600, 2018.	Public (Purchasable)	Standard	DE
[19]	MITNETZ Gas: Forschungsprojekt HYPOS: H2-Netz, 2019.	Public (Freely available)	Project	DE
[20]	Honeywell: Suppliers declaration, Declaration-no. and Revision: Elster H2 BGZ r02.	Non-Public	Communication	EN
[21]	Jens Mischner und Peter Schley: System- und netzplanerische Aspekte der Wasserstoffeinspeisung in Erdgasnetze – Teil 2 page 159/160 , gwf 1-2/2015.	Public (Purchasable)	Paper	DE
[22]	Testing Hydrogen admixture for Gas Applications (THyGA): WP3, Intermediate report on the test of technologies by segment - Impact of the different H2 concentrations on safety, efficiency, emissions and correct operation, 2023.	Public (Freely available)	Report	EN
[23]	Pietsch, Ph.; Wiersig, M.: The influences of hydrogen in thermoprocessing plants, Prozesswärme 01/22, p. 33 ff.	Public (Purchasable)	Paper	EN
[24]	EUTurbines, H2 Ready Power Plants: H2-Readiness of Turbine based Power Plants, September 2021.	Public (Freely available)	Definition	EN
[25]	Frank Grewe, 2G: Use of hydrogen in gas engines over 100 kW, Grüne KWK – Dekarbonisierung hocheffizienter KWK-Anlagen, 15.03.2023 Magdeburg.	Non-Public	Paper	EN
[26]	Dr. Marco Schultze, Caterpillar Energy Solutions GmbH: Use of hydrogen in gas engines over 1 MW, Grüne KWK – Dekarbonisierung hocheffizienter KWK-Anlagen, 15.03.2023 Magdeburg.	Non-Public	Paper	EN
[27]	Joint research project reCoCon – Green Combustion ControlTeilprojekt 2 in der Leittechnologie „TTgoesH2“, Förderkennzeichen: 32 LBG, Projektträger / Fördermittelgeber: AiF / BMWi (IGF)	Non-Public	Project	DE
[28]	P. Adam, F. Heunemann, C. von dem Bussche, S. Engelshove und T. Thiemann: Hydrogen infrastructure - the pillar of energy transition: The practical conversion of long-distance gas networks to hydrogen operation, 2020.	Public (Freely available)	Paper	EN
[29]	Hartmann: Wasserstoff-Prüfungen, 2023.	Public (Freely available)	Communication	DE

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Thank you!

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COFFEE BREAK

VI. Presentations of the Standing Committees SCGU&H2+

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Technical Association of the European Gas Industry

