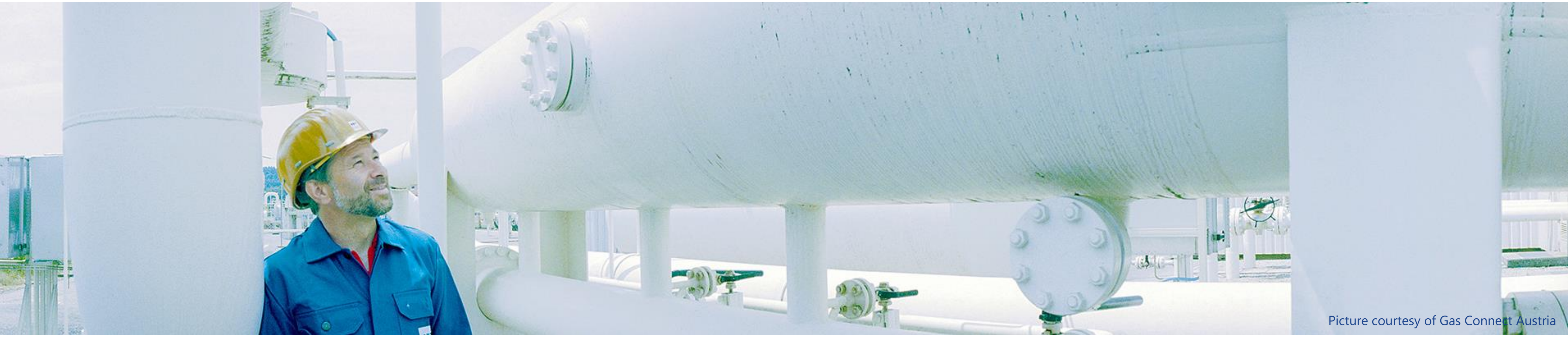


Picture courtesy of Gas Connect Austria

Prime movers' group on Gas Quality and H_2 handling

#3 meeting, 25 November 2020 (10:00 – 13:30 CET)

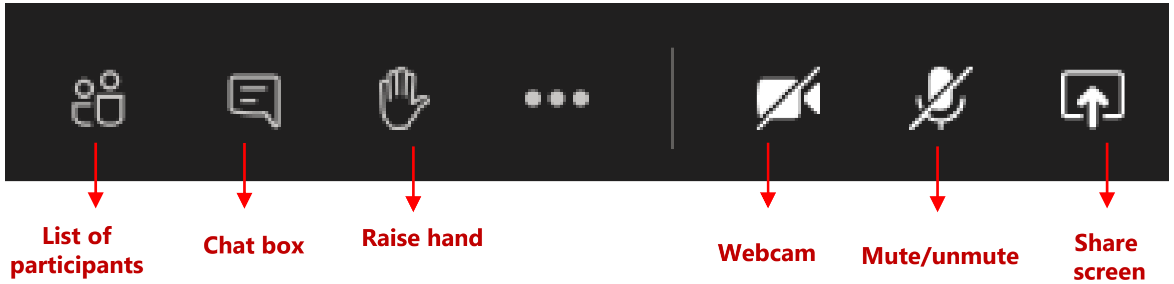
Online

Disclaimer

The information included in this presentation is subject to changes. The proposals are presented for informative purposes only since the work is still in progress.

The organisation is not liable for any consequence resulting from the reliance and/or the use of any information hereby provided.

Housekeeping



General:

- Please **mute your microphone** during the session
- Please **do not use the webcam** function since this can affect the stability of call
- Please do **not connect via multiple devices**, as this will overload the Microsoft Teams tool
- If you dialled into the meeting, please **press *6 to mute/unmute**

Posing questions/interventions:

- **New!** For questions, **join at slido.com #7755**
- Use the **raise hand** feature to ask for **interventions**
- When questions are left unanswered, the meeting organisers will answer by email

Agenda

Agenda

01	Welcome and introduction	**10:00 – 10:10**
02	Take-aways from last meeting	**10:10 – 10:20**
03	Presentation of answers - Stakeholders intervention	**10:20 – 12:40**
04	Conclusions from assessment exercise	**12:40 – 12:50**
05	Identification of potential solutions	**12:50 – 13:10**
06	Next steps and way forward	**13:10 – 13:30**

Welcome and introduction

Around 40 organisations have joined

Appliances/applications & Industrial/commercial/residential users

Euromot	EASEE-gas	GERG	IFIEC	NGVA
EU Turbines	COGEN	GWI*	Cerame-Unie	Afecor
ETN	Euramet	ERIG	EFET	Hydrogen Europe
CECOF	Eugine		Eurelectric	CEFACD
Marcogaz	Farecogaz		CEFIC	EHI

EC
ACER
CEER
CEN/CENELEC
Energy Community
FCH JU

System operators

Eurogas DIST	Hydrogen Europe
CEDEC	EASEE-gas
GD4S	Marcogaz
GEODE	GERG
ENTSOG	GIE

Shippers/gas producers

EBA	Eurelectric
EFET	Hydrogen Europe
IOGP	EASEE-gas
Landwärme	
Eurogas	

*GWI is an independent and neutral research organisation focusing on applied research in the use of gaseous fuels, with members from all parts of the value chain. J. Leicher joins the prime movers' group as expert on gas quality issues due to his contributions and involvement in the CEN process regarding the WI.

Take-aways from last meeting

Key messages

Most of the issues are related to **fluctuations in gas quality**, the difficulty in forecasting H2 volumes, and finding ways to mitigate these variations, **stability** of the blend, **costs** associated, lack of clarity regarding **liabilities**, and **increased complexity** for cross-border coordination

Potential mitigation solutions referred to: development of proper **forecasting systems**, update **interoperability rules**, assessing the possibilities of implementing near **real-time data provision**, need to increase cooperation among parties, upgrade of **metering and tracking equipment**, control systems for end-users, and the development of appropriate control units

Regarding dedicated H2 networks, the issues provided by the attendees referred mostly to **safety** concerns, lack of **regulation** and **purity** specifications

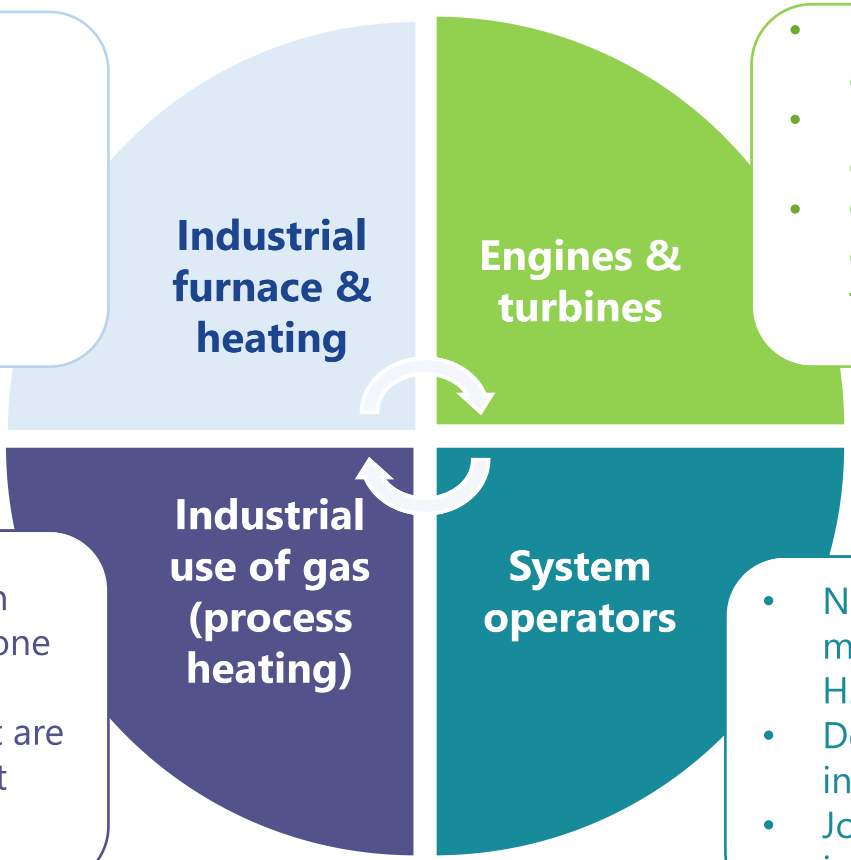
A **'whole system planning'** where all parties from the gas vale chain are involved was appointed to be one of the key points in finding a way forward for the dedicated H2 network while ensuring timely involvement of companies from outside the EU

Avoid an unbalanced situation since the **industry faces international competition** that might be negatively impacted

Lack of in-depth **data about the sensitivity** of the different technologies concerning H2 and gas quality variations

Stakeholders’ views (in a nutshell)

- Risk of unstable blends (CV, WI, flame)
- Impact product quality and emissions
- R&I needed about impact ‘pure’ H2 on safety, equipment and product



- Plants can run with all sort of gases, but cannot accept different type of gases at the same time
- Ideally all EU should have a common gas quality
- Gas turbines manufacturers have committed to deliver products that can deal with 20% H2 and to offer retrofitting solutions existing installations

- The main concern is gas quality variation and the use of a fuel different from the one systems were designed and adjusted for
- Technological solutions are available but are expensive and need tailoring to different applications & processes

- Need to discuss jointly about potential tools for mitigation (i.e. storage, methanisation, alternative H2 to plan the loads, etc.)
- Define stability criteria for the percentage of H2 into the blending
- Joint approach between operators and producers is needed to manage stability of H2

Stakeholders' intervention

Stakeholders' intervention

Session 1: ENERGINET* nationalgrid* CEER Council of European Energy Regulators

Session 2: afecor ehi association of the European Heating Industry gwi Gas- und Wärme-Institut Essen e.V. DBI*

* These organisations were invited to present due to their experience and knowledge of the topics discussed within this group, although they are not part of the prime movers' group

Session 1: Energinet, National Grid, CEER

ENERGINET

GAS QUALITY & H2 HANDLING AT INTERFACES

Prime movers' group on gas quality & H2 handling

25 November 2020

Jens Sørensen (jsv@energinet.dk)
Martin Graversgaard (mgn@energinet.dk)

ENERGINET

PRIME MOVERS’ GROUP ON GAS QUALITY & H2 HANDLING

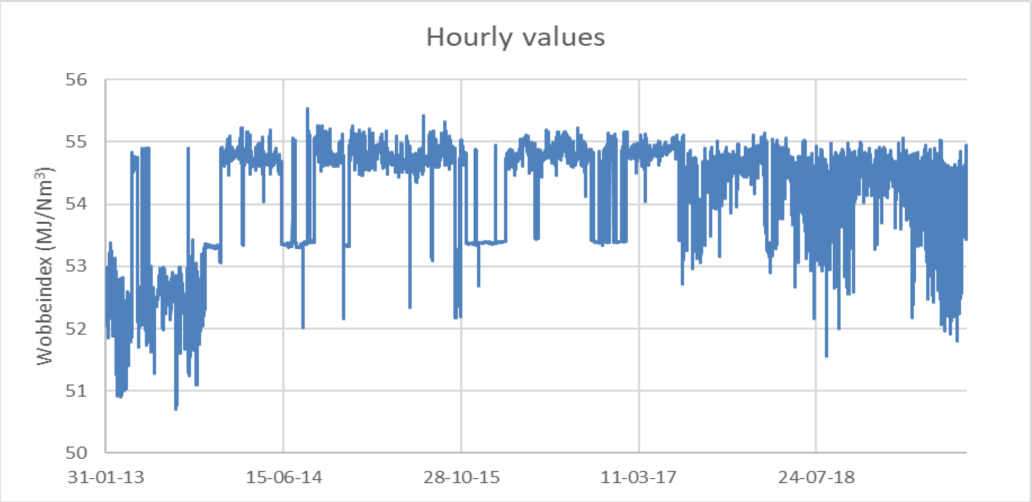
Content

- Provision of information at exit points
  - TSO-DSO, TSO – Direct Customers
- Allowing off-spec gas to enter grid if on-spec blending is possible
  - Upstream – TSO
- Handling of off-spec gas at interconnection point
  - TSO-TSO

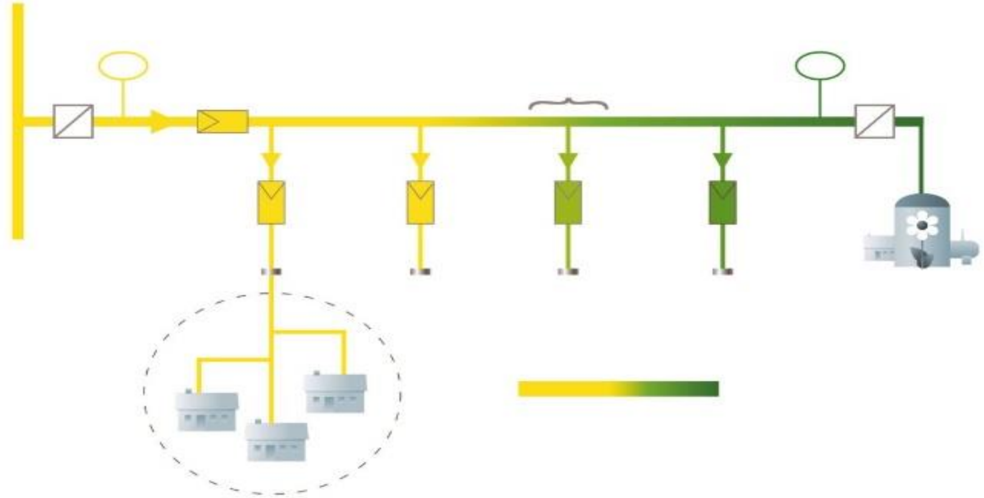
Baltic Pipeline Project November 2020

PRIME MOVERS' GROUP ON GAS QUALITY & H2 HANDLING

Provision of information at exit points



*Wobbe index 25/0



Energinet as a TSO holds data for all exit and entry point and monitors variation in gas quality.

Problem: Gas quality variation can affect end user applications and occur differently dependent on geographical position and time

Need: Consumers benefit of having information about the gas quality they receive

Solution: Open source data about gas quality to provide user information and create a dialogue based on real data

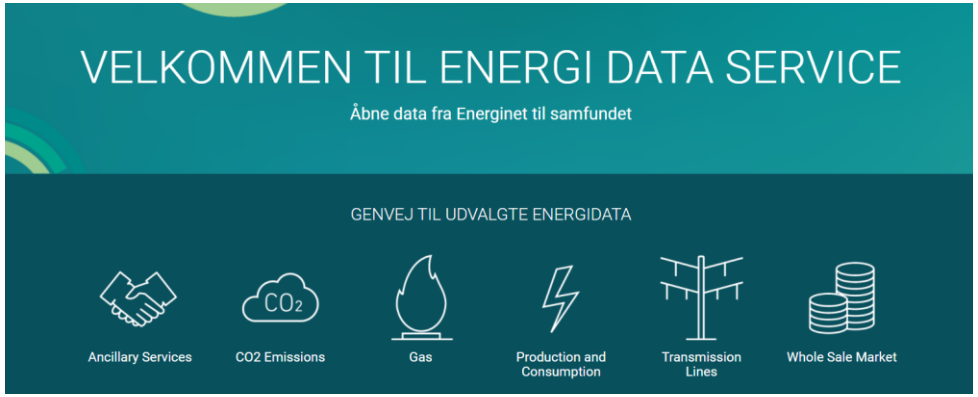
PRIME MOVERS' GROUP ON GAS QUALITY & H2 HANDLING

Provision of information at exit points

Energinet hosts Energidataservice.dk

- Open data portal
  - Quick overview
  - Download data to conduct own analysis
- Service multiple consumers
  - API to integrate data in app and services
  - Data guide

Energinet's site provides direct contact with gas quality experts



EntryExitPoint	HourUTC	GrossCalorificValue-kWh_per_Nm3	NormalDensity	Methane Number	WobbeIndex-kWh_per_Nm3	NetCalorificValue-kWh_per_Nm3	NetCalorificValue-MJ_per_Nm3	WobbeIndex-MJ_per_Nm3	GrossCalorificValue-MJ_per_Nm3
Stenlille	2020-11-2	11,29	0,75		14,86	10,19	36,67	53,48	40,65
Nybro	2020-11-2	12,49	0,86		15,35	11,31	40,72	55,25	44,98
Lille Torup	2020-11-2	11,27	0,74		14,85	10,16	36,59	53,46	40,57
Ellund	2020-11-2	11,26	0,74		14,84			53,44	40,53
Egtved	2020-11-2	11,26	0,74		14,85	10,15	36,55	53,45	40,53
Dragør Border	2020-11-2	11,26	0,74		14,85	10,16	36,56	53,45	40,53
Bevtoft	2020-11-2	11,01	0,72		14,74	9,92	35,70	53,06	39,62
Stenlille	2020-11-2	11,29	0,75		14,86	10,19	36,67	53,48	40,65
Nybro	2020-11-2	12,49	0,86		15,35	11,31	40,72	55,25	44,97
Lille Torup	2020-11-2	11,27	0,74		14,85	10,16	36,58	53,46	40,56
Ellund	2020-11-2	11,26	0,74		14,85			53,45	40,53
Egtved	2020-11-2	11,26	0,74		14,85	10,15	36,56	53,44	40,53
Dragør Border	2020-11-2	11,26	0,74		14,85	10,16	36,56	53,45	40,53
Bevtoft	2020-11-2	11,00	0,72		14,73	9,91	35,69	53,01	39,60
Stenlille	2020-11-2	11,29	0,75		14,86	10,19	36,67	53,48	40,65

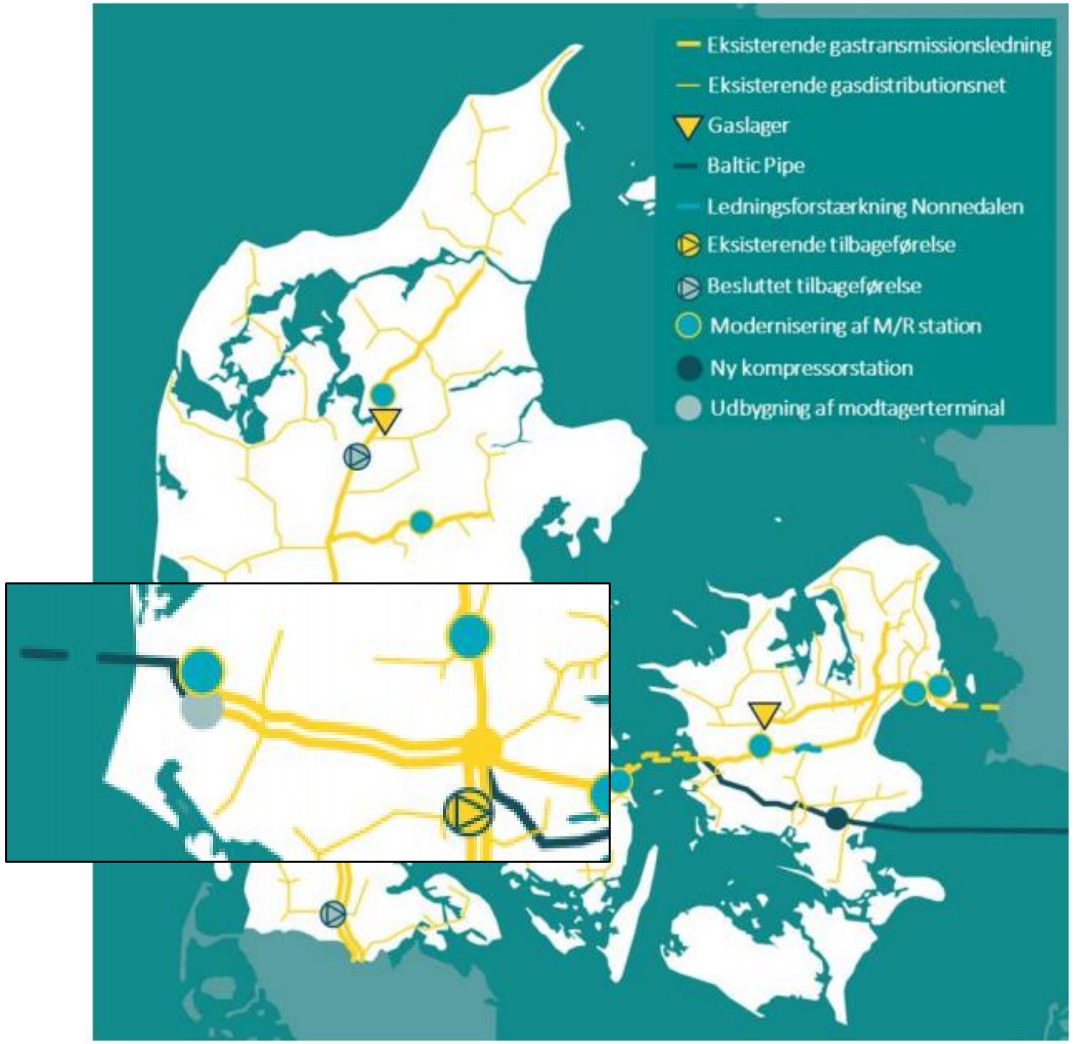
*Wobbe index and Calorific value 25/0

PRIME MOVERS' GROUP ON GAS QUALITY & H2 HANDLING

ENERGINET

Allowing off-spec gas to enter grid if on-spec blending is possible (Upstream-TSO)

- Connection agreement addressing gas quality standards
- Control Centre cooperation to handle small every day operational gas quality incidents
- Reduced production in the North Sea
    - The operator of the gas platform Tyra has announced a shutdown for a multi-year redevelopment project (October 2023)
    - Entry Nybro shippers might face a challenge with the upper limit of 52.9 MJ/m3 on Wobbe index
    - Energinet expects to be able to receive and transport gas at Nybro entry point, which complies with the quality and delivery specifications except for upper limit on Wobbe index;
        - Time limited to Period of the Tyra Redevelopment due to flow conditions;
        - Wobbe index not higher than 53.6 MJ/m3; and
        - Sufficient flow at Ellund entry point.
    - The shipper shall pay a small off-spec fee according to rules for gas transport. The fee is redistributed to the market.

