THyGA: Testing Hydrogen admixture for Gas Applications

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Hydrogen in the gas grid to decarbonise the European energy system

Hydrogen, along with green electricity from wind and solar power, provides a pathway to decarbonise the European energy systems. Hydrogen blending in the gas grid would reduce the carbon footprint of gas utilisation, contributing to an overall reduction of greenhouse gas emissions.

HYDROGEN INJECTION IN THE GAS GRID

One way to use hydrogen as an energy vector is to **inject it directly into the existing natural gas grids.**

INCREASED LEVELS OF HYDROGEN

End-use equipment across all sectors need to deal with higher levels of hydrogen in natural gas in **a safe, efficient and environmentally friendly way.**

NEW CHALLENGE FOR END-USE EQUIPMENT

Hydrogen is not part of natural gas compositions, i.e. **existing equipment was not designed with hydrogen in mind.**

200 MILLION GAS APPLIANCES

There are an **estimated 200 million gas appliances** installed in the European residential sector alone

THyGA

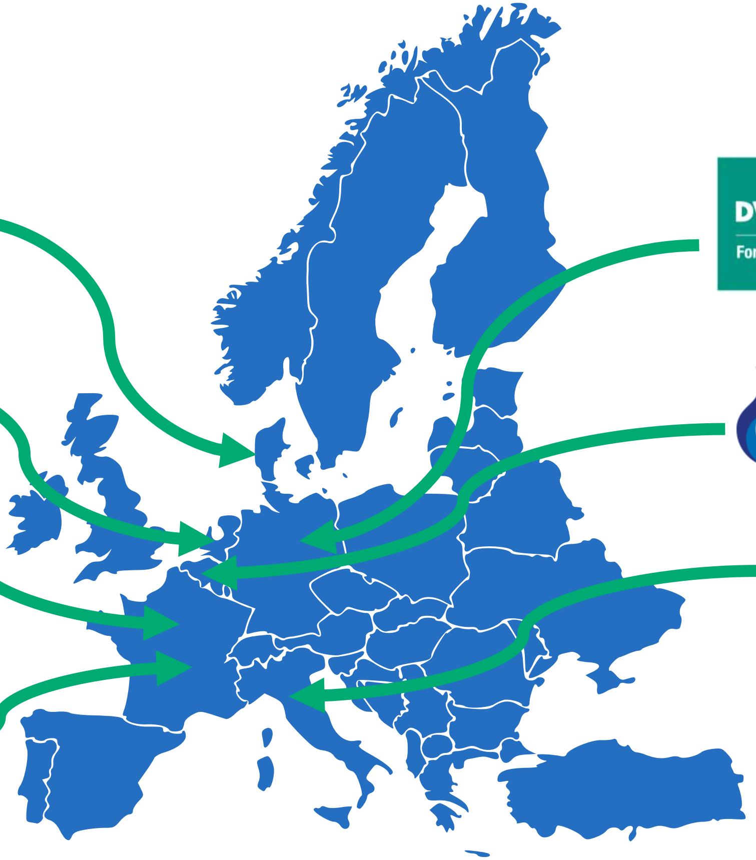
THyGA consortium

Call year: 2019

Call topic: FCH-04-3-2019 - Hydrogen admixtures in natural gas domestic and commercial end uses

Project dates: January 2020 – December 2022

FCH JU contribution: 2.5M€



This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No (No. 874983). This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

Objectives and expected results

CLOSE KNOWLEDGE GAPS

Closing knowledge gaps regarding **technical impacts on residential and commercial gas appliances**.

IDENTIFY STANDARDS TO MODIFY

Identify standards that should be adapted to answer the needs for new appliances and proposals on test gases.

CLARIFY THE ACCEPTABLE HYDROGEN PERCENTAGE

Clarify the acceptable hydrogen percentage that wouldn't compromise **safety and performance**.

Organization

WP1
Project management

WP2
Status of gas utilisation technologies
Actual knowledge and test protocol

WP3
Experimental work
What happens on the field with H2 injection?

WP4
Standardisation
How can we certify an appliance according to H2 rate in NG?

WP5
Recommendation for mitigation measures
How can we increase the acceptable H2 rate?