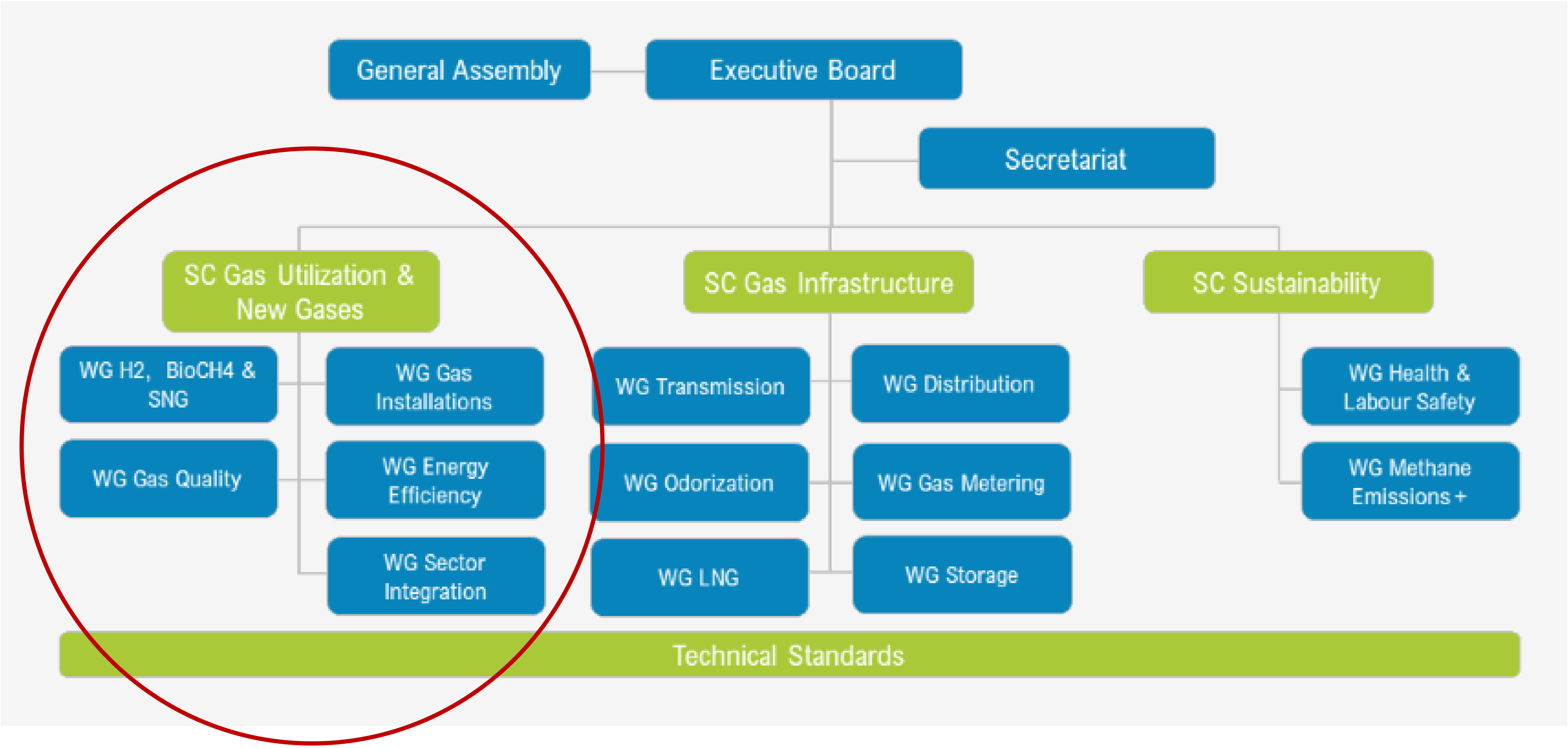
Executive Board

Reporting on activities

Frank Graf and Kris De Wit, Co-Chairs of the SCGU&H2+

EB – 13th of Sept 2023

Gas Utilization & New Gases



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Gas Utilization & New Gases : WG H_2, $BioCH_4$ & SNG

New Marcogaz project

Scope

- study on technological and gas infrastructure related aspects as well as the climate impact of new gases

Structure

- analysis of existing studies on new gases (e.g. IRENA)
- definition of topics for detailed examination (e.g. terminals, gas infrastructure, gas quality)
- elaboration of Marcogaz related work items with experts from different WGs

Kick-off meeting

- 25th May online

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Gas Utilization & New Gases : WG H_2, $BioCH_4$ & SNG

PROJECT TEAM	
Attikis	**PSG**
➢ Dionysopoulos Panayiotis	➢ Katarzyna Polarczyk
➢ Ioannis Tsiblakis	➢ Michal Szpila
DVGW	➢ Andrzej Żero
➢ Christiane Staudt	**Sedigas**
➢ Frank Graf	➢ Fernando de Los Riscos Garcia
Enagas	➢ Marlene Steppeler
➢ Antonio Gomez	➢ Ana Belèn Rubio de Santos
France Gaz	**Synergrid/Gas.be**
➢ Nicolas Lafortune	➢ Simon Cauwe
Gasunie	➢ Quentin Degroote
➢ Peter Van Wesenbeeck	➢ Olivier Thibaut
Marcogaz	
➢ Francesco Arena	

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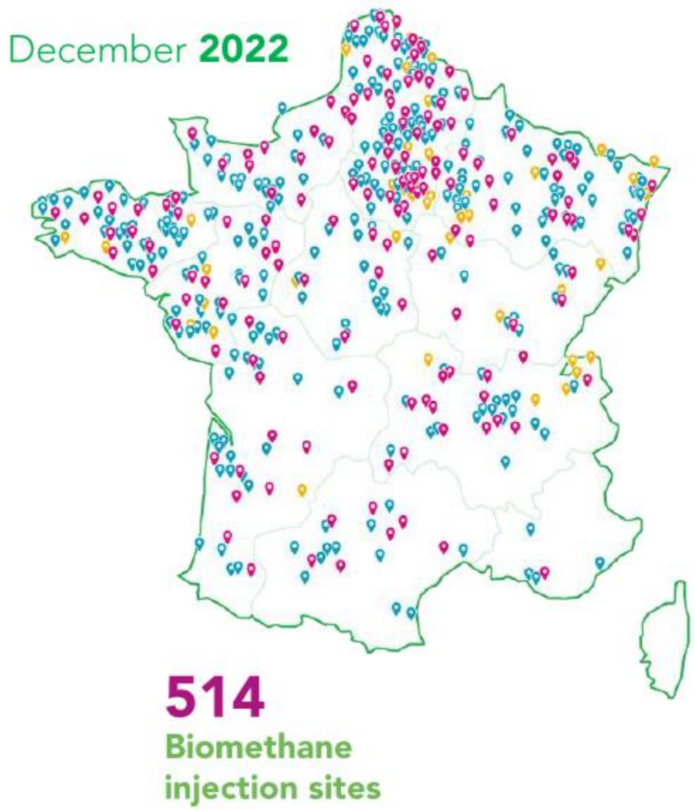
Gas Utilization & New Gases : WG H_2, $BioCH_4$ & SNG