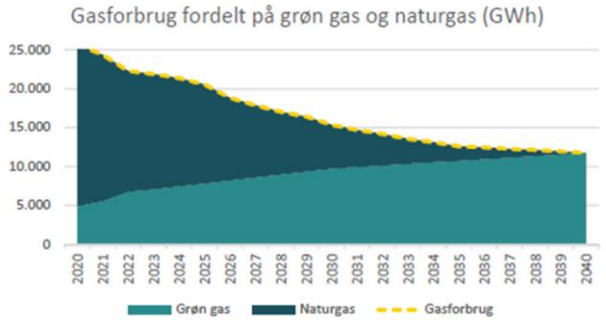


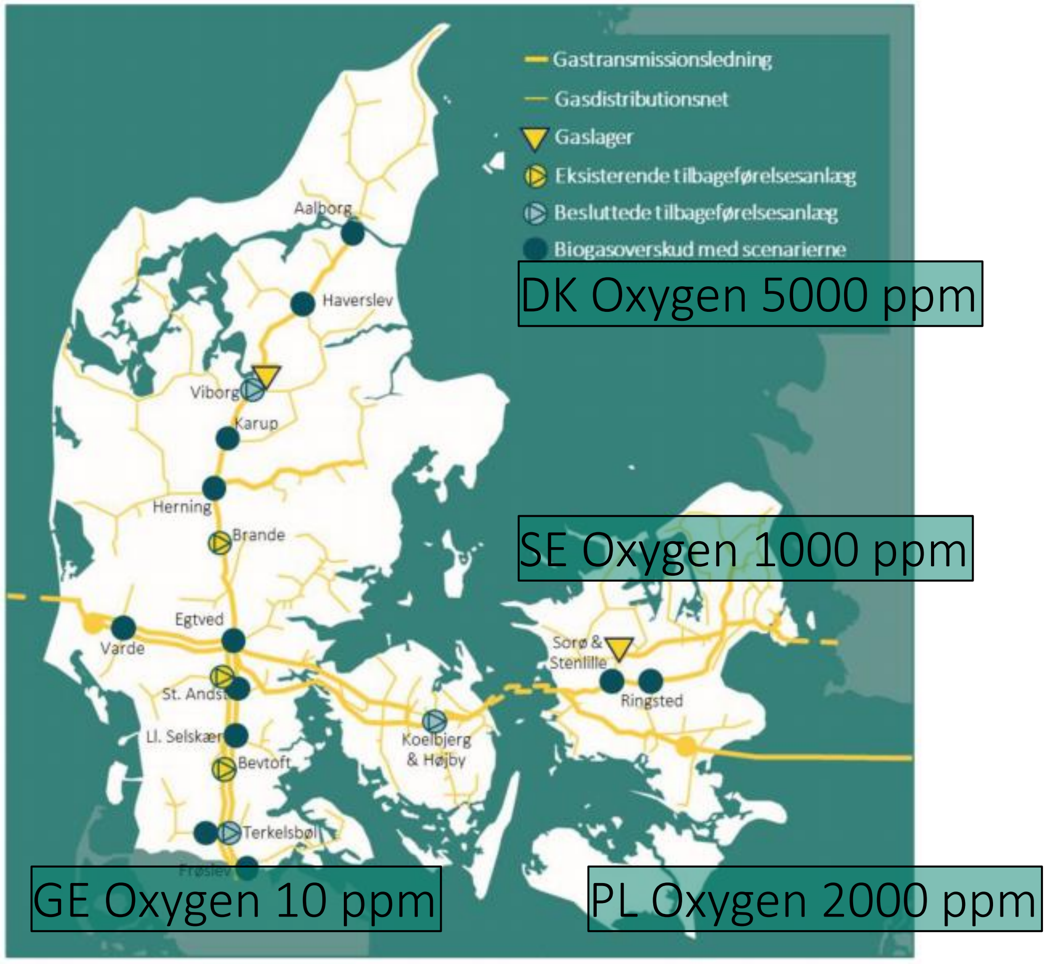
PRIME MOVERS' GROUP ON GAS QUALITY & H2 HANDLING

ENERGINET

Handling of off-spec gas at interconnection points (TSO-TSO)

- Interconnection agreement addressing gas quality standards.
- Control Centre cooperation to handle small every day operational gas quality incidents
- Requirements for oxygen is different at the interconnection points to the Danish system.
- Seasonal Oxygen Concentration Issue (summer)
  - Frøslev-Egtved I pipeline is closed towards Germany
  - Export gas to Germany directly from North Sea i.e. no blending with biomethane
- Future possible mitigation measures (2023)
  - Procedures for blending at Egtved with transit flow to Poland
  - Procedures for buying blending service from Danish Gas Storage by moving gas from Ll. Torup Gas Storage to Stenlille Gas Storage
  - Converting Førslev-Egtved I to a distribution pipeline reducing bidirectional flow at TSO-DSO interface
  - Stricter oxygen limits for biomethane plants connected to the gas grid

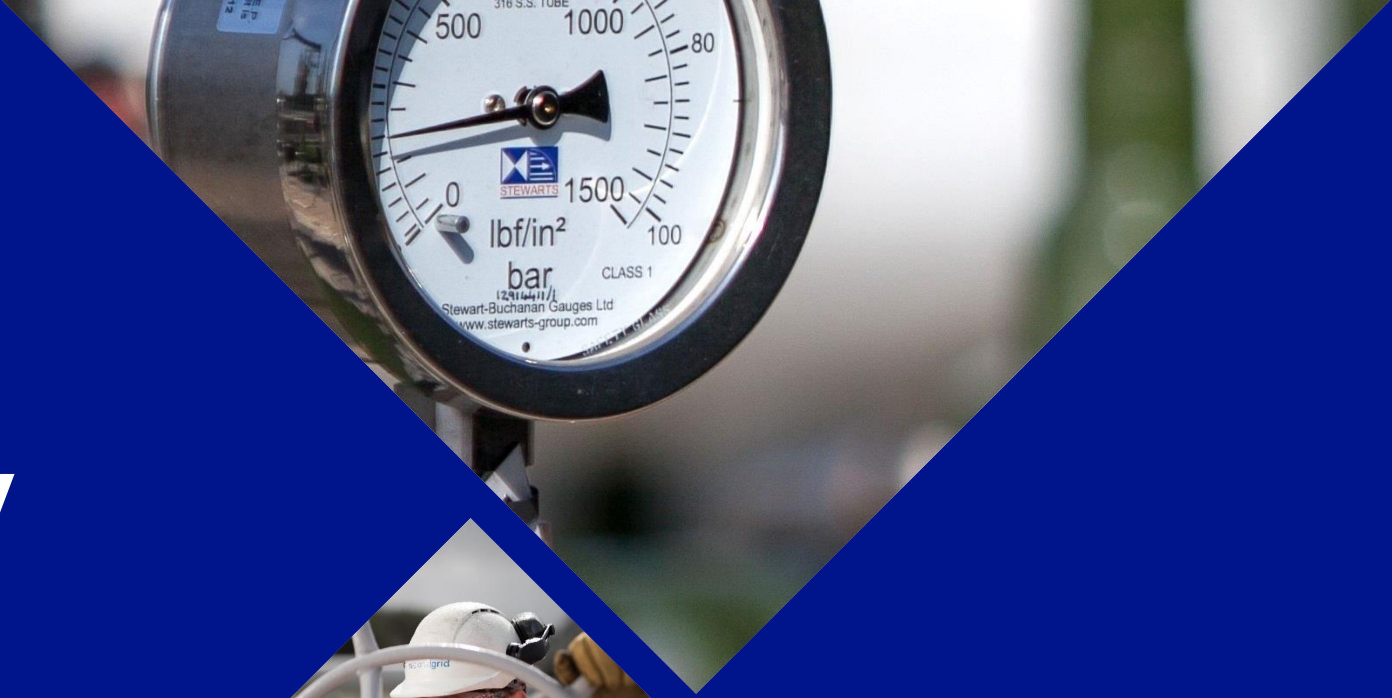




LANGSIGTEDE UDVIKLINGSBEHOV I GASSYSTEMET (Link)

Gas
Transmission

Managing Gas Quality Today



25th November 2020

Phil Hobbins

Philip.Hobbins@nationalgrid.com

nationalgrid

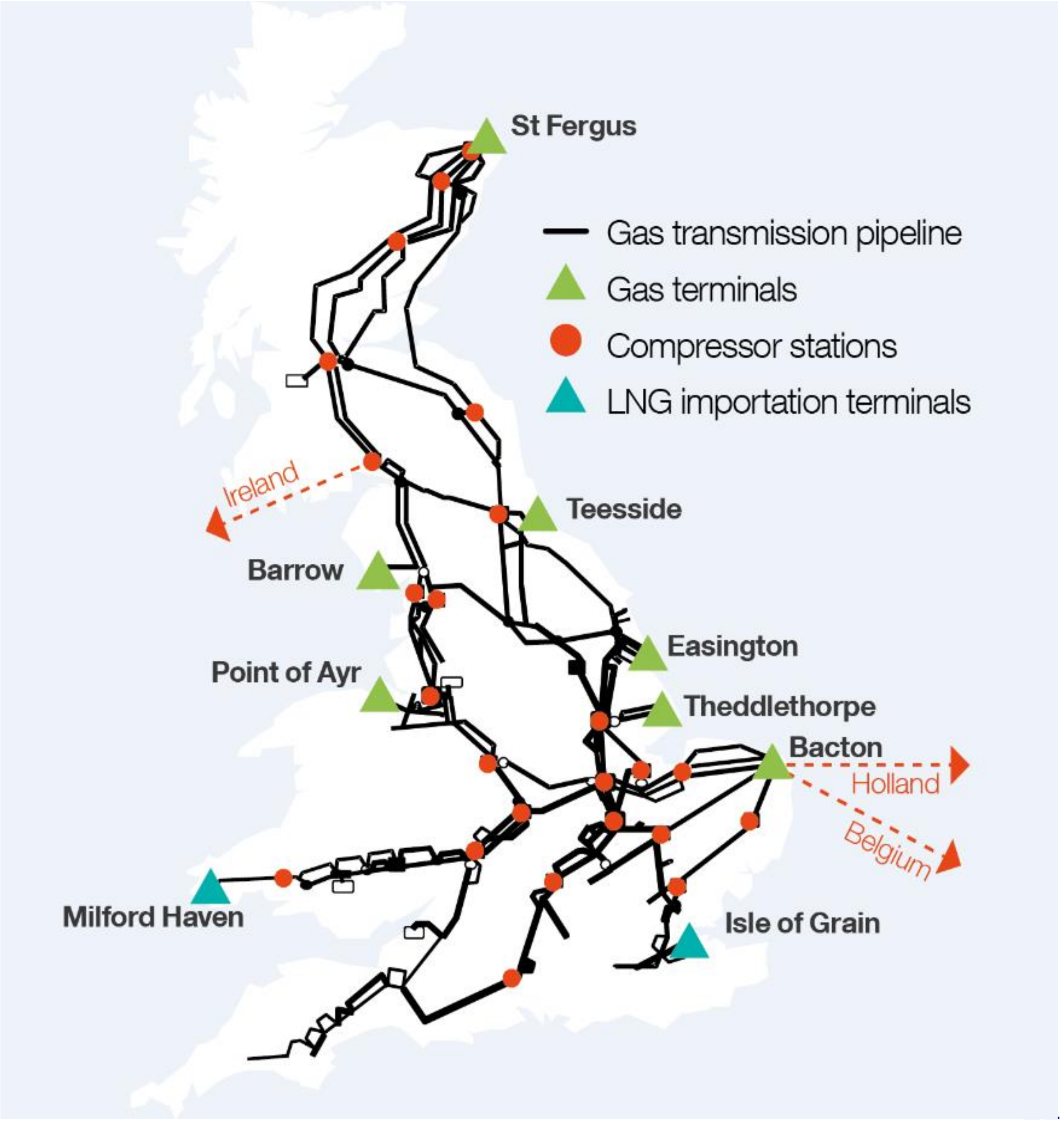
Our Network

An 'interconnected island'

High diversity of supply

Third party operator terminals at each entry point

Gas quality limits apply at each terminal



Where are the rules for gas quality?

Gas Safety (Management) Regulations

- GS(M)R establishes the **UK gas quality specification;** essentially what is safe for domestic consumption
- GS(M)R requires **UK gas transporters** to only convey gas **in their networks** which meets that specification
- It therefore states **what** the rules are **AND** **who** has the obligations

Gas 'Ten Year Statement'

- We place additional limits on gas entering our network (e.g. CO_2)
- The limits that are usually acceptable are included in our '**Ten Year Statement'** (appendix 2) https://www.nationalgrid.com/uk/gas-transmission/insight-and-innovation/gas-ten-year-statement-gtys

Agreements with terminal operators

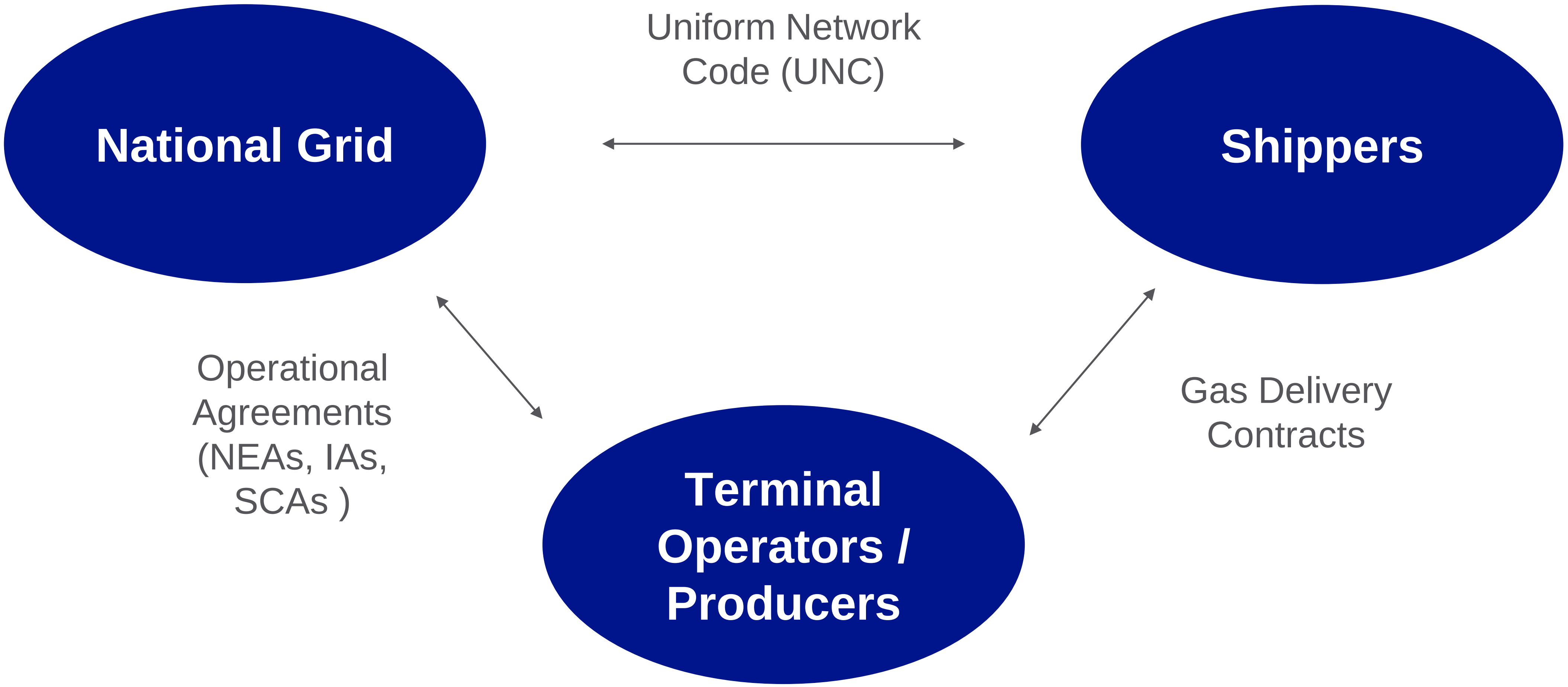
- We record the permitted technical limits (e.g. Wobbe Index, H_2S, dewpoints etc.) in **agreements with adjacent operators**
- Network Entry Agreements, Interconnection Agreements, Storage Connection Agreements

How do we manage gas quality?

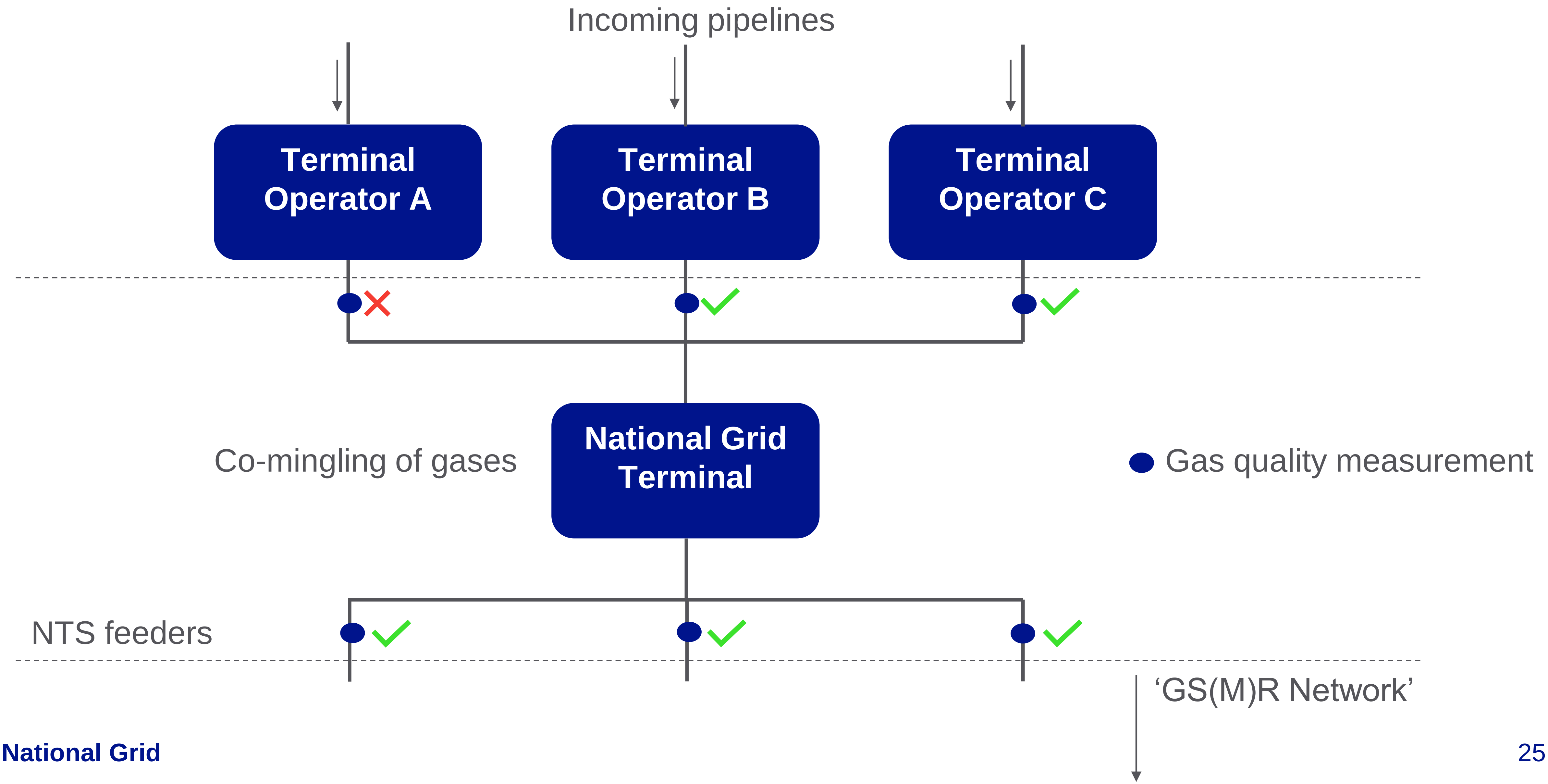
- We **constantly monitor** the content and characteristics of gas at each terminal
- **Gas chromatographs** measure the relevant parameters every few minutes
- The results are **telemeted** to our control room at Warwick
- When gas is recorded as being **non-compliant** we:
  - **Notify** the relevant terminal
  - If not promptly rectified, **instruct curtailment** of the non-compliant supply source