WP6
Communication dissemination exploitation

Advisory Panel group
Manufacturers, associations, DSO…
And strong links with other European projects

WP2 – Status of gas utilization technologies

T2.1

Screening and segmenting the **portfolio** of domestic and commercial **appliance technologies** and assessing the **impact of hydrogen admixtures**.

T2.2

Setting a joint background of **combustion theory for hydrogen admixtures**.

T2.3

Defining and explaining the variety of studied technologies and publishing **a first assessment of potential hydrogen impacts** based on experts view and literature study.

T2.4

Studying the hydrogen impacts on materials – focus on **hydrogen embrittlement**.

T2.5

Developing a method to prioritise the appliance market segments for **representative testing**.

T2.6

Selection of appliances for testing.

WP2 – Status of gas utilization technologies

T2.1

Screening and segmenting the **portfolio** of domestic and commercial **appliance technologies** and assessing the **impact of hydrogen admixtures**.

~ 50 appliance type/technologies segments (Boilers, water heaters, cookers, catering, space heaters, CHP, GHP, others)

Table 2-2 : Market Segmentation of gas-fired appliances. The overview table shows the appliance population of each market segment in EU, 2020. Unknown: no accurate data available.

THyGA Segment	Type of appliance	Category	Burner type	Standard	Estimation of Total EU Appliance Population 2020 (x 1,000)
101	BOILERS	open flued (former EN 297)	partial pre-mix/conv. (atmos. & fan-assisted)	EN 15502	13,588
102			low NO_x		2,012
103			full pre-mix		152
104		room-sealed (former EN 483)	partial pre-mix/conv. (atmos. & fanned)		25,333
105			low NO_x		1,972
106			full pre-mix		1,781
107		condensing boiler (former EN 677)	partial pre-mix fan-assisted		2,920
108			full pre-mix (including CCB)		56,492
109		Forced-draught burners / jet burners (former EN 303-3)	Forced-draught / jet		1,129
201	WATER HEATERS	instantaneous open flued	partial pre-mix/atmos.	EN 26	14,945
202		instantaneous room sealed	partial pre-mix/fanned		
203		storage, open flued	partial pre-mix/atmos.	EN 89	3,121
204		storage, room-sealed	partial pre-mix/fan-assisted		
301	COOKERS	surface burner (cooktops) with atmospheric burner or "Venturi" burner (vertical venturi burner)	single ring	EN 30-x	32,574
302			single crown		
303			multi ring (mainly double or triple ring)		
304		surface burner (cooktops) with partially pre-mix burner (long horizontal venturi)	single ring		1,352
305			single crown		
306			multi ring (mainly double or triple ring)		
307		cavity burner "tubular" (ovens, freestanding ranges)	atmospheric burner		3,853
308			"venturi" burner		
309			partially pre-mix		27,712
310		cavity burner "metal sheet" (ovens, freestanding ranges)	atmospheric burner		13,056
311			"venturi" burner		
312			partially pre-mix		14,658
401	CATERING	open burners and wok burners	circular burner with vertical slots	EN 203-2-1	unknown
402			circular burner with holes		
403		mixed ovens	draught burners	EN 203-2-2	unknown
404		ovens	tubular or circular burners		
405		boiling pans / pasta cookers	micro-perforated burner	EN 203-2-3 EN 203-2-11	unknown
406		fryers	pre-mix burner	EN 203-2-4	unknown
407		salamanders / rotisseries	ceramic or blue flame burners	EN 203-2-7	unknown
408		brat pans	multi-ramp tubular slot burners	EN 203-2-8	unknown
409		covered burners (griddles, solid tops, pancake cookers)	tubular burner or multi-ramp tubular burner	EN 203-2-9	unknown
410		barbecues	chargrill with burner tubes w/ holes on top	EN 203-2-10	unknown
501	SPACE HEATERS	Independent gas-fired convection heaters type B	heating & decoration	EN 613	4,678
502		Independent gas-fired convection heaters type C	heating & decoration, balanced	EN 613	1,839
503		Decorative fuel-effect gas appliance/burner	heating & decoration	EN 13278 + EN 509	2,529
504		Independent gas-fired flueless space heaters	heating & decoration	EN 14829	98
601	CHP	Stirling engines	heating & electricity production	EN 50465	14.8
602		Internal combustion engine			40.8
603		Micro gas turbine			0.5
604		PEM Fuel Cell			5
605		SO Fuel Cell			2.7
701	GHP	engine HP	Heating	EN 16905	60
702		adsorption		EN 12309	
703		absorption			
801	OTHER	commercial dryers		EN 12752-1 and -2	unknown
802		infrared radiant heaters (former EN 416-1)	non-domestic, tube radiant heaters	EN 416	1,000
803		infrared radiant heaters (former EN 419-1)	non-domestic, luminous radiant heaters	EN 419	
804		infrared radiant heaters (former EN 777-1)	non-domestic, tube radiant heaters	EN 416	
805		air heaters (former EN 1020)	non-domestic, forced convection, fan, <300kW	EN 17082	1,000
806		air heaters (former EN 525)	non-domestic, forced convection, <300kW	EN 17082	
807		air heaters <70kW (former EN778)	Ducted warm air; forced convection air heaters	EN 17082	
808		domestic washing machines		EN 1518	< 10
809		domestic dryers		EN 1518	< 10
				sum	**approx. 228,000**