Project meeting 19th July

- Presentation of Etienne Goudal (GRDF)
  - Scenarios and perspective of new gases in France
  - Overview on projects
- Presentation of Christiane Staudt (DVGW-EBI)
  - Ship-based import options for hydrogen and derivatives
  - Assessment based on different parameter (e.g. energy demand, TRL, infrastructure needs)
- General discussion on further activities
  - Future of existing LNG terminals
  - Gas quality aspects for hydrogen pipelines
  - Country-specific activities in other Marcogaz member countries

Next meeting: 29th September



Source: GRDF

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Gas Utilization & New Gases: WG Gas Quality

- *Last meeting on 25/05, next one on 26/09*

- *CEN-MARCOGAZ liaison*
  - J. Lana participating in CEN/TC234 WG11 & CEN/TC408 meetings
    - Notes of meetings available for WG members in MARCOGAZ intranet

- *Harmonization of gas quality*
  - Standard EN16726:2015: Gas quality H-gas
    - CEN TC234/WG11 meeting on 18th July
    - First draft for public consultation ready in August 2023
      - Public consultation will be launched to NSB in November, with 12 weeks for comments.
    - Proposal included for all the quality parameters, although several of them are still under discussion in WG11.
      - It is expected that comments received during public consultation will help to close the gaps and will improve the standard.
      - Wobbe index: inclusion of class system proposed by CEN SFGas GQS WG
        - Different views for TSO/DSO and some end users organizations

  - *MARCOGAZ LNG quality in Europe data base*
    - Starting of activity pending of participation of enough LNG terminals to have a wide set of data and being fair with the ones suppling data
      - To be decided in next meeting

- *Hydrogen*
  - *CEN/TS 17977 Gas infrastructure – Hydrogen used in rededicated gas system* approved by 91.7 %
    - Publication expected by 30th October 2023

Gas Utilization & New Gases : WG Energy Efficiency

- *Ecodesign recast*
  - a position paper on revision of Ecodesign for central heating appliances and water heaters was written by the WG EE members → link
  - position paper has been approved by the Executive Board (meeting 01/06/23) as such for external communication in the concerned regulatory framework
  - a technical meeting on the ecodesign and energy labelling of space heaters took place on 12th of June → Marcogaz represented by B. Magneux (GRDF), F. Arena (Marcogaz), S. Rossato (France Gaz) and P. Milin (Engie)

- *EPBD recast*
  - trialogue discussions started on 6th of June
  - followed by several technical meetings (4th, 5th, 17th and 19th of July)
  - final text expected by the end of this year

- *EED recast*
  - final text published in July

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Gas Utilization & New Gases : WG Gas Installations

- Last meeting : March 15th // Next meeting : Oct 5th (BXL)

- *Setting up Marcostat to collect data for :*
  - EGAS C data (accidentology)
  - Maintenance of appliances – Methane emissions

- *Maintenance of appliances – Methane emissions*
  - Currently no regulatory work at EC level on this key issue, but considered important to be prepared
  - CH4EU Project presentation on gas end uses methane emissions by J. Schweitzer (DGC) on 11th of Sept

- *Blend NG/H2 and H2 issues*
  - interest in sharing any possible issues regarding the existing experiments

- *CLASP on cooking appliances*
  - Active monitoring of the subject and CLASP publications: new report with in-situ measurements was announced for summer but no news yet

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Gas Utilization & New Gases : WG Sector Integration