Some entry points have **multiple sources of supply**, others are **single source**…

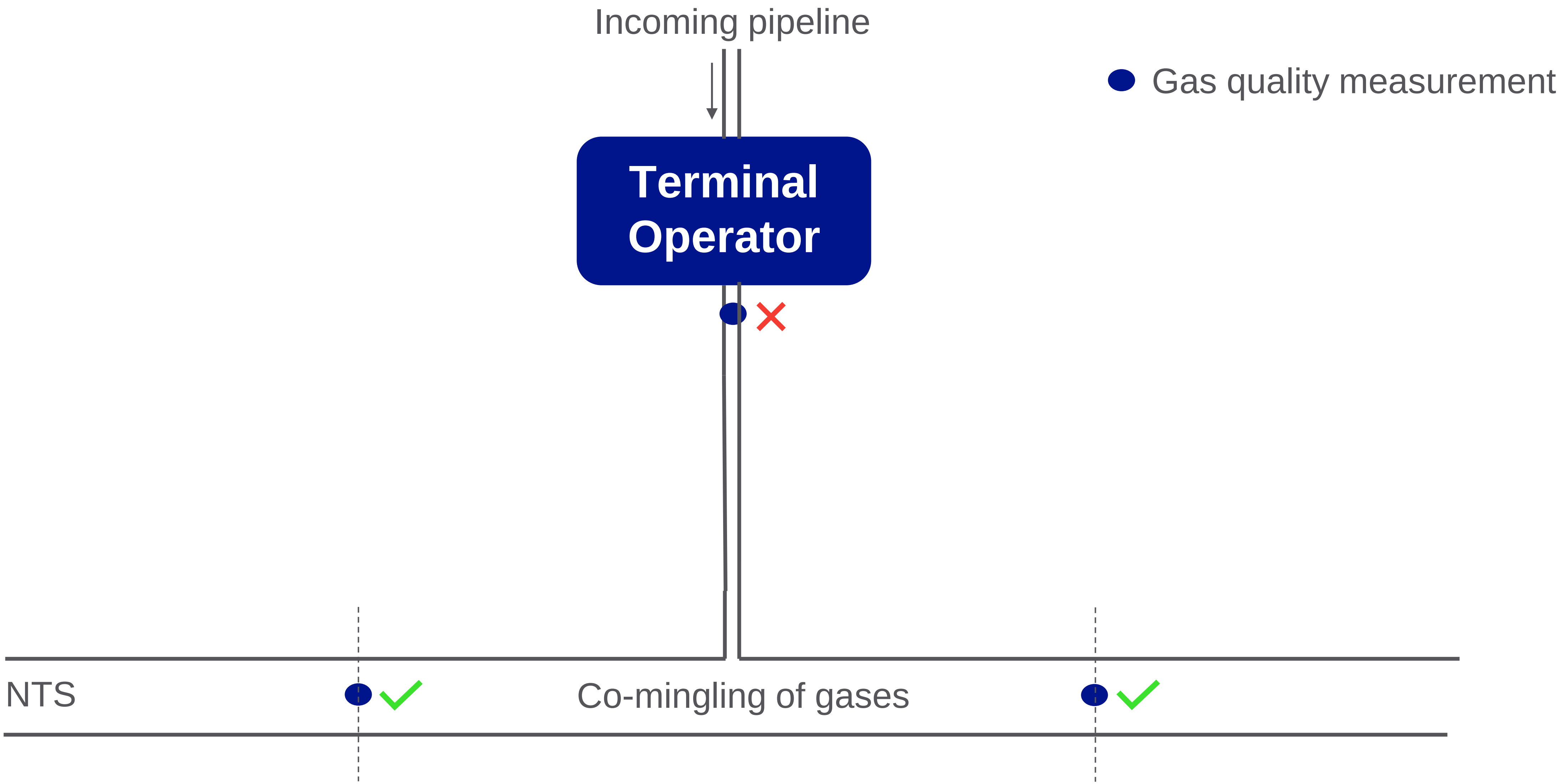
Current Contractual Relationships at NTS Entry Points



‘Multiple Supply’ Entry Point



‘Single Supply’ Entry Point



Summary

- We require gas quality compliance at all points of entry to our network
- The extent to which gases co-mingle before entering our network varies between entry points
- We do not currently provide gas quality services, for example:
  - Bespoke specifications at exit points
  - Blending or processing services
- However, we are currently developing blending services at entry and have recently consulted on this topic. Details can be found on our website at https://www.nationalgrid.com/uk/gas-transmission/about-us/business-planning-riio/stakeholder-groups/have-your-say-our-current-business-plans

HyNTS

Principal knowledge gaps

There are five principal knowledge gaps we are seeking to address:

Materials concerns

Pipelines and mechanical assets e.g.:
- Hydrogen embrittlement
- Seals & soft parts
- Weld quality

Safety concerns

Risk assessment and new safety case development including:
- Hazardous areas
- Electrical equipment
- Plant operations

Flow characteristics

How will hydrogen move around our network?
- Gas velocity
- Pressure drop
- Saltation

Compression

What will need to change in our compressor strategy?
- Turbine compatibility
- Gas compressibility
- Investment cycles

Network management

How do we ensure we can maintain security of supply?
- Storage capacity
- Network inputs
- Deblending

nationalgrid

COMISIÓN NACIONAL DE LOS MERCADOS Y LA COMPETENCIA

CEER's contribution

Questionnaire on gas quality and H2 handling. CNMC (1)

- The answers in the questionnaire reflect only CNMC views
- The objective when filling in the questionnaire is to review the main regulatory issues when dealing with promoting green gases and their cross-border trading
- Answers are based on ACER's evaluation of responses document about their questionnaire on H2, reflecting the situation in each country
- CNMC does not have competences regarding gas quality

Questionnaire on gas quality and H2 handling. CNMC (2)

Interface Type	Conversion	Type of issue	Potential barriers	Criticality	Potential solutions
TSO - TSO (IPs)	H2NG <=> H2NG	Regulatory	Different regulatory frameworks	High	EU legislation when needed
TSO - TSO (IPs)	H2NG <=> H2NG	Regulatory & Market	Interconnection agreements	Medium	Adaptation or new interconnection agreement
TSO - TSO (IPs)	H2NG <=> H2NG	Technical	Different readiness for H2 blends	High	EU -wide harmonization of hydrogen blending limits
TSO - TSO	H2NG <=> H2NG	Technical	Metering equipment requires upgrades or chromatograph replacement in order to be able to measure hydrogen concentrations in the gas network	Low	Adaptation or replacement of the equipment

Questionnaire on gas quality and H2 handling. CNMC (3)

Interface Type	Conversion	Type of issue	Potential barriers	Criticality	Potential solutions	Comments
TSO - TSO	H2NG <=> H2NG	Technical	Gas turbines, compressor stations, compressed natural gas tanks ans some type of storage can only accept low hydrogen concentration (<5%) and may also need retrofitting	Medium	Retrofitting of the equipment	
DSO - Industry	H2NG <=> H2NG	Technical	Sensitivity of specific industrial processes to the H2 concentrations	High	Establishing EU limits to the blend	Safety issues should be taken into account
DSO - Residential	H2NG <=> Methane	Technical	Sensitivity of domestic appliances to H2 concentrations	High	Establishing EU limits to the blend	Safety issues should be taken into account

Questionnaire on gas quality and H2 handling. CNMC (4)

Interface Type	Conversion	Type of issue	Potential barriers	Criticality	Potential solutions	Comments
DSO - Industry	Hydrogen => Hydrogen	Technical	Sensitivity of specific industrial processes to the H2 concentrations	High	Establishing EU limits to the blend	Safety issues should be taken into account
DSO - Industry	Hydrogen => Hydrogen	Regulatory & Market	Needed specific regulation	Medium		Safety issues should be taken into account
DSO - Industry	Hydrogen => H2NG	Regulatory & Market	Needed specific regulation	Medium		Safety issues should be taken into account
TSO - TSO	Other	Regulatory	Unbundling of activities for the TSO	High		

Thank you for your attention!

Q&A session 1

Session 2: AFECOR, EHI, GWI, DBI

About Afecor

afecor
European Controls
Manufacturers Association

... was founded in 1963 EGCMA (European Gas Control Manufacturers Association)

... is active in the field of legislation and technical standards

... is located officially in Vilvoorde near Brussels

... has no office – no staff – network of experts only

... has 22 liaisons with committees of CEN and ISO

EMERSON

VHB
Verband der Hersteller von Bauelementen
für wärmetechnische Anlagen e.V.
German Controls Manufacturers Association

resideo

MERTIK MAXITROL®

Honeywell
MAXON

DUNGS®
Combustion Controls

B&P
BERTELLI & PARTNERS
APPLIANCE CONTROLS SPECIALIST

Honeywell
krom schroder

SIEMENS

MAXITROL®

Hydrogen and Controls

afecor
European Controls
Manufacturers Association

For hydrogen a lot of focus is on hydrogen production and distribution and field trials using HNG or in some cases pure hydrogen.

To actually roll out hydrogen applications in the field requires activities which need to be started immediately.
Enabling controls for use of hydrogen needs to be addressed.

Controls are building blocks used in many applications.

Controls need to be certified.

For the certification of controls harmonized standards are needed.

The current standards are not developed for HNG or pure H2.

Relevant parameters

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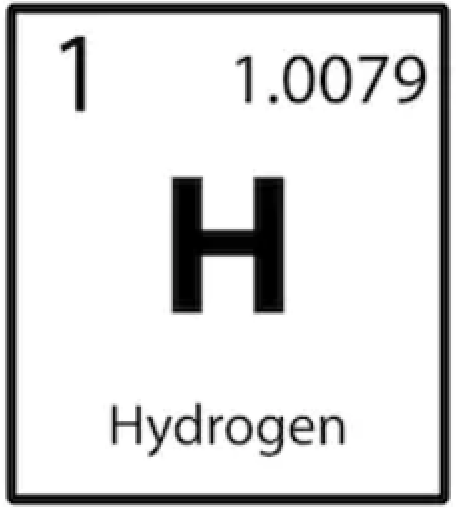
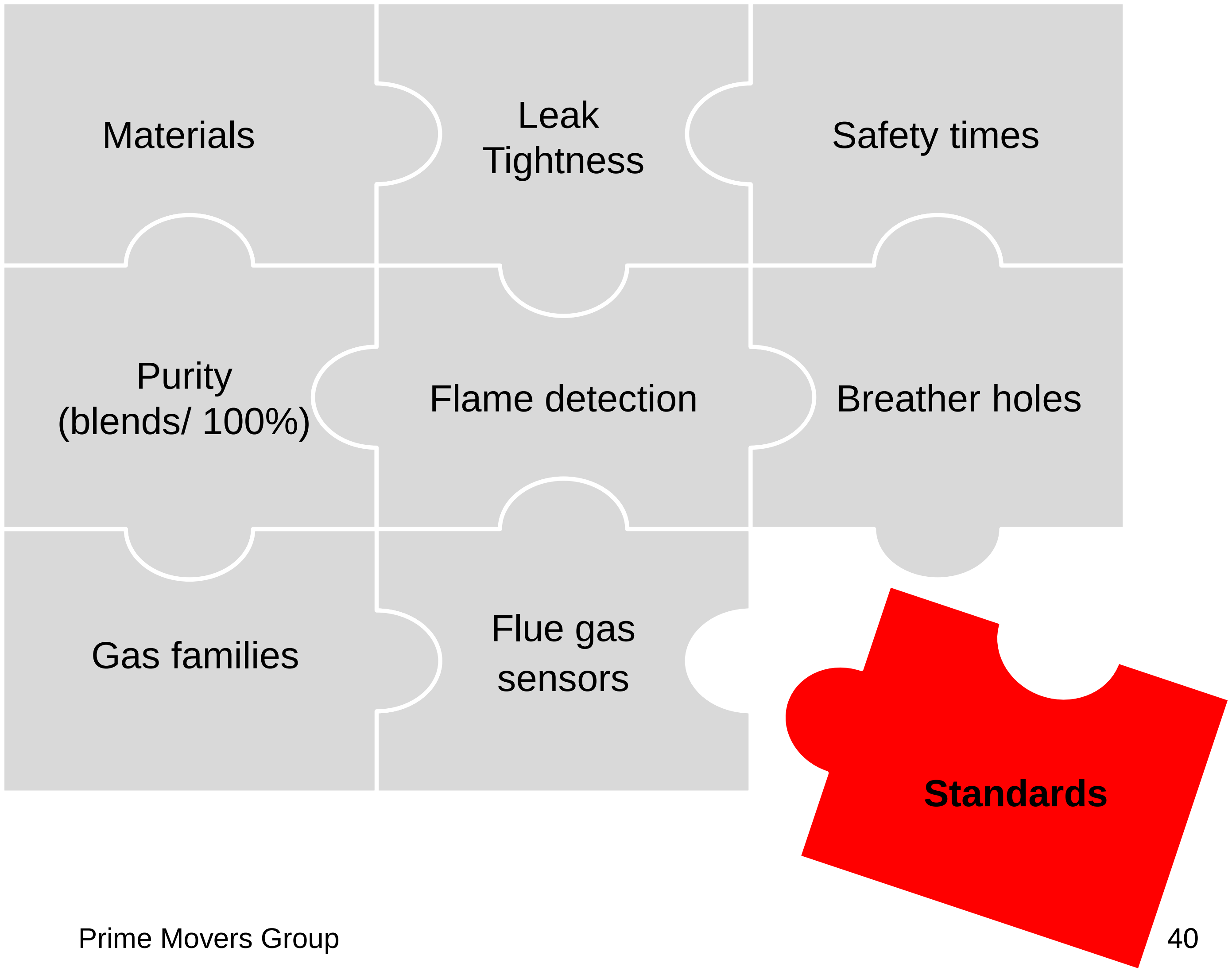
Topics to be investigated and discussed





Requirements to be revisited

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European Controls
Manufacturers Association

Task 1: Leakage

Today's standards define permissible rates for internal and external leakage.

With smaller molecules these limits have to be reassessed not just considering how much H_2 may escape, but what risk this may pose.

It has to be taken into account, that for a certain application several gas carrying controls may be installed.

Requirements will most certainly have to be changed

Requirements to be revisited

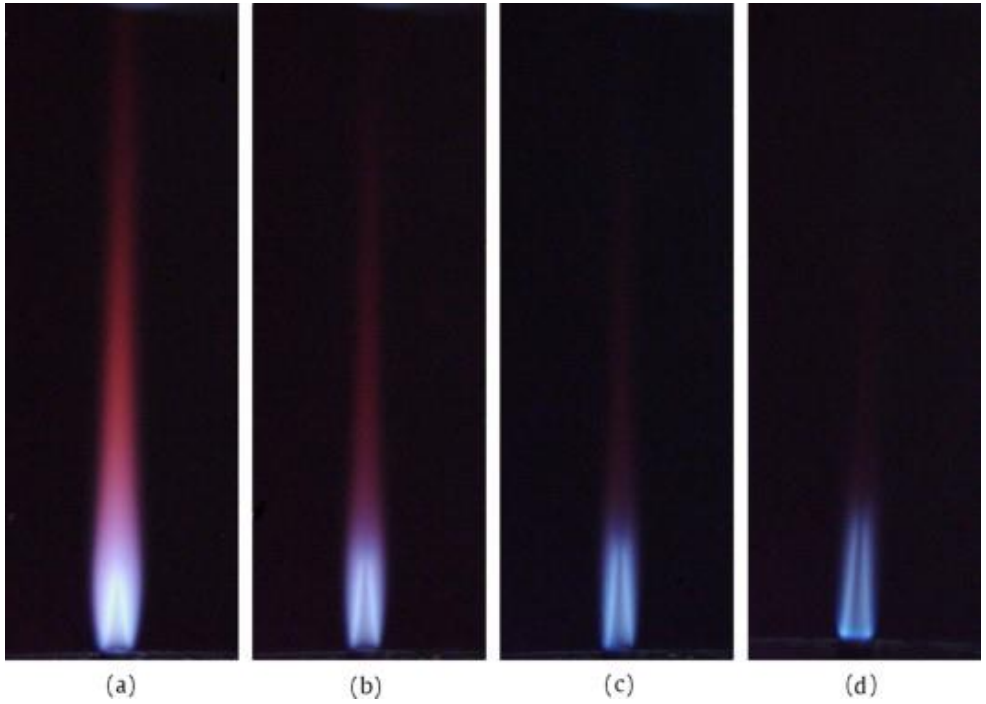
Task 2: Flame proving

Some sensor technologies used today for flame proving reach their limits for very high shares of H_2 in the gas.

The limits for different sensor principles have to be investigated.

It may also be necessary to see of the safety times used today in flame supervision are still o.k.

Standards will have to be adapted.



Requirements to be revisited

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European Controls
Manufacturers Association

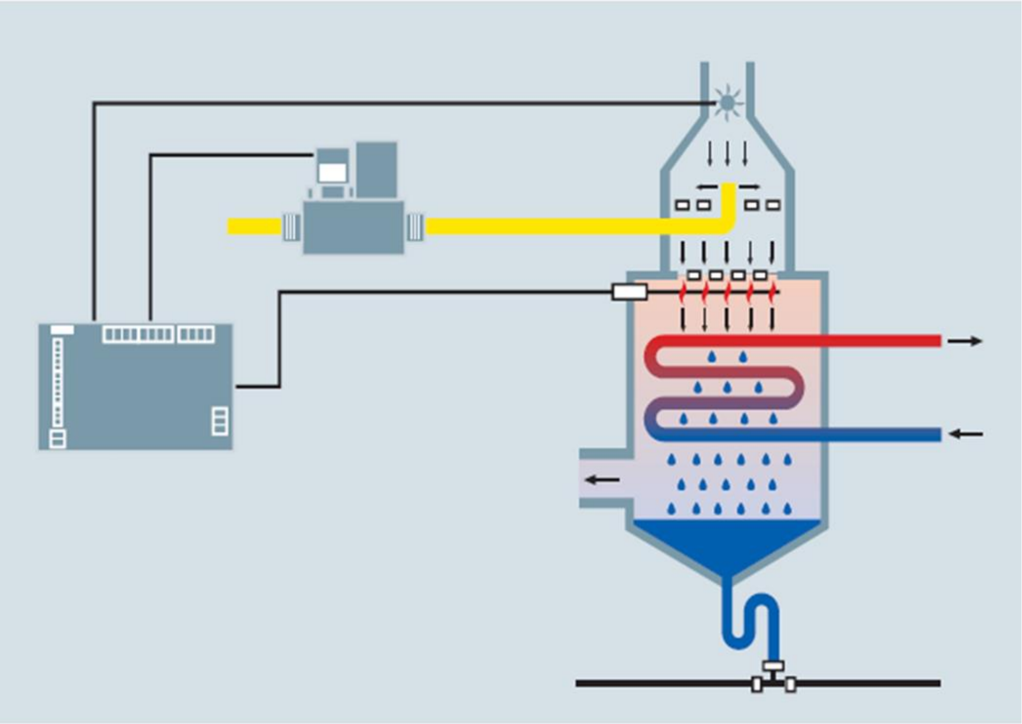
Task 3: Adaptive combustion control

There are different methods of adaptive combustion control.

Using ionization signals to measure combustion quality finds a limit for high percentages of hydrogen in the gas

Combustion product sensors may have issues with humidity.

It is essential to investigate the limits of current systems



Requirements to be revisited

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Manufacturers Association

Task 4: Detecting incomplete combustion

For large capacity boilers incomplete combustion may be an issue.

When burning natural gas an incomplete combustion can be detected by using a CO sensor.

For the incomplete combustion of hydrogen a detection method is to be investigated and determined.

More research being needed.

Conclusion

European Controls Manufacturers Association

For the safe operation of controls using hydrogen a number of parameters have been identified, which need further work.

Work on a number of tasks has been started

The results will be used to be included in standards for the relevant products.