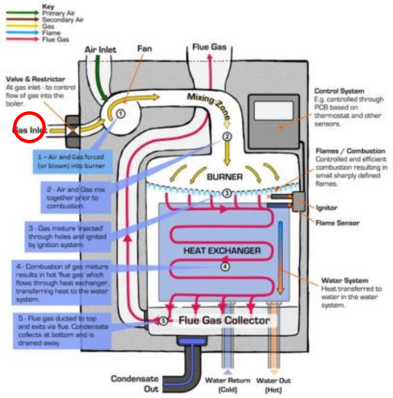
WP2 – Status of gas utilization technologies

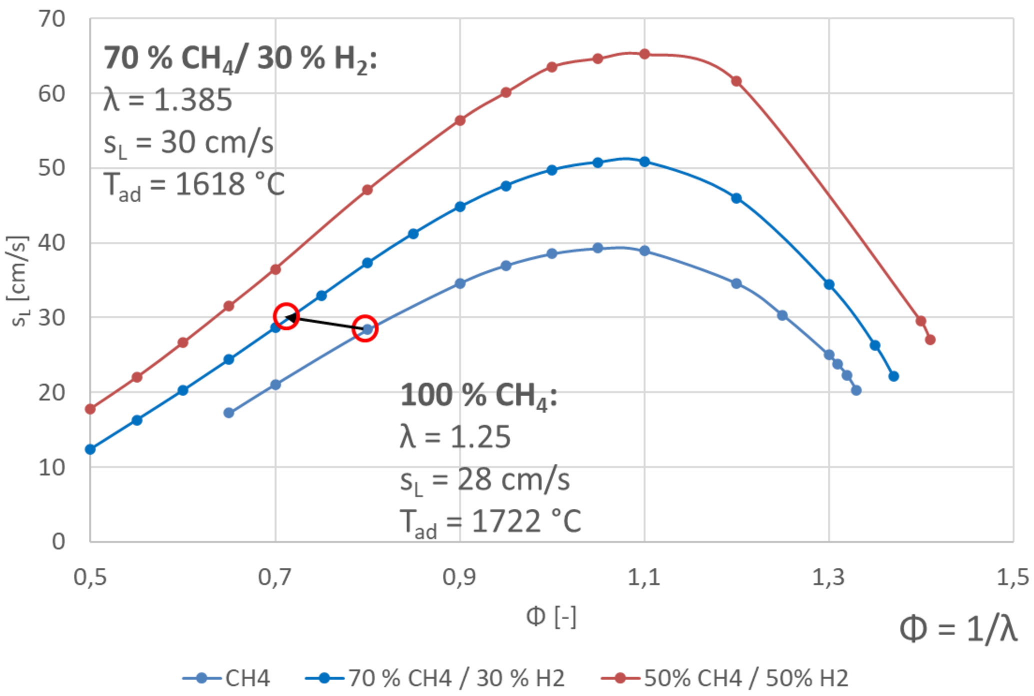
T2.2

Setting a joint background of **combustion theory for hydrogen admixtures**.