Minor update only

- First meeting on 21st of Apr with only 4 participants (BE, ES, IE and CH)
- Requesting *more participants* ⇒ meeting foreseen with Marcogaz secretariat to find ways to increase the number of members and diversify origin
- Targeting policy makers but also valuable knowledge for industry and other stakeholders
- No precise way forward established (yet) → need for co-construction
- No discussion (yet) on possible collaborations with e.g. GERG and ERIG
- Preliminary list of issues identified by the group:
  - Explore aspects related to *geological H_2 storage at different scales*
  - Study the *role of pipelines* (compared to electricity cables) in transporting energy from off-shore wind plants to onshore distribution and usage points (e.g. industrial sites near harbors and others)
  - Analyze *sector coupling of NG and electrons through H_2* → how will the installation of electrolyzers concretely happen within an integrated planning at both local and national/international scales ?
  - Understand the *interplay between energy efficiency measures and sector coupling* to mitigate costs

Gas Utilization & New Gases: Standing Committee

- last meeting on 24th of May // next meeting on 9th of Oct
    - main takeaways of last meeting already presented at EB of 1st of June
    - EU public consultation on action plan for accelerated roll-out of heat pumps in Europe → answered to questionnaire incl. upload of a position paper
      → position paper "published on Marcogaz' website
    - CEN liaisons:
        - SFG-U : next meeting on 20/09
        - TC 238 on test gases, test pressures and appliance categories:
            - next meeting on 18/09
            - WG1 working on including H2NG blends
        - TC 109 on central heating boilers: next meeting on 26/10

VII. Administration and Secretariat

Update on Secretariat

I. Outboarding of Personnel – for information

II. Onboarding of Personnel – for information

III. Upcoming recruitment of technical profile – for information

IV. Status of Budget 2023 (following slide)

VII. State of Budget of 2023 as of 31/08/2023

	Approved Budget (15/12/2022)	Received / Paid (as of 31/08/2023)	Expected (01/09 to 31/12/2023)	TOTAL Projection
INCOME	€ 594 (000)	€ 616 (000)	€ 18 (000)	€ 634 (000)
EXPENSES	€ - 668 (000)	€ - 444 (000)	€ - 214 (000)	€ - 658 (000)
TOTAL PROFIT/LOSS	€ - 74 (000)	€ 172 (000)	€ - 196 (000)	€ - 24 (000)

AMOUNT AVAILABLE AT BANK (€ 1 618 000):

€ 117 (000) AT CURRENT ACCOUNTS
€ 101 (000) AT FLEXIBLE DEPOSIT
€ 1 400 (000) AT FIXED TERM DEPOSIT (3M & 11M)

VIII. Communications & Liaisons

Communications

- The next MARCOGAZ Tech Forum on *'Cost Estimation of Hydrogen Admission into Existing Natural Gas Infrastructure and End-Use',* based on the document elaborated by the TF Hydrogen, is aimed to take place during the European Hydrogen Week 20-24 November.
- The new Annual Report 2022-2023 is being prepared and it is aimed to be published by February 2024 for distribution.
- The 55th MARCOGAZ Anniversary Conference & Gala Dinner took place last 22 June 2023 and communications related to the anniversary year of MARCOGAZ will continue until December 2023.
- MARCOGAZ will continue partnering and participating in relevant energy-related events on the second half of 2023.

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Liaisons

- MARCOGAZ will participate in the Stakeholder Council of EURAMET and strengthen our work conducted in the WG Metering.
- The WG Gas Metering is being represented in two technical working groups of WELMEC.
- MARCOGAZ will be participating in the upcoming annual meeting of GIIGNL in November.
- MARCOGAZ plans to participate in the following upcoming European Commission Forums:
  - Stakeholder Forum IV: heat pumps action plan (09/10/23)
  - 15th Citizens Energy Forum (09/11/23)
  - European Hydrogen Week (20-24/11/23)
  - Carbon capture, utilisation and storage Forum (27-28/11/23)

IX. Dates of next meetings

Dates of Next Meetings/Events

13 Dec. 2023:	Executive Board Meeting in Zurich, Switzerland
	Welcome dinner the night before (12 Dec. 2023)
13 Mar. 2024:	Executive Board Meeting in Dublin, Ireland
	Welcome dinner the night before (12 Mar. 2023)
17 June 2024:	Executive Board Meeting in Hamburg
17 June 2024:	General Assembly in Hamburg
	Welcome dinner (jointly with EGATEC 2024)
18-19 June 2024:	EGATEC 2024 in Hamburg

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X. AOB