Thank you for your attention

Dr. Martin Bergemann

President of Afecor

EHI brings together manufacturers of heating systems in Europe

ehi
association of the
European Heating Industry

SPACE HEATING

WATER HEATING

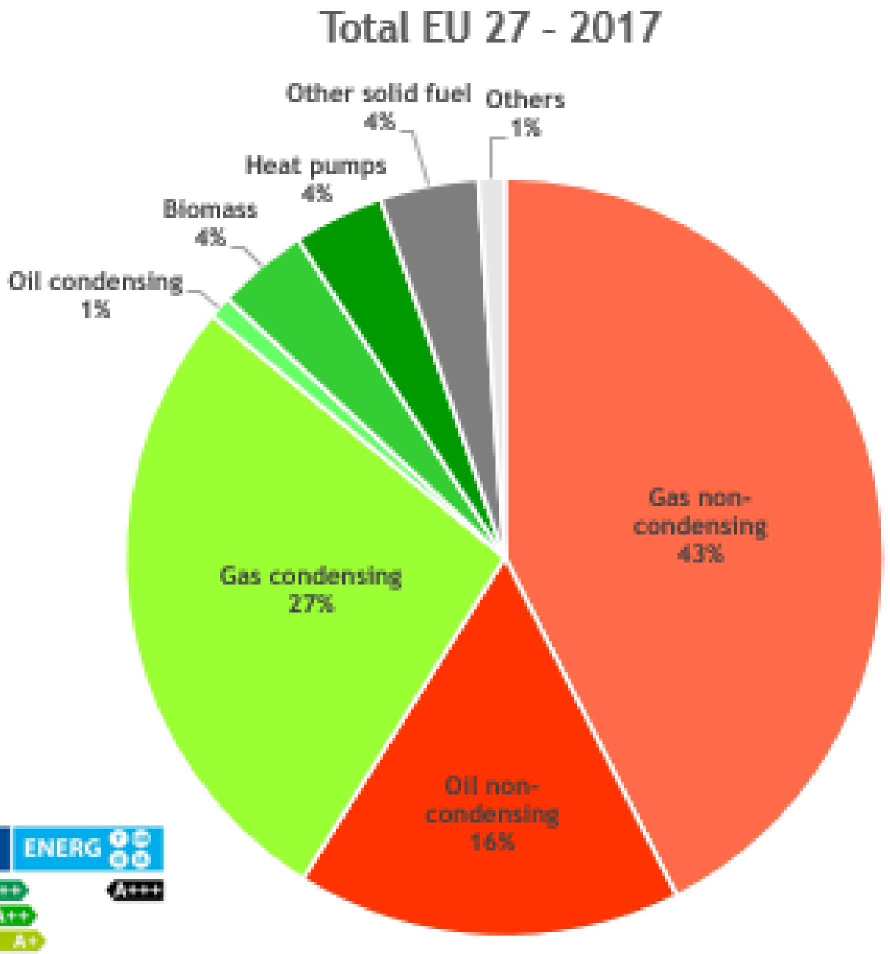
CONTROLS

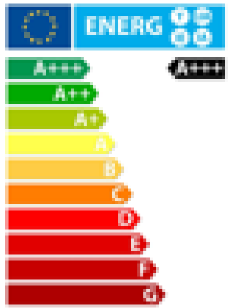
EMITTERS
- UNDERFLOOR HEATING
- RADIATORS

125 000
people employed directly by the industry

1 billion €
yearly investment in energy efficiency

State of Play





Please note: colours based on the EU energy label for new heaters.

EHI data, installed stock of hydronic heaters.

- **Building sector = single largest source of CO2 emissions** in the EU and biggest energy consumer.
- **Most of EU buildings today are connected to gas grids**; 70% of the installed stock of hydronic heaters is gas-fired, and largely inefficient.
- Hence **replacing the old stock with new efficient heating technologies working with green gases** is an opportunity to decarbonise buildings cost-efficiently, along other efficient and renewable solutions.

ehi
association of the European Heating Industry

The Green Deal needs green gases in EU buildings, because they are needed for ...

- Leaving nobody behind

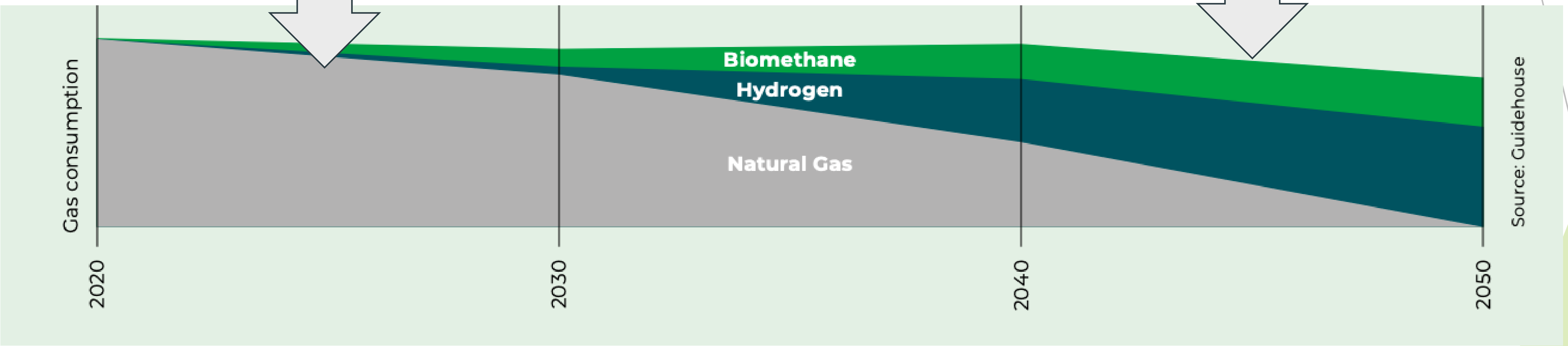
→ multiple technologies and energy carriers needed, to have decarb options for diverse buildings + investment capacities of people

- Energy system optimization

→ green gases for buildings complement electrification / heat pumps and district energy
→ enabling simultaneous decarb/electrification of heat and transport
→ e.g. Germany: cost-optimal system decarbonisation includes about 6 mln heat generators 2050 running on decarb gaseous fuels - elec only has higher price tag e.g. due to resource adequacy, need for stronger grids and more generation capacities
→ diversification = stronger resilience of the energy system

Synchronize!

A gas boiler placed on the market in 2025 will stay in operation until 2045 on average.
→ Thus we need to prepare **today** the environment for green gas applications



Synchronize!

Synchronized roadmaps and regulatory frameworks for

- Enabling gas distribution grids for hydrogen blends + pure
- Installation of end-use equipment capable for CH_4 and H_2
- Replacing fossil CH_4 by decarbonized gases
- Allowing production of sufficient quantities of renewable and decarbonised gases (hydrogen, biomethane, synthetic methane, bioLPG)

→ **enhance certainty for investments in the H_2 value chain**

→ **affordable cost for end-users to decarbonize**

→ **accelerate the pathway to decarbonized building stock and overall energy system**

Installation of *end-use equipment* capable for CH_4 and H_2

Work in progress @ CEN: conformity assessment for equipment capable to process H_2

- For blends: admixture up to 20 Vol % H_2

→ with current boiler platforms: capability to process 20 Vol-% - 30 Vol-% achievable
→ beyond 20- 30 Vol-%: different platforms needed - different burners, combustion control, safety concepts

- For 100% H_2

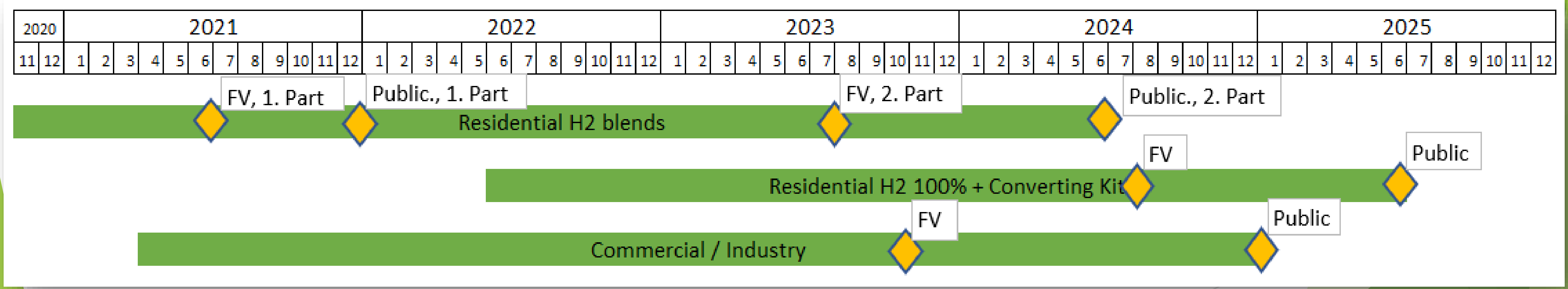
Work in progress @ EU COM: revision ecodesign + energy label for heaters
Needed: appropriate mix of requirements putting the heater stock on track for decarb gases
→ ensure that most of newly installed equipment is able to handle changing gas composition
→ e.g. snapshot 2045: about 80% -x% of stock pre-2025 could have the right capabilities at replacement rate 4%/a tor 5%/a

Roadmap *Standardization* Process

Regulatory / Standardization Gas appliances (boiler)

EU process:

- EU-COM (2020-11-18): No need to revise GAR (2016)
- Standardization mandate M/495 will be used to implement the H2 standardization work program



In the UK: a switch to 100% H2 residential heating solutions could be mandated earlier than 2030.

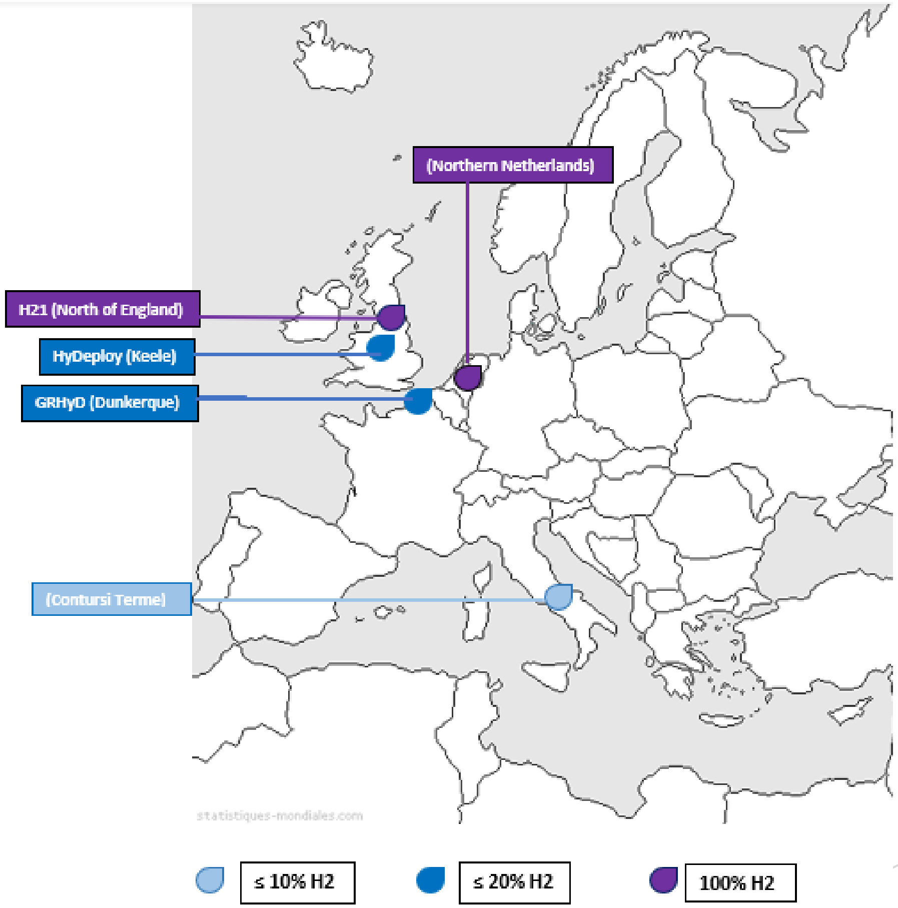
Hydrogen for heating is happening - some examples of pilot projects in Europe

H2 blends:

- GRHyD (FR): successful test in local DSO grid up to 20% H2
- HyDeploy (UK) ongoing field test of 20% H2 on existing equipment
- Avacon (DE) 20% existing equipment
- Contursi Terme (IT): 10% in TSO grid
- EU project THyGA: tests on 100 different residential and commercial appliances

100% H2 for heating:

- Hy4Heat (UK): 100% hydrogen field trial (200 homes to be connected)
- Rozenburg (NL): hydrogen boiler prototype in field trial



Heating appliances are ready to use renewable and decarbonised gases

How to make it work? EHI recommendations on gas quality and H2 handling

- Enable the heating market to make use of green gases as one of the pathways to decarbonise buildings, leaving no one behind. Why? Renewable and decarbonised gases can be used in **existing buildings** and they make an **optimised use of existing energy infrastructure.**
- **Support the uptake of efficient heating appliances** – efficiency is key to achieve decarbonisation. Generally different uptake of hydrogen in old installed vs. new appliances. **Today in the EU, 64% of installed systems are old and inefficient** (class C or D or lower on Energy Label).
- **Achieve a synchronised roadmap between green gas supply and roll-out of future proof gas end use solutions**. Blends useful step before switching to 100% hydrogen (modern boilers today on the market are compatible with low blends), and field tests are ongoing for the installed stock.

Our expectations for the Prime Movers' Group

- **Favour the production and distribution of renewable and decarbonised gases (e.g. via EU-wide targets)** and enable their use for heating – not only for industry and transport. Targets are very effective to increase supply.
- **Develop technical rules defining the interaction between new gases and heaters, to synchronise** the roll-out of compatible appliances with the production and distribution of decarbonised and renewable gases in the grid.

Gas- und Wärme-
Institut Essen e.V.

Gas quality impacts on glass manufacturing

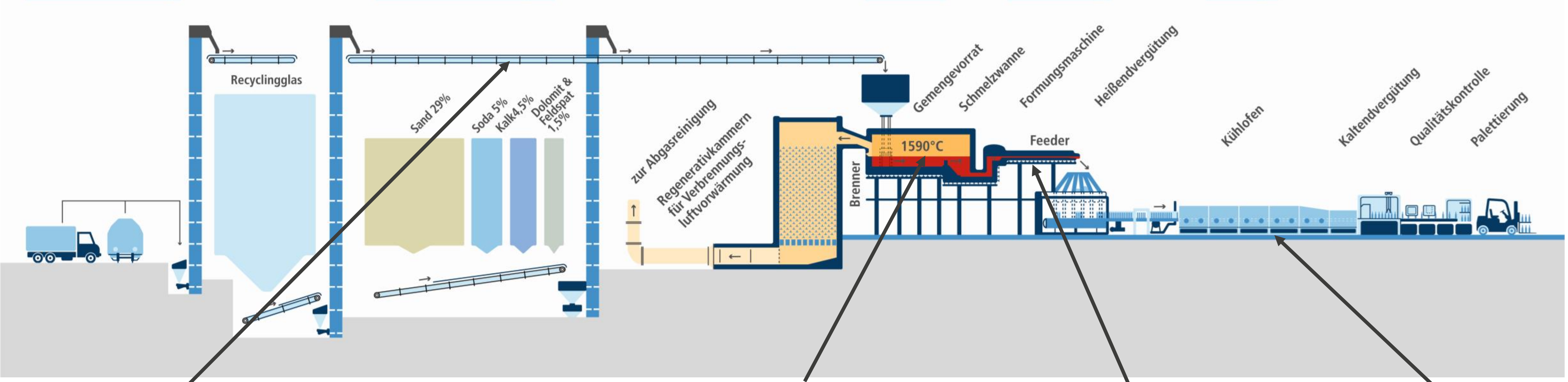
Prime Movers Group, 3rd Meeting

Jörg Leicher, November 25th, 2020

Gas utilization in glass manufacturing

Combustion !

Raw materials | Cullet | Batch mixing | **Melting** | **Forming** | **Annealing** | QA & packaging



Source: BV Glas

Natural gas quality and the glass industry

- The European glass industry is **highly dependent on natural gas**. In Germany, it covers about **75 %** of its **final energy demand** with natural gas. In turn, the German glass industry is responsible for about **2 %** of the German **total natural gas consumption**. The biggest furnaces can have firing rates of up to **100 MW** and produce up to **1,200 t/d**.
  Glass manufacturing sites are often **connected to DSO grids**.

- The **melting process** (temperatures about 1,600 °C) is responsible for about **85 %** of the total energy demand for glass production. In terms of **product quality**, the **feeders** and the **forming process** are the most critical and highly sensitive. Even small changes in the **temperature homogeneity** of the melt can result in **reduced product quality**.

- Glass manufacturing is generally considered to be among the most sensitive manufacturing processes in the context of natural gas quality. Processes are highly optimized for **product quality**, **efficiency**, **pollutant emissions**, **equipment lifetimes**…

Quelle: GWI, 2020

Sensitivity assessment (DVGW, 2018)

Industry		Process / Application		Efficiency				Safety (Emissions + Thermal Overload)				Product Quality			
				Variation of Wobbe Index or calorific value compared to the adjustment value of the process											
				±2 %	±4 %	±5.5 %	±7.5 %	±2 %	±4 %	±5.5 %	±7.5 %	±2 %	±4 %	±5.5 %	±7.5 %
Heat	Space heating	luminous radiant heaters*		green	green	yellow	red	green	green	yellow	red	green	green	yellow	yellow
		infrared radiant heaters*		green	green	yellow	red	green	green	yellow	red	green	green	yellow	yellow
		air heaters*		green	yellow	red	red	green	yellow	red	red	green	yellow	yellow	red
	Process heating	boilers / steam generators		green	yellow	yellow	yellow	green	yellow	yellow	red	green	yellow	yellow	red
		direct and indirect drying		green	yellow	yellow	yellow	green	yellow	yellow	red	green	yellow	yellow	red
Power Generation		gas turbines	Diffusion Mode	green	green	yellow	red	green	green	yellow	red	green	yellow	yellow	red
			DLE Mode	green	green	yellow	red	green	red	red	red	green	yellow	yellow	red
		gas engines		green	yellow	red	red	green	red	red	red	green	yellow	yellow	red
Metals		preheating (metals)		green	green	green	yellow	green	yellow	yellow	red	green	green	green	yellow
		thermo-chemical heat treatment		green	yellow	yellow	yellow	green	green	green	yellow	yellow	red	red	red
		endothermic gas generation		yellow	red	red	red	green	green	green	yellow	yellow	red	red	red
		galvanization processes		green	yellow	red	red	green	green	green	green	yellow	red	red	red
		melting processes (non-ferrous metals)		green	yellow	yellow	red	green	yellow	yellow	red	yellow	yellow	yellow	red
Ceramics		calcination		green	green	green	yellow	green	green	green	yellow	green	green	green	yellow
		bricks and tiles manufacturing		green	green	yellow	yellow	green	yellow	yellow	red	yellow	red	red	red
		porcelain firing		green	yellow	yellow	yellow	green	yellow	yellow	red	yellow	red	red	red
Glass		glass melting (container glass)		green	yellow	yellow	red	green	yellow	yellow	red	green	yellow	yellow	red
		glass melting (float glass)		green	yellow	yellow	red	green	yellow	yellow	red	yellow	yellow	yellow	red
		glass melting (special-purpose glass)		yellow	red	red	red	green	yellow	yellow	red	yellow	red	red	red
		feeders and lehrs (annealing)		yellow	yellow	yellow	red	green	yellow	yellow	red	yellow	yellow	yellow	red
Chemical		chemical engineering, plastics		green	yellow	yellow	red	green	yellow	yellow	red	green	yellow	yellow	red

Assumption: no control system

*For radiant heaters and air heaters: product quality means space heating quality

- green: no intervention required
- yellow: possibly intervention required
- red: intervention required

Source: Krause, H., Werschy, M., Giese, A., Leicher, J., Dörr, Hauptstudie zur Analyse der volkswirtschaftlichen Auswirkungen von Gasbeschaffenheitsschwankungen auf die Sektoren des Gasverbrauchs und deren Kompensation Phase 2 (Hauptstudie Gasbeschaffenheit), DVGW, 2018

Impressions


Underport burner configuration in a glass melting furnace
Image: HVG


Oxy-fuel furnace with top burners
Image: Linde


Inside view of a feeder furnace
Image: HVG


Regenerative cross-fired furnace
Image: ENCIRC


Regenerative cross-fired furnace
Image: CelSian


Outside view of a feeder furnace
Image: HVG

Case study: glass manufacturing site, Eastern Germany (2011)

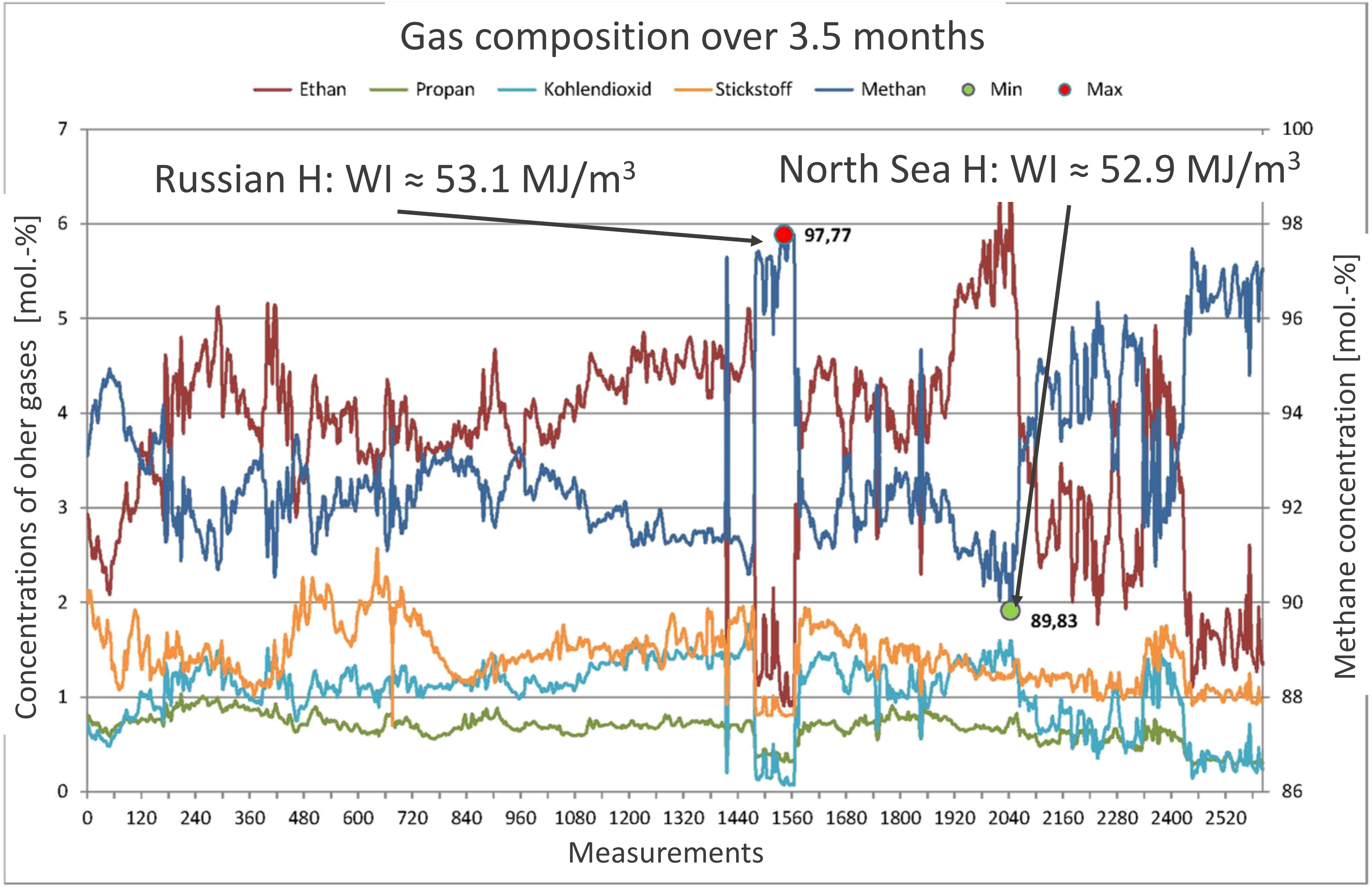
- In 2011, the operator of glass manufacturing plant noticed that the flame length in his furnace would „spontaneously“ increase significantly for no apparent reason.

- The changing flame lengths resulted in **reduced heat transfer** and hence **loss of efficiency**. The operator also considered this issue **relevant for safety**, as he feared that the flame might impinge on the opposite furnace wall and damage the refractory.

- Numerous investigations were carried out to determine the cause for this change of the combustion process. Among other things, the composition of the supplied natural gas was monitored with a GC.

Quelle: GWI, 2020

On-site gas quality fluctuations in Eastern Germany (2011)



Quelle: GWI, 2020

Impact on a non-premixed burner system (CFD study)

Reference case:

Russian H-Gas
(P = 200 kW, λ = 1.1)

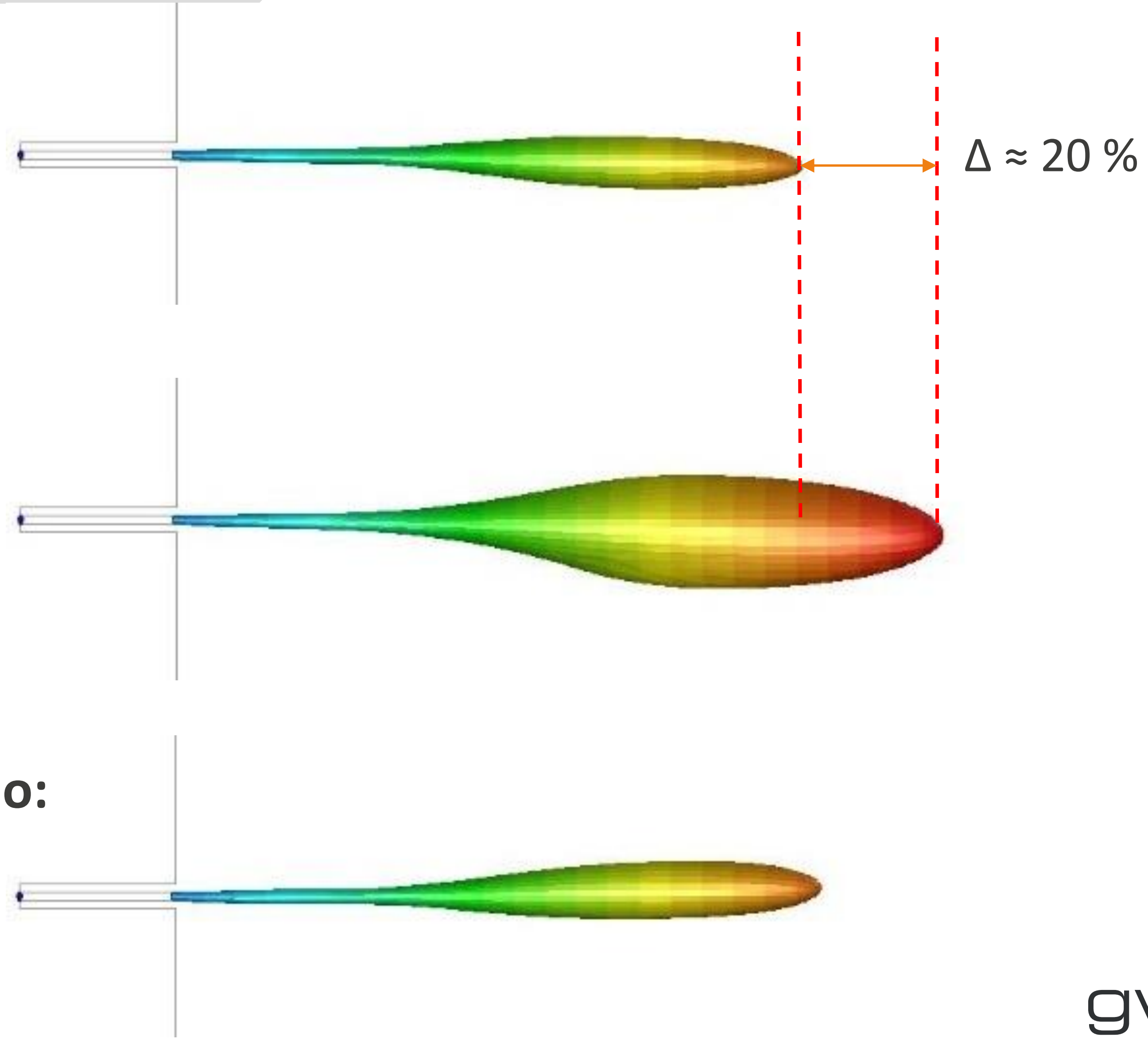
Δ W_S = 0.4 %
Δ H_i = 4 %

No control:

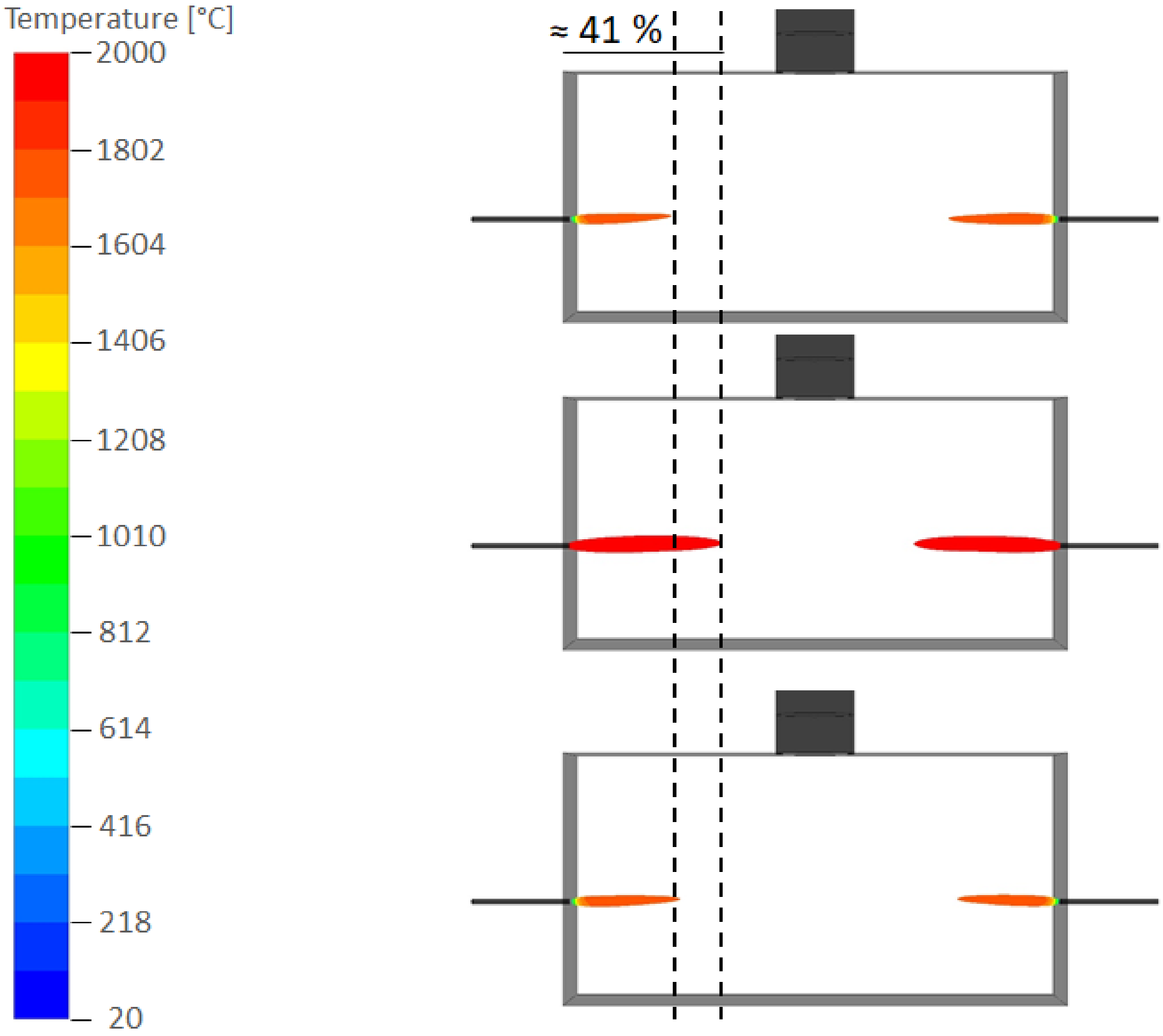
North Sea H-Gas
Volume flows constant
(P = **208 kW**, λ = **1.056**)
↑ 4 % ↓ 4 %

Control of firing load and air excess ratio:

North Sea H-Gas
(P = **200 kW**, λ = **1.1**)
Air and fuel volume flows adjusted



Impact on a premixed burner system in a feeder section (CFD study)



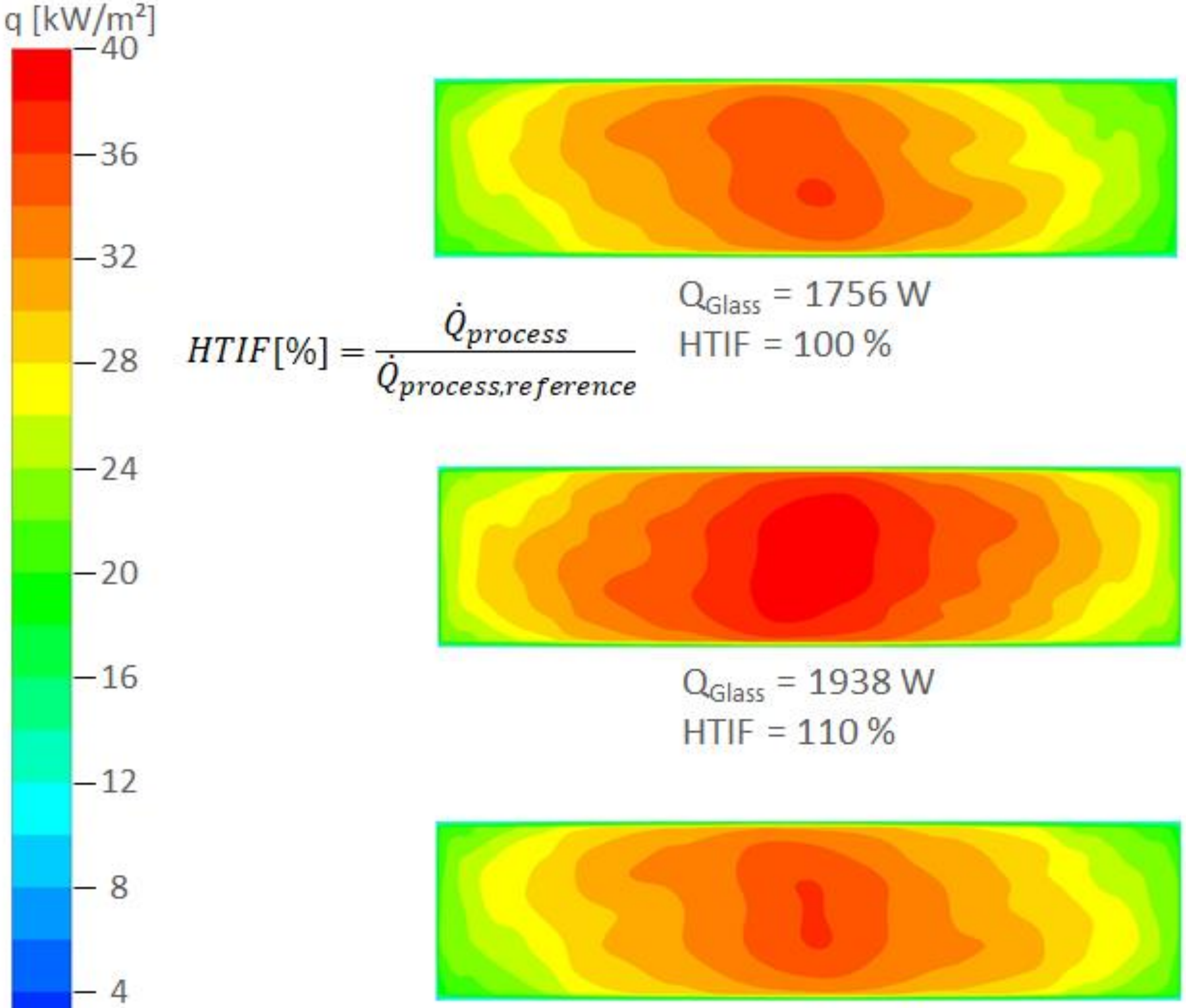
Reference case
P = 7 kW
λ = 1.05
Russian H-Gas

Scenario 1
North Sea H-Gas
No compensation

Scenario 2
North Sea H-Gas
full compensation
(P and λ constant)

 Quelle: GWI, 2020

Changing heat transfer characteristics in a feeder section



$$HTIF[\%] = \frac{\dot{Q}_{process}}{\dot{Q}_{process,reference}}$$

Q_{Glass} = 1756 W
HTIF = 100 %

Reference case
P = 7 kW
λ = 1.05
Russian H-Gas

Q_{Glass} = 1938 W
HTIF = 110 %

Scenario 1
North Sea H-Gas
No compensation

Q_{Glass} = 1768 W
HTIF = 100.7 %

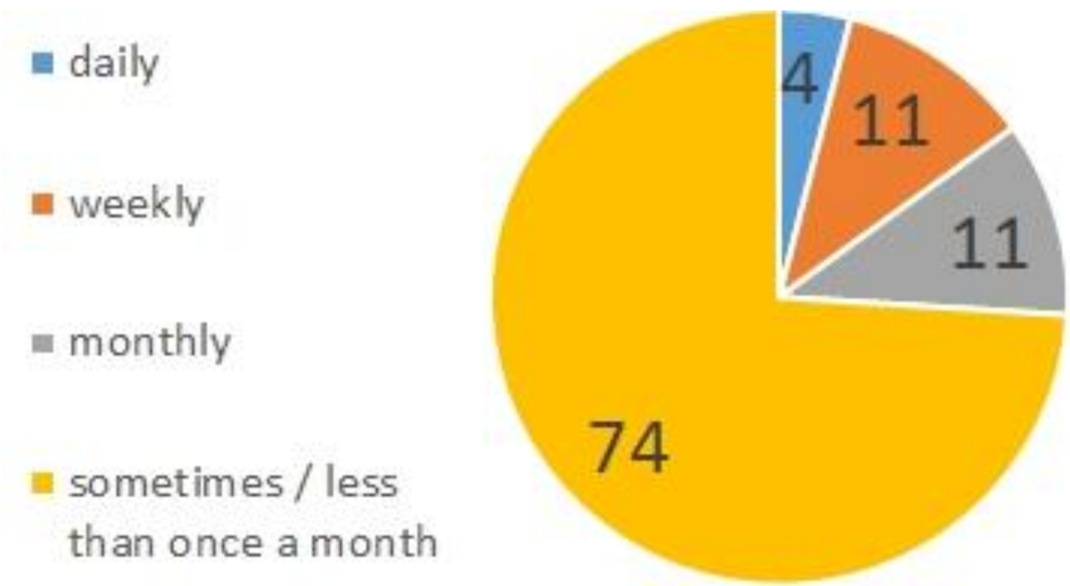
Scenario 2
North Sea H-Gas
full compensation
(P and λ constant)

gwi

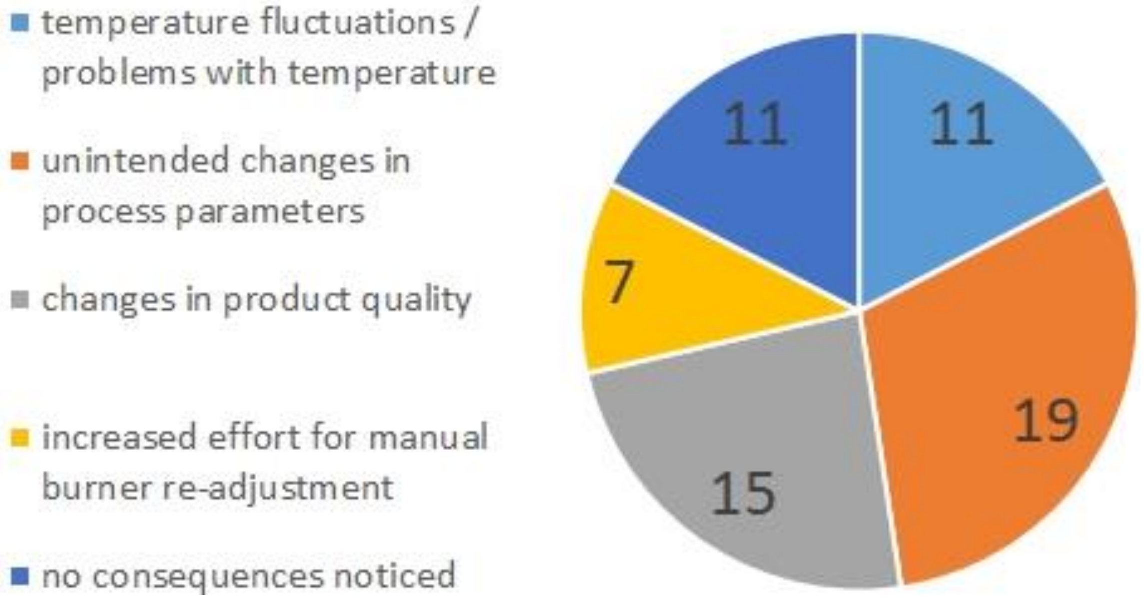
Quelle: GWI, 2020

Experience with gas quality fluctuations in thermal processing industries (DVGW survey)

48 % of the participating industrial equipment operators state that they have experienced significant gas quality fluctuations (> ± 3 % of a relevant criterion) in recent years.



Frequency of significant gas quality fluctuations [%]



Effects of gas quality fluctuations [%] (Top 5)

Depending on the application, gas quality fluctuations can have very different consequences. It is not easy to predict what these consequences might be.

Quelle: GWI, 2020

What can be done?

- **Adjust** appliances and equipment to a **more robust setting**, usually a higher λ
  => only really an option for residential/commercial appliances
- Use **on-site gas quality measurement** equipment in combination with **advanced combustion control** (e. g. constant P, constant λ, **independent** control)
  => can be very effective for combustion processes, but adds costs and may be less sensible for furnaces with dozens or hundreds of burners
  => usually not an „off-the-shelf“ solution
- **On-site gas quality measurement** in combination with **local fuel conditioning**
  => effective, but may be costly
- **Improved communication** between TSO/DSO and (sensitive) end users
- **Grid-level** measures to **minimize local gas quality fluctuations**, e. g. grid management, grid-level fuel conditioning, …

end user

TSO/DSO

 Quelle: GWI, 2020

Conclusion

- Gas quality fluctuations can pose significant challenges to industrial manufacturing processes, especially for users who are not used to them. The glass industry is just one example. Consequences can range from **reduced product quality** or **process efficiency** to **increased pollutant emissions** or even **safety-related aspects**.
  Often, the Wobbe Index is **not the relevant GQ criterion**. The **NCV** is often considered more important.

- Some **technological solutions exist** to manage gas quality variations, even for sensitive end users. They often have to be **tailored to the specific application**, there is no „off-the-shelf" solution. They can also be quite expensive and have to **comply** with specific **safety-related requirements**, e. g. SIL/PL (SIL: Safety Integrity Levels; PL: Performance Levels).

Thank you for your attention

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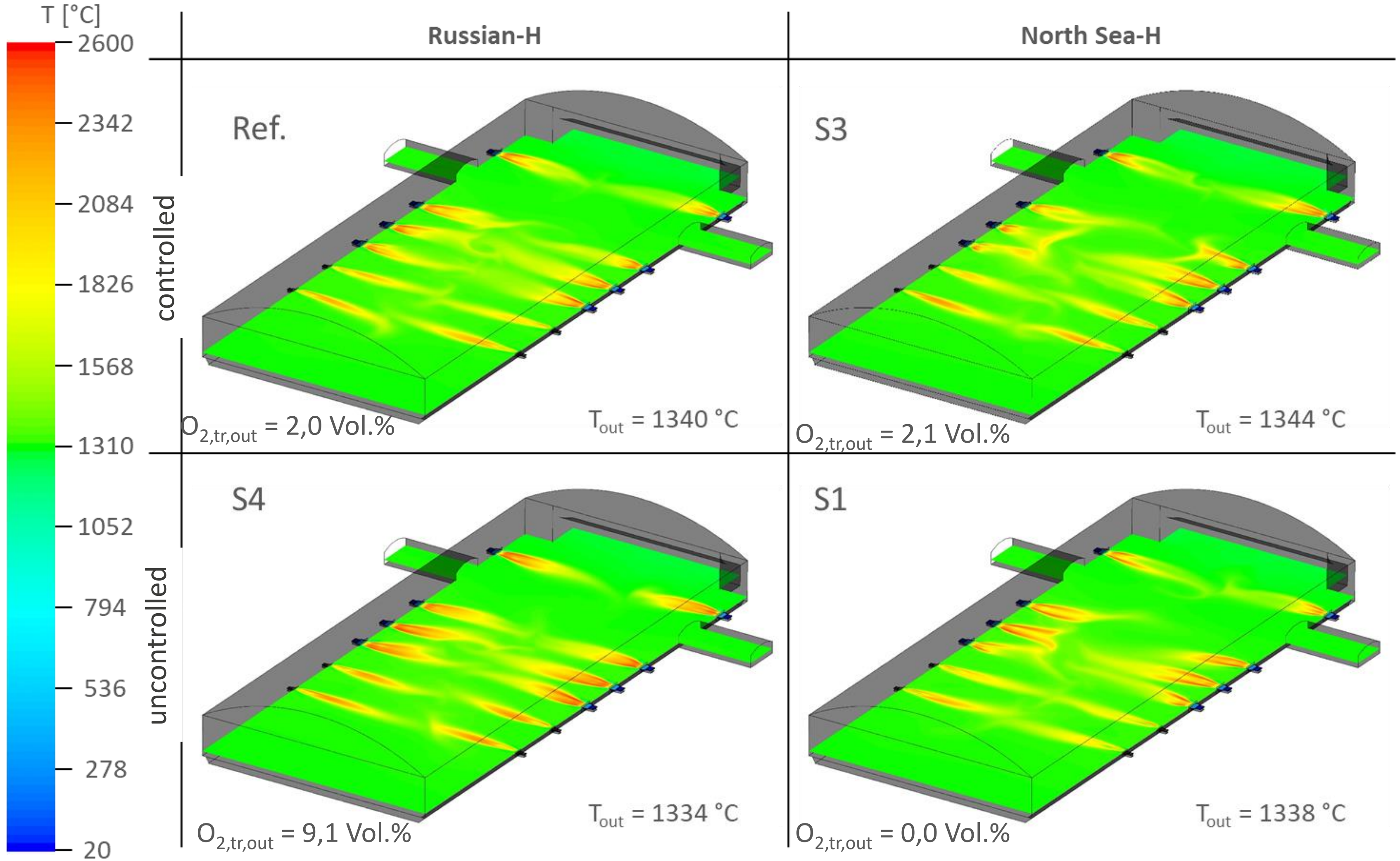
Example: Oxy-fuel glass melting furnace (P_{total} = 14 MW, λ = 1.03, 12 burners) temperatures in burner plane



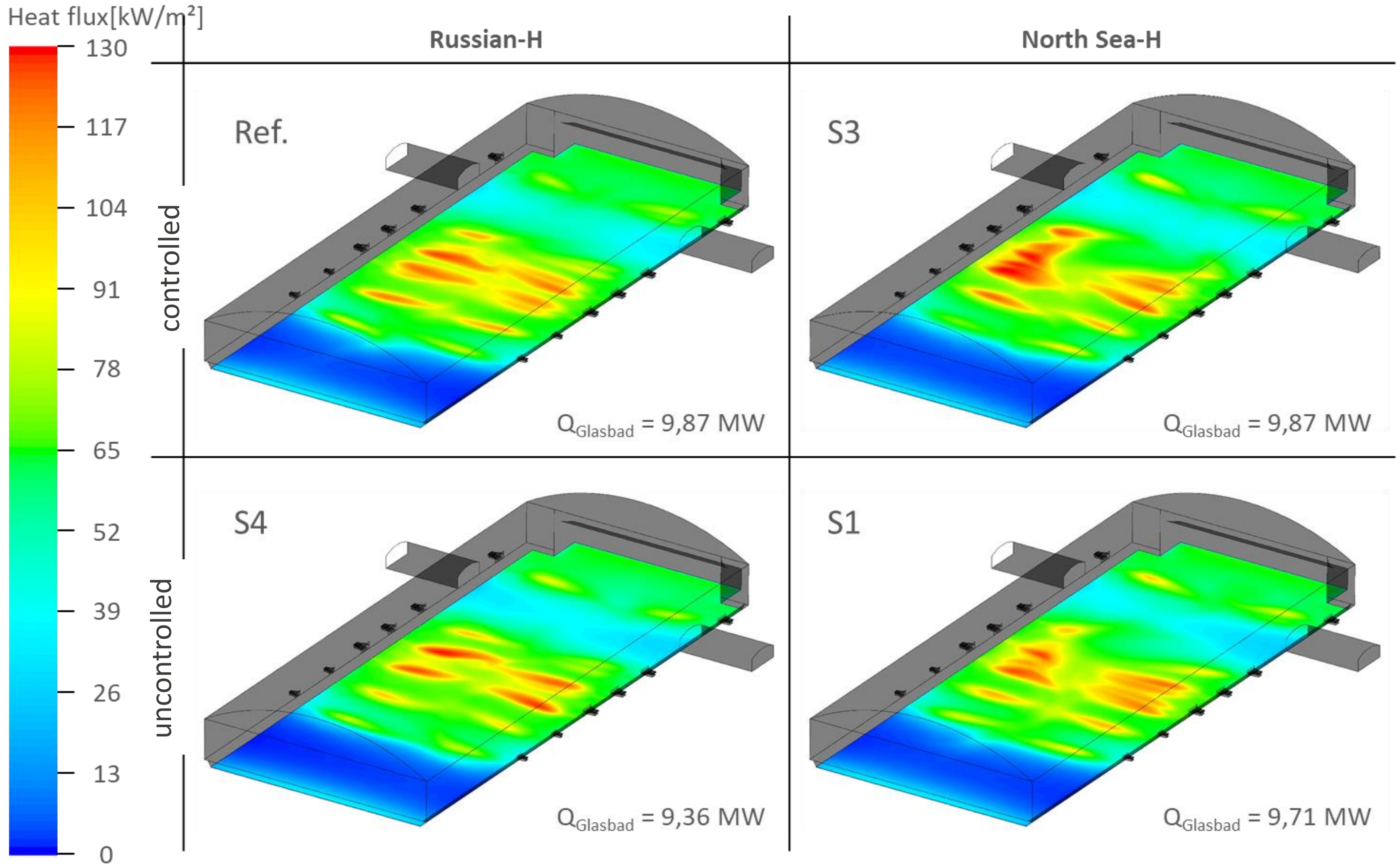
S1: volume flows constant

S3: firing rate and air excess ratio constant

S4: like S1, but switching from North Sea H to Russian H

← λ < 0 !

Example: Oxy-fuel glass melting furnace (P_{total} = 14 MW, λ = 1.03, 12 burners) heat flux into the glass melt



S1: volume flows constant

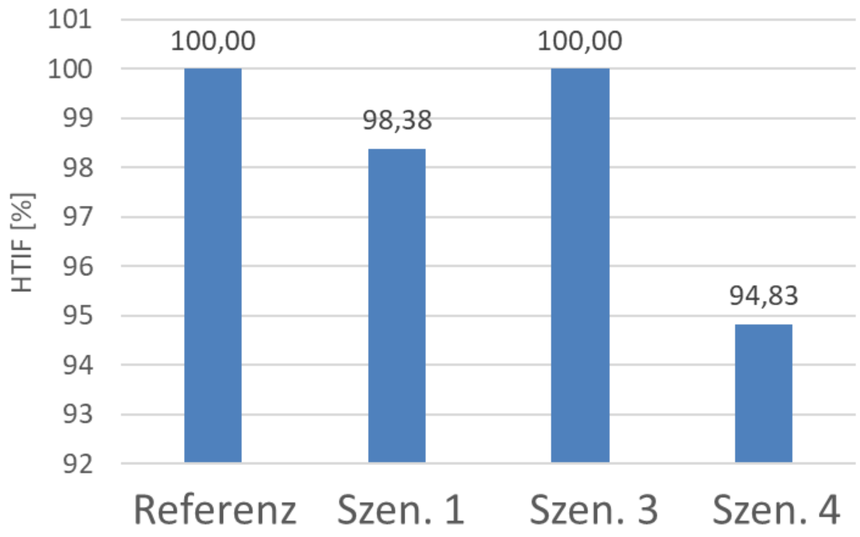
S3: firing rate and air excess ratio constant

S4: like S1, but switching from North Sea H to Russian H

← λ < 0 !

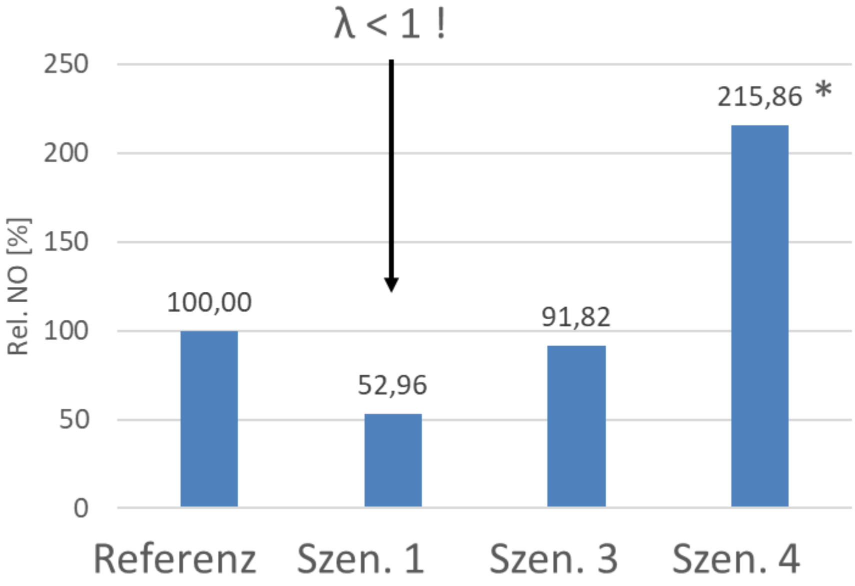
 Quelle: GWI, 2020

Heat transfer efficiency and NO_X



Heat Transfer Impact Factor:

$$HTIF[\%] = \frac{\dot{Q}_{glass}}{\dot{Q}_{glass,reference}} \cdot 100$$



Relative NO emissions:

$$\Delta NO[\%] = \frac{X_{NO,Case}}{X_{NO,Reference\ Case}} \cdot 100$$

*: referenced to S3

Separation of NG / H_2 mixtures - Membranes

Udo Lubenau

DBI Gas- und Umwelttechnik GmbH

Prime movers' group GQ&H2

25.11.2020

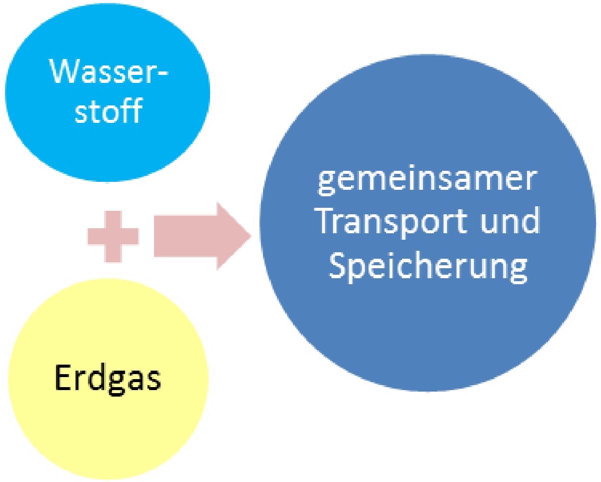
Motivation

current challenge for the gas industry

- slow growth of the available hydrogen volume
- Flexibility of gas application technology has limitation
- Necessity to work with H_2 / natural gas mixtures

The generation and storage of hydrogen will (in the start-up phase) have access to the infrastructure of the natural gas network - options for the coexistence of natural gas and H_2 are necessary

Note: There will be mixtures not only in the distribution network, but also in the underground gas storages (UGS) . The UGS are a decisive factor in the storage of "green energy" throughout Europe. These storage facilities will be converted from natural gas to hydrogen over a period of several years.



Separation by means of membranes

H_2

Question for example:

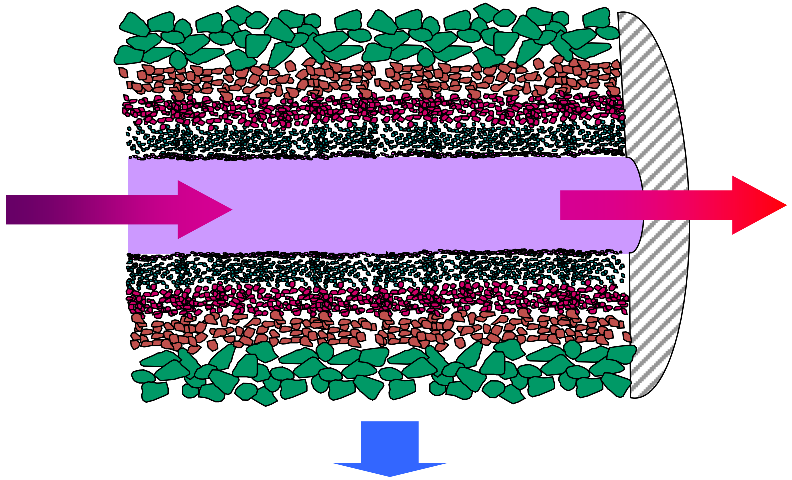
1. What membrane material is suitable for the hydrogen / natural gas separation task?
2. What operating conditions do these membranes require (e.g. pressure, temperature)?
3. Costs

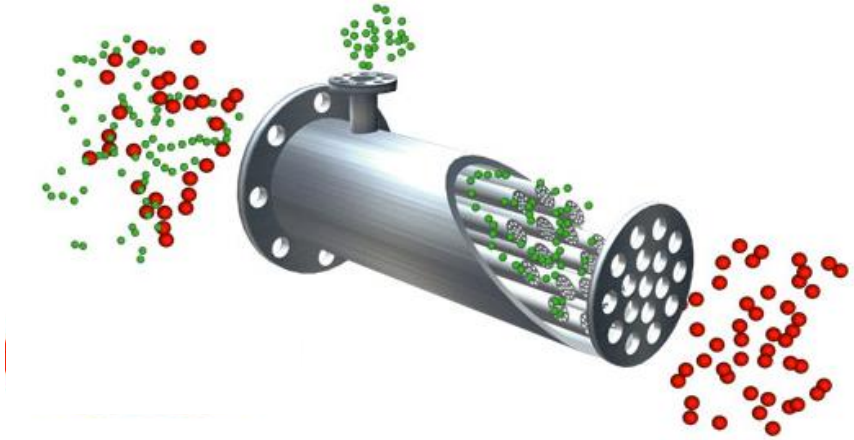
Different projects in Europe

Actually questions e.g.

- Effects of different hydrogen concentrations (10, 20, 30 Vol.-%) on the separation process (system d costs)
- design of the membrane plant (membrane ares, dressure stages, handling the separated gas flow)
- Stability of the membrane material
- Effects of discontinuous operation on the operation and design of the membrane plant

Membrane filtration

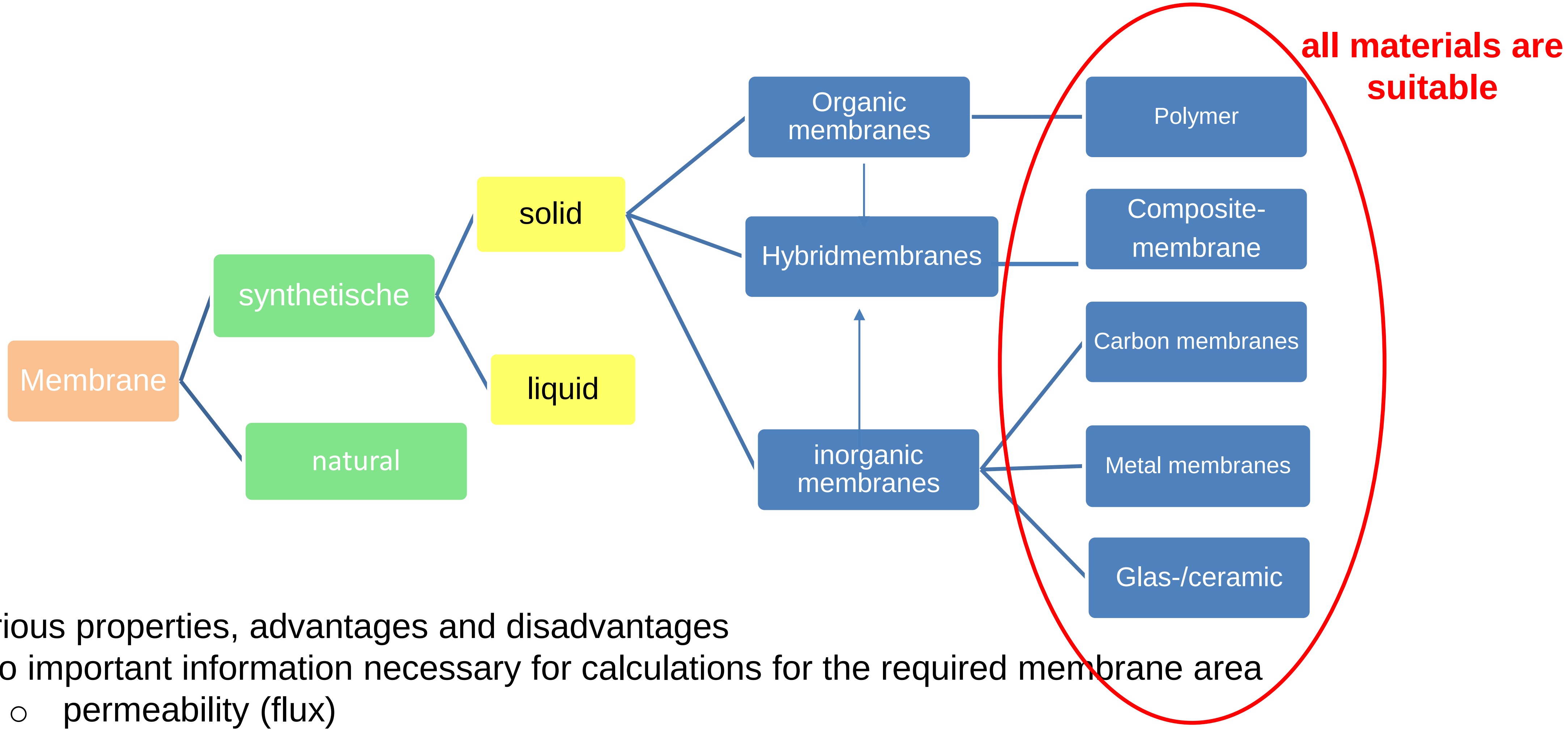




- simple, pressure or concentration driven, continuous separation process
- low energy consumption, low product lost, short start-up time, very little pressure loss, modular construction,
- non-organic membranes of high thermal, chemical, mechanical stability

→ membrane separation at conditions of connected processes

Membrane Materials



various properties, advantages and disadvantages

Two important information necessary for calculations for the required membrane area

- permeability (flux)
- selectivity

State of the art

- Feasibility
  - Organic membrane use **in Chemistry** (e.g. UOP, MTR, EVONIK)
  - Membrane systems for gas processing from **100 - 300,000 m³ / h exist** (TRL 9)
  - only one polymer membrane (Evonik) has been tested for this application (natural gas, low H_2-konzentration), data are thin
  - More test with this membranes in natural gas start next year
  - Some inorganic membranes are on TRL 5 –also some data available
  - Palladium membranes – data on use in natural gas not available, possibly to be derived from completely different applications
  - A lot of other membranes tested in Laboratory (different conditions, comparison often not possible)
- Availability
  - EVONIK polymer membrane (Evonik + Linde is currently promoting this membrane)
  - Pd-Membrane – without tests
  - For tests at TRL 5 – 6 (pilot planes), some projects in Europe will start next year

Example Polymermembranen

- **Applications of polymer membranes for H2 separation**
  - ➢ ammonia synthesis, PSA-Tailgas, Hydrocracker
  - ➢ Production of methanol

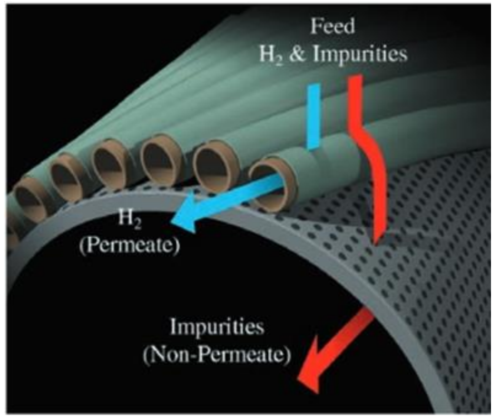
Producer

- **UOP (PolySepTM)**
- **Air Products (Prism®)**
- **MTR (VaporSep-H2 TM**)
- Evonik Industries AG (SEPURAN®Noble),
- Air Liquide S.A. (MedalTM – H2)

- *Hydrogen purity:* *< 95%*
- *Hydrogen recovery:* *< 90%*
- *H_2-product pressure:* *< feed pressure*
- *Feed pressure:* *15 – 128 bara*

Application forms actually

- Cartridges or modules with hollow fibers
- Primarily polyamides and polyimides
- In general: higher H_2 purity is associated with lower recovery and vice versa

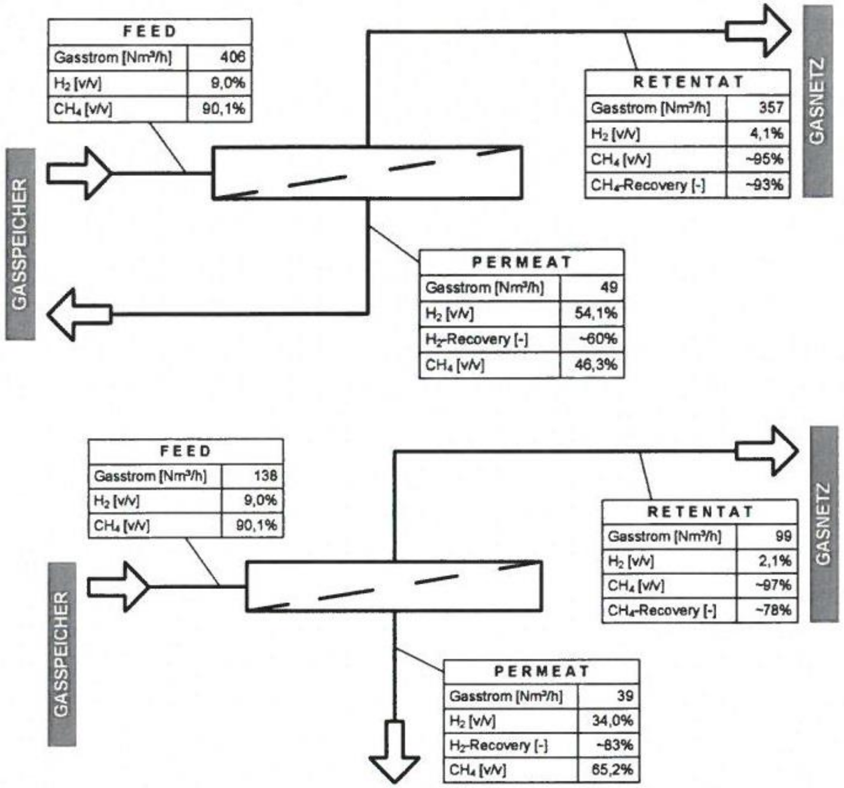


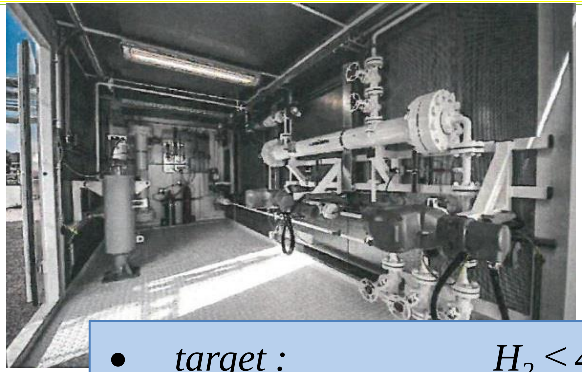
PolySep Hohlfasermembran (Quelle UOP)

Task

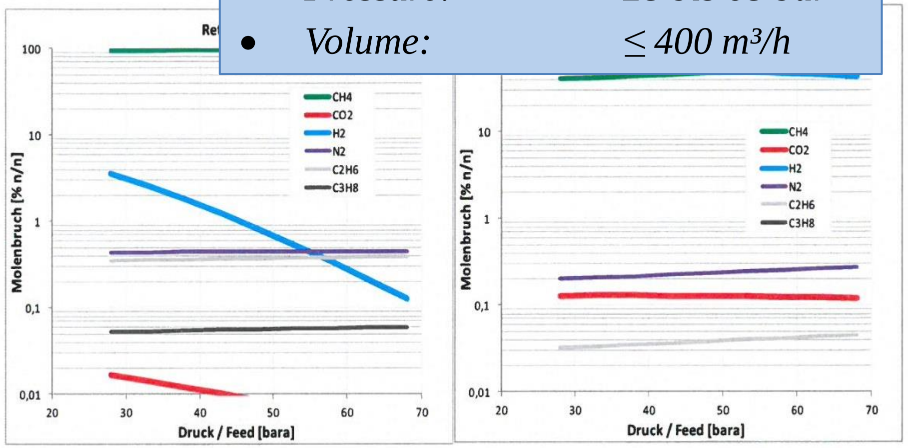
- <u>Membranes have to be adapted (initial concentrations of H_2 so far from 40 to 70% in the feed, natural gas accompanying substances)</u>

Example Polymermembrane– RAG-Project Sun Storage





- *target :* $H_2 \leq 4\%$
- *Pressure:* *28 bis 68 bar*
- *Volume:* ≤ 400 *m³/h*



Different operating modes of the membrane system

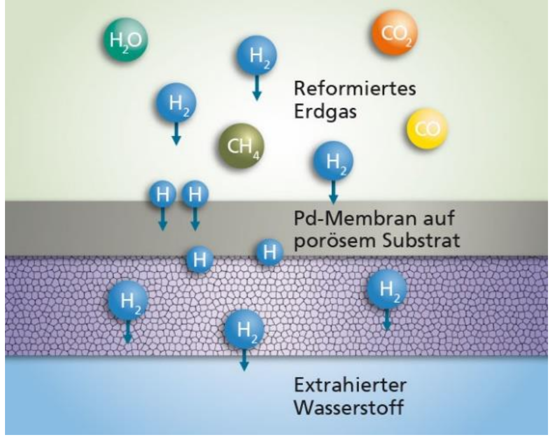
1. H_2 (Vol.-%): Feed 9,8/ Retentat 4,1/ Permeat 54,1
2. H_2 (Vol.-%): Feed 9,8/ Retentat 2,1/ Permeat 34,0
3. Trennfaktoren H_2/CH_4: 11,7 bzw. 5,2

Concentration curves in retentate and permeate

Example Palladium membranes (Pd bzw. Pd-Alloy)

Characteristics

- High temperature membranes, typically from 300 ° C
- Permeabilities can be very high: 5 - 25 m³ / (m²hbar)
- Very high purities possible: 99.9999% H_2 in the permeate
- Costs relatively high
- Alloy metals improve thermal and chemical stability
- problem S compounds - irreversibly destroy material – desulfurisation
- on porous support (e.g. aluminum oxide)

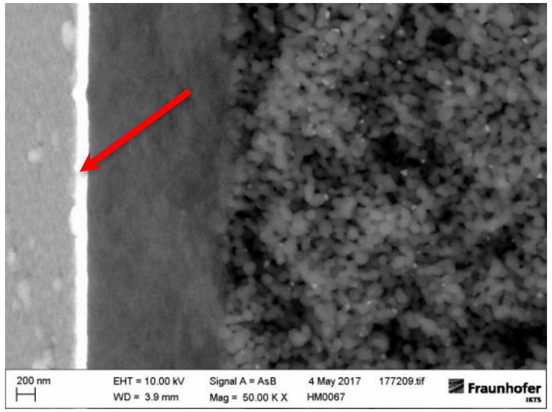


Producer / researcher

- **Johnson Matthey, Media and Process Technology Inc.**
- Nichtkommerzielle Lieferanten (TECNALIA, Linde, SINTEF)

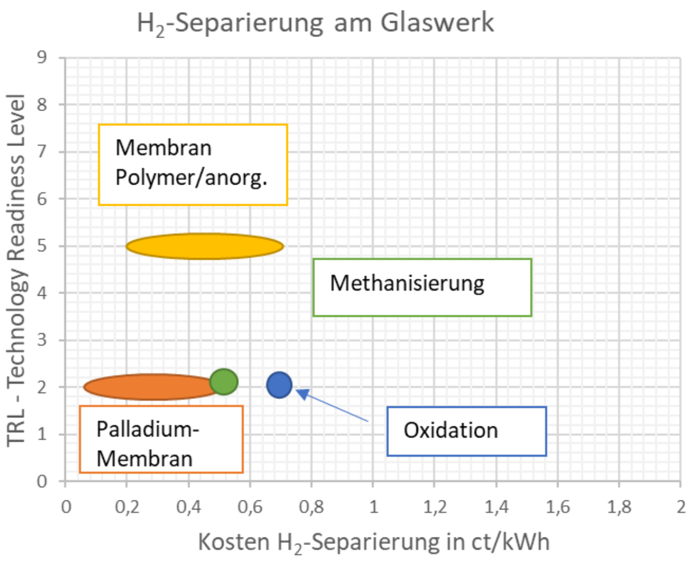
Research

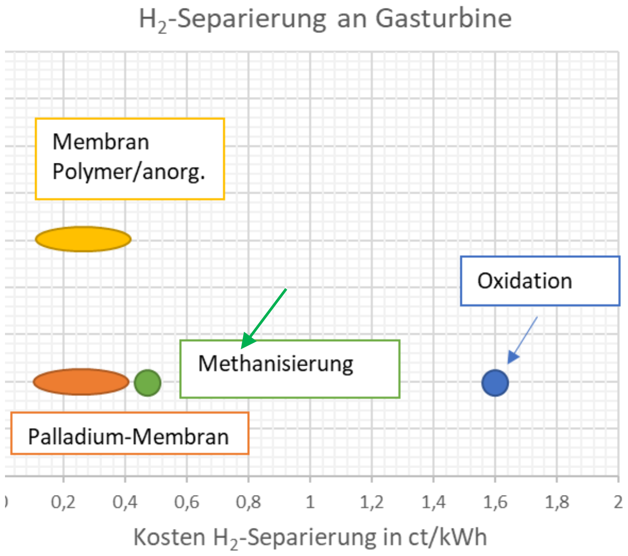
- Very thin palladmium
- High flows of H_2 (> 10 m³ / m²hbar) and high H2 / N2 selectivity, but above 400 ° C
- Installation of palladium in pore structures - chemically more stable



<200 nm Pd layer on ceram. Support (source Fraunhofer IKTS)

Economic and technical classification of the protective function





TRL 1 – basic principles observed
TRL 2 – technology concept formulated
TRL 3 – experimental proof of concept
TRL 4 – technology validated in lab
TRL 5 – technology validated in relevant environment
TRL 6 – technology demonstrated in relevant environment
TRL 7 – system prototype demonstration in operational environment
TRL 8 – system complete and qualified
TRL 9 – actual system proven in operational environment

- Case 1 : 16 bar, 2.000 m³/h, 10 % H_2
- Case 2 : 25 bar, 150.000 m³/h , 10 Vol. -% H_2 to 2 Vol.-%

Note: TRL of the membrane (the TRL of the membrane process is 9)

Hydrogen separation costs depend heavily on the volume flow (filling stations are expensive)

Summary :

- Uncertainties in membrane separation behavior and membrane stability are to be examined by the research centers.
- Pilot projects are necessary to raise the Technology Readiness Level from TRL 7 (prototype in use) to TRL 9.

Example test side – pilot plant

Pilot plant

- ONTRAS / MITNETZ / GRTGaz and DVGW e.V. finance the installation of a pilot system near Berlin
- Test with approx. 2 m³ / h natural gas / hydrogen mixture (conditions such as pressure and H_2 content variably adjustable
- H_2 test concentration 10-20 % in natural gas

Financing of the actual membrane testing via DVGW

Energy with Future.
Environment and Responsibility.

Thank you very much for your attention!

Your contact person

Udo Lubenau

Head of department

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Q&A session 2

Conclusions from assessment exercise

Feedback received

CECOF

EUROMOT
The European Association of Internal Combustion Engine Manufacturers

gwi

ehi
association of the European Heating Industry

CEER
Council of European Energy Regulators

EFET
European Federation of Energy Traders

cefic

afecor

EASEE-gas
Streamlining the gas business

marcogaz

EURAMET

Energy Community

gie

Gas Distributors GD4S For Sustainability

GEODE

CEDEC

eurogas 30 years

entsog

ERIG
European Research Institute for Gas and Energy Innovation

Feedback received

Appliances/applications & Industrial/commercial/residential users

Euromot
EASEE-gas
CEFIC

Euramet
CECOF
Marcogaz

Afecor
EFET
EHI

GWI*

Missing some end-use representation?

ERIG
Energy Community
CEER

System operators

Eurogas DIST
EASEE-gas
GD4S
GEODE

CEDEC
GIE
Marcogaz
ENTSOG

Shippers/gas producers

EFET
EASEE-gas
Eurogas

Lack of upstream representation?

*GWI is an independent and neutral research organisation focusing on applied research in the use of gaseous fuels, with members from all parts of the value chain. J. Leicher joins the prime movers' group as expert on gas quality issues due to his contributions and involvement in the CEN process regarding the WI.

Feedback received – Concerns

Feedback received - Blends & GQ variation solutions

Regulation & market rules

- Review current rules and the need for new or updated ones
- Provide a regulatory framework for WI classification system proposal (duration validity, communication procedures)
- Align at MS level on H2 injection possibilities
- Develop rules to provide system operators with a more active role in GQ management

Specifications, standards, interconnection/national connection agreements, and interoperability rules

- Modification of regulations and technical, metrology and safety standards
- IA including technical possibility to accept H2 blends at IPs, and defining mitigation measures

Metering, tracking, forecasting systems

- Assess the need to increase the number of gas quality measurements on the network, introduce dynamic simulation tools
- Accredited calibration
- Laboratories to evaluate the performance of the gas analysers assuring traceability on the measurement
- Analysers' specs with low detection and quantification limit concerning H2 content and low cycle time
- Develop new models correlating gas composition with CV along with validated process GC

Assets, equipment, storages readiness

- Technical assessment of connected end-users and identifications possible limits or mitigating measures
- Assessment of whether all parts of the grids can handle the blend limit of the MS
- Impact of O2 and H2 on storages

Blending, de-blending services

- Build separation facilities at interfaces between TSO and LSO
- Technology maturity (R&D in separation techniques)
- Remuneration mechanisms
- Operating conditions

Injection control, blend stability mechanisms, and associated costs

- Define gas quality stability criteria at H2 injection points
- Adopt safety measures, control units and loops in the case of changing blends
- Correct physical planning for the injection plants/blending stations
- Large-scale seasonal hydrogen storage at the injection point
- Injection constraints could be defined at P2G units to limit gas quality variations in the mix
- Grids with reverse flows may need specific rules and procedures

Feedback received - Dedicated H2 systems solutions

Market rules

- Approval of regulatory documents governing access of H2 producers to the gas infrastructure
- Revision of market NCs (e.g. balancing, interoperability)

H2 specifications

- Develop an EU-wide H2 specification (i.e. 'purity')
- Assessment of suitable odorants for hydrogen

Flame & leak detectors, flow metering

- Innovation activities to close the gap between what is needed and what is in the market
- Assess need for replacement of gas metering devices, development of technical rules for fiscal metering concerning hydrogen
- Online analysis capable to assess the impurities in hydrogen going into the grid, and calibrate flow meters with varying impurity concentrations
- Understand conditions for hydrogen storage

EU regulatory framework

Safety & emissions

- Technology developments & standarisation for H2 solutions (e.g. for combustion processes)

Cross-border planning (EU and non-EU)

- Start planning a wide coordination with third countries
- H2 network development jointly coordination between MS

Identification of potential solutions

Proposal of process structure

1. Identify **‘what’** needs to be done
    1. Gather all the issues, concerns and questions (First work deliverable)
    2. Cross-check them with ongoing, finalized or future initiatives: EU funded projects, R&D work or associations that are working on the topic with a great stakeholder’s involvement
    3. Identify knowledge gaps and prioritise the work to be done considering current dynamics at EU level
    4. Agree on ‘what’ this group should work on
2. Assess **‘how’** it can be done
    1. Sub-groups to work on specific topics
    2. Goal: Each sub-group to deliver specific solutions, recommendations or best practices on “how” to proceed with each process considering all the possible “what” identified
    3. Provide the group with clear technical feedback about “what” each part of the value chain can do and “how” can they move forward
    4. Facilitate, and eventually reach, an agreement/consensus for each of them

Solution template proposal

- For each issue or cluster of related issues, the following questions should be answered by the sub-group in charge:
  1. **Which is the issue and why it is important?** (impact, consequences)
  2. **Did it exist before or is it a consequence of introducing renewable gases** (biomethane, H2, syngas, etc)?
  3. **Stakeholders directly impacted**
  4. **How immediate should it be tackled?** (in years)
  5. **Is there any project or initiative already addressing this issue?** If yes, which one and when would the deliverable be ready?
  6. **Which solutions or mitigation options already exist? Which are the associated costs?** (knowledge sharing of how this issue is currently being tackled in different countries or in other processes but could be extrapolated)
  7. **Is there a solution that could be widely applicable in most cases?**
  8. **If yes, what would be needed to make it widely available and applicable? If not, why?** (is it lack technical experience, regulatory framework, market rules? At EU or national level? Go deeper into the specifics)
  9. **Is there any solution/idea that should be further investigated?** (field tests, knowledge gaps, etc)
  10. **Final decision or recommendation** (is the issue already addressed and analysed? Should the prime movers' group work on this specific topic? Or should this issue be tackled in another organization or level?)

Example 1: Odorisation & de-odorisation

1. **Which is the issue and why it is important?** The odorisation and odorant used today for natural gas can cause issues for sensitive end-users, as such gas is not odorised over the whole value chain, with reverse flows this may need to change
2. **Did it exist before or is it a consequence of introducing renewable gases (biomethane, H2, syngas, etc)?** Increase of decentralised injection creates an issue when the flows are reversed rather than only working in vertical way
3. **Stakeholders directly impacted** TSOs and DSOs – sensitive users depending on the molecule used to odorise (sulphur discussion)
4. **How immediate should it be tackled? (in years)** next 3 years
5. **Is there any project or initiative already addressing this issue? If yes, which one and when would the deliverable be ready?** Reverse flows development in several countries will bring experience + de-odorisation units built in BE (as far as aware)
6. **Which solutions or mitigation options already exist? Which are the associated costs?** De-odorisation unit - (approx. 100,000€ for an adsorption unit)
7. **Is there a solution that could be widely applicable in most cases?** De-odorisation unit/ change molecule used to odorise/change the responsible for odorisation
8. **If yes, what would be needed to make it widely available and applicable? If not, why?** TRL increase for deodorisation units by increasing uptake/regulation change to modify the actor responsible for odorising
9. **Is there any solution/idea that should be further investigated?** make sure molecules that would replace THT do not create issues for sensitive end-users
10. **Final decision or recommendation?**

Example 2: Operating conditions for de-blending services

1. **Which is the issue and why it is important**? Blends are likely to increase across the grid, end-users may wish to procure 100% hydrogen for their processes and uses which would require deblending facilities/membranes in many scenarios. The question is who could operate these membranes
2. **Did it exist before or is it a consequence of introducing renewable gases (biomethane, H2, syngas, etc)?** Has existed before. It will be a consequence of blending in certain grids which connect sensitive users, the question of operation is a direct consequence of this
3. **Stakeholders directly impacted**: Industrial users/sensitive users/storages – for the operation anyone across the operator/user/service provider who could be willing to provide that service
4. **How immediate should it be tackled?** (in years) immediately
5. **Is there any project or initiative already addressing this issue? If yes, which one and when would the deliverable be ready?** Membranes are being assessed in several projects across the EU e.g. Germany, Spain, UK, Austria.
6. **Which solutions or mitigation options already exist? Which are the associated costs?** Membranes already exist in market, eg. are used for the separation of CO2 in biogas plants. Cost depend strongly on purity of gases needed. Research continues.
7. **Is there a solution that could be widely applicable in most cases?** Membranes will be applicable in most cases – who should operate them is an open question
8. **If yes, what would be needed to make it widely available and applicable? If not, why?** Addition to an existing NC needed for this? Guideline could be useful? Or follow existing rules for service provisions?
9. **Is there any solution/idea that should be further investigated?** Accelerate TRL development to lower CAPEX+OPEX and in parallel assess who operates the membranes in current demonstrator projects/tests
10. **Final decision or recommendation**

Next steps & way forward

Identified 'Cross-cutting' topics

Blended gas

Regulation & market rules with blended gas

- Review current rules. Assess need for new or updated ones
- Regulatory framework for WI classification system proposal (duration validity, communication procedures)*
- Align at MS level on H2 injection possibilities

Standards, connection agreements, and interoperability rules

- Modification of regulations and technical, metrology and safety standards
- IAs including technical possibility to accept H2 blends at IPs, and defining mitigation measures
- Develop rules to provide system operators with a more active role in GQ management

Dedicated H2 systems

Market rules for dedicated H2 systems

- Approval of regulatory documents governing access of H2 producers to the gas infrastructure
- Revision of market NCs (e.g. balancing, interoperability)

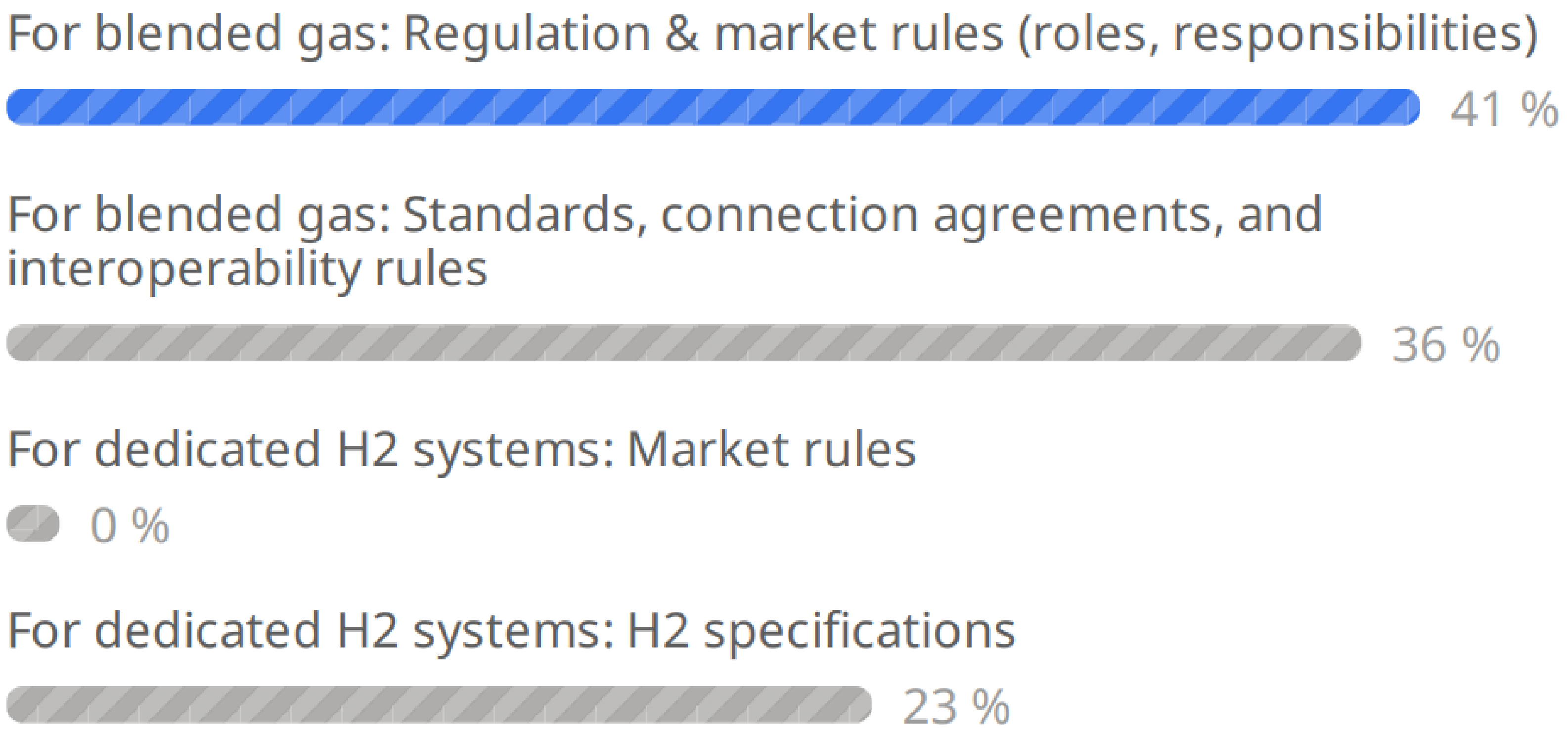
H2 specifications

- Develop an EU-wide H2 specification (i.e. 'purity')
- Assessment of suitable odorants for hydrogen

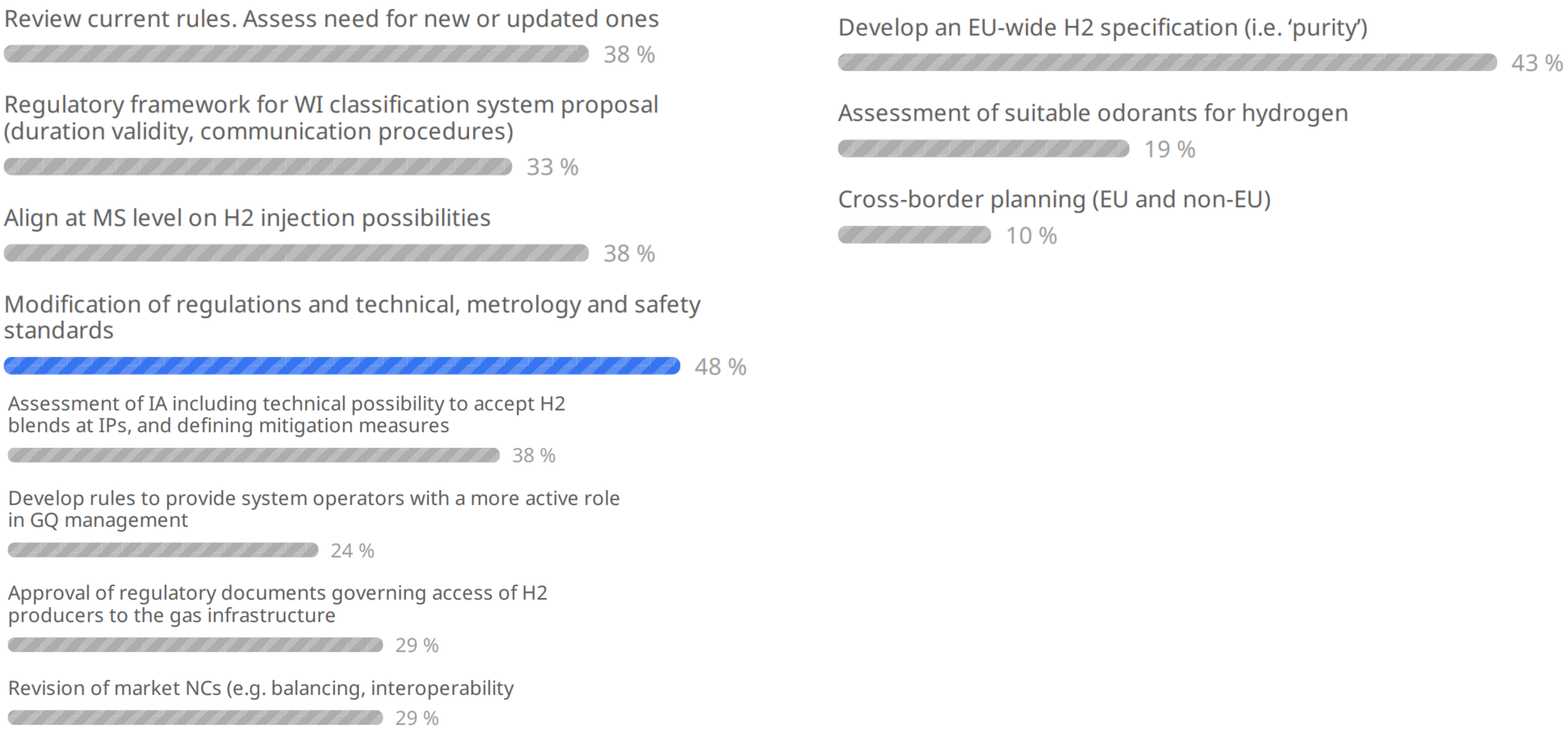
Cross-border planning (EU and non-EU)

*Regulatory framework for WI classification system proposal : Although it is a regulatory topic, this group seems to be the appropriate set up to start this work

Which of the 'cross-cutting' topics you find most important to be tackled? Only 1 option



Which sub-topics within the 'cross-cutting' ones should be tackled first? You can choose several options



Proposal: Sub-groups examples

Metering, measurement & tracking
- Adaptation of gas analysis & tracking methods
- Digitalisation & smart services/devices
- Adaptation of metrology, metering, measuring, billing
- Injection control
- Flame & leak detectors, flow metering for 100% H2

Readiness
- Grids
- Storages (e.g. UGS)
- End-users

Blending/de-blending
- Operating conditions
- Remuneration mechanisms
- Technology options & maturity

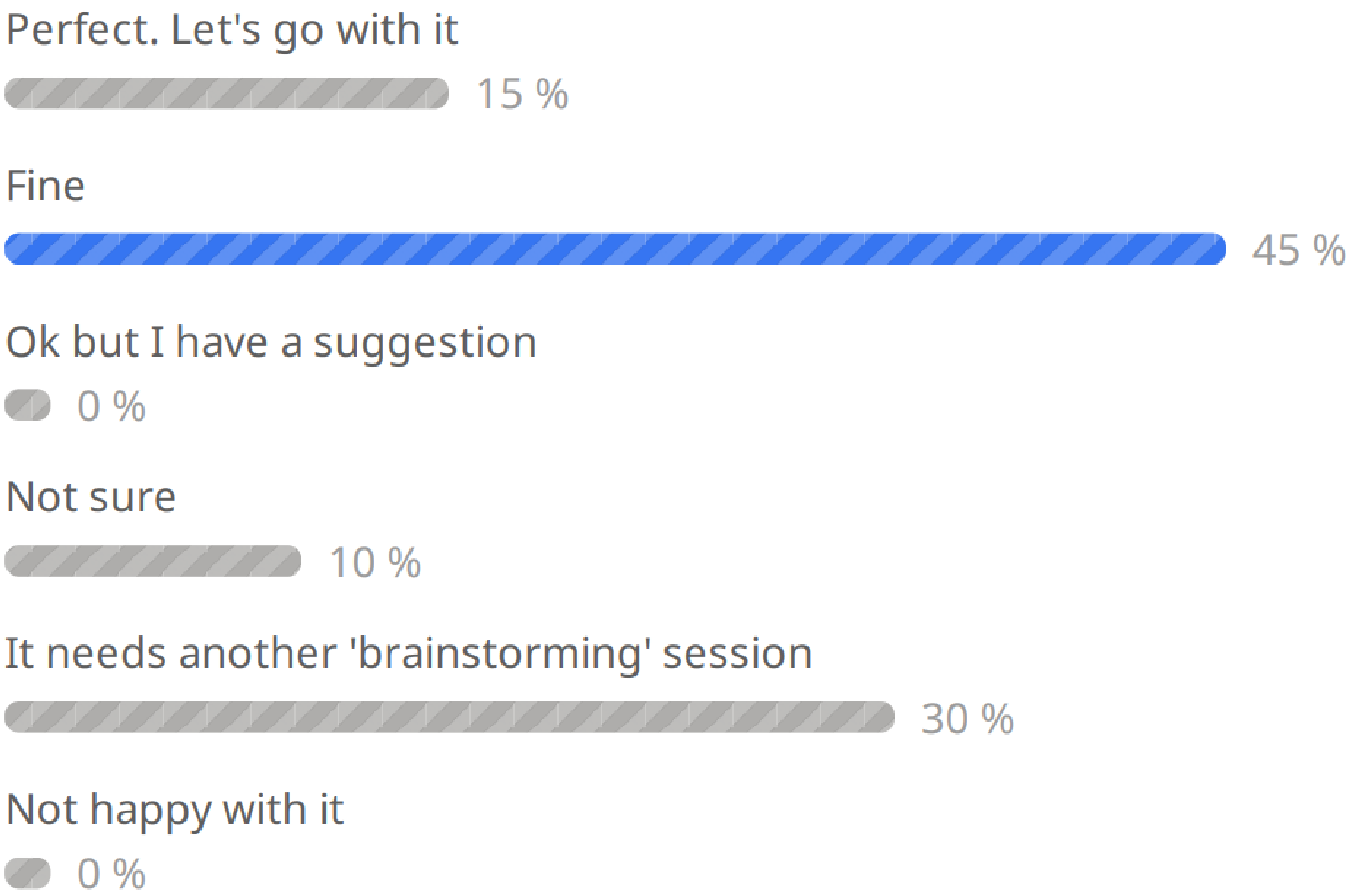
Blend stability mechanisms
- Define gas quality stability criteria at H2 injection points
- Safety measures, control units and loops in the case of changing blends
- Correct physical planning for the injection plants/blending stations
- Reverse flows

Safety and emissions
- Technology developments
- Standarisation for H2 solutions (e.g. certifications)

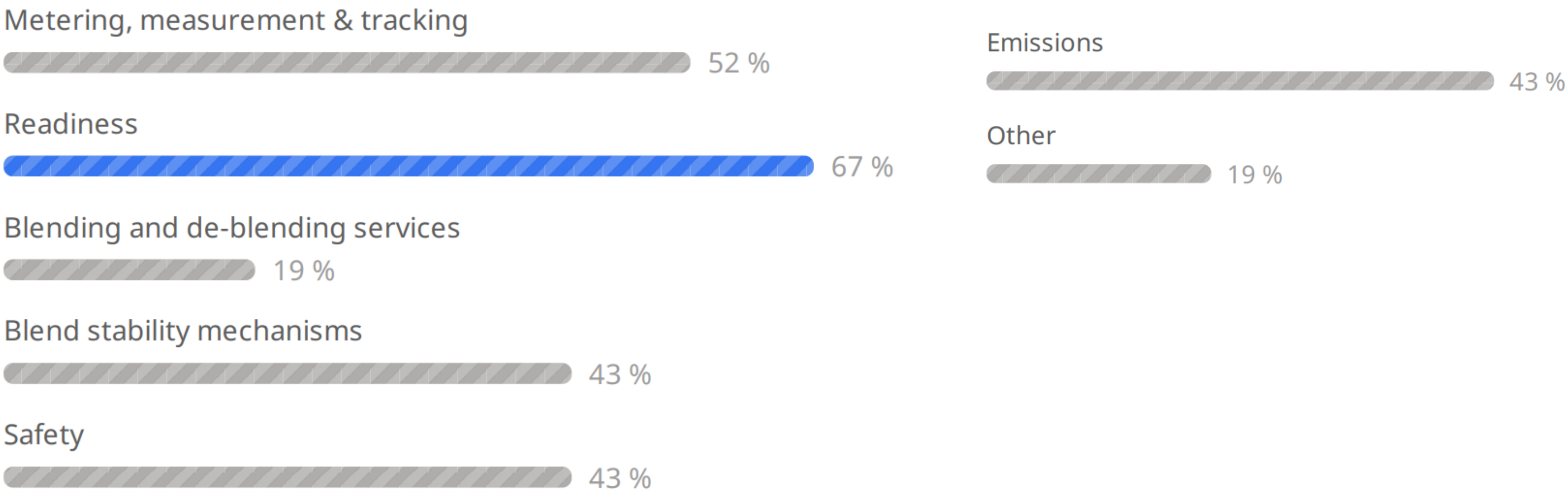
Regulatory framework for WI classification system proposal*
- Duration validity, communication procedures

*Although it is a regulatory topic, this group seems to be the appropriate set up to start this work. An ad-hoc sub-group could be created for that purpose

How did you find the proposal of sub-groups?



In which sub-group you would like or could contribute? You can choose several options



On which specific topics would you like, or could you contribute? You can choose several options

Adaptation of gas analysis & tracking methods
30 %

Digitalisation & smart services/devices
0 %

Adaptation of metrology, metering, measuring, billing
25 %

Injection control
0 %

Flame & leak detectors, flow metering for 100% H2
15 %

Technology options & maturity for blending/de-blending services
10 %

Define gas quality stability criteria at H2 injection points
50 %

Safety measures, control units and loops in the case of changing blends
25 %

Correct physical planning for the injection plants/blending stations
15 %

Reverse flows
10 %

Readiness of grids
35 %

Readiness of storages (e.g. UGS)
15 %

End-users' readiness
55 %

Operating conditions for blending/de-blending services
15 %

Remuneration mechanisms for blending/de-blending services
10 %

Technology developments for safety & emissions
40 %

Standarisation for H2 solutions (e.g. certifications) related to safety & emissions
50 %

Other
10 %

None
0 %

Are we missing any relevant topic? Please specify which one

Addtional GQ criteria

WI classification

social acceptance of hydrogen

funding for adaptation

Gas Quality information exchange

Proposal of way forward

#3 meeting (today)

- Proposal of sub-group' work & topics
- Call of interest for sub-groups

#4 meeting (17th Dec.)

- Finalise sub-groups formation & agree on way of working
- Draft 2021 goals and deliverables

#5 meeting (28th January)

- Finalise agreement on 2021 goals and deliverables
- Presentation of first drafted solutions

Your opinion matters! Your suggestions are welcomed and appreciated

Proposal of way forward

- Before next meeting, we encourage you to provide your feedback on the following questions. Please use this link to submit your answers.

1. Check the **"solution template proposal"** (slide 93) and let us know your thoughts: is this proposal useful? Would it help to find solutions? Are we missing relevant questions?
2. Check the **"Next steps & way forward"**: (slides 97 - 104)
   - Are the sub-groups proposed well appointed? What could be improved?
   - Some "cross-cutting issues" (slide 97) may need to be tackled now, others may be already discussed in another set up while the rest may need to be tackled when the assessment of issues and solutions is over. How do you see it? What is realistically possible to tackle within this group?
   - How would you suggest to move forward? Is there any specific task or deliverable you see important to tackle during 2021?

Please use this link to submit your answers

Next meetings

- Next meeting **17th December** from 10:00 to 13:30 CET

- Proposal for next meetings:
  - 28th January from 09:30 to 13:00 CET
  - 24th February from 09:30 to 13:00 CET
  - 23rd March from 09:30 to 13:00 CET

From January we will start earlier!

You can download the meeting invitations from SharePoint [here]

Thank you for your attention