Impact on a fully premixed heating appliance

→ **Air excess increases and stabilizes flame velocity**



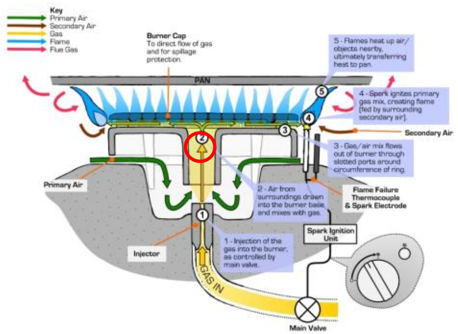


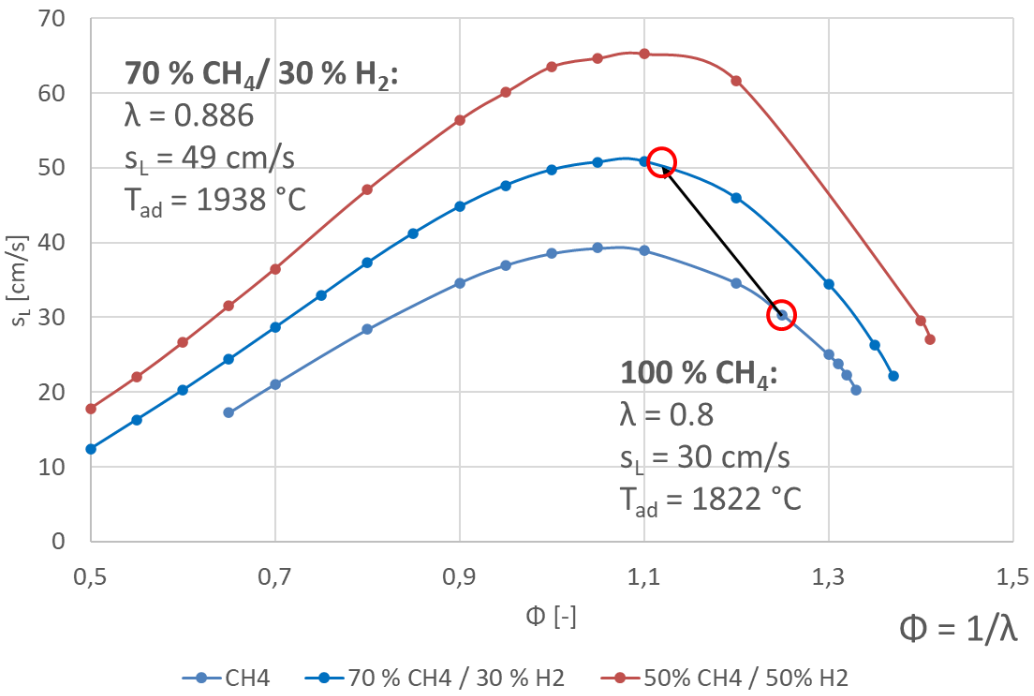
WP2 – Status of gas utilization technologies

T2.2

Setting a joint background of **combustion theory for hydrogen admixtures**.

Impact on a partially premixed cooking hob
→ **Starting with air default means increased impact of blending on flame velocity**





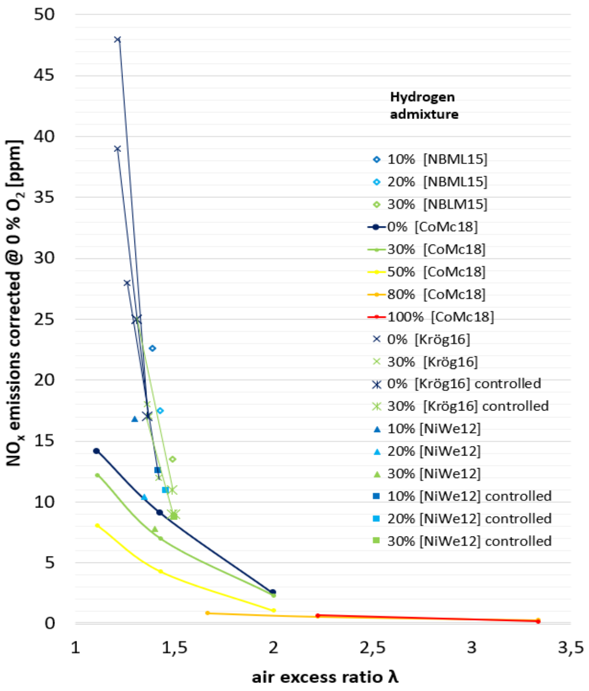
WP2 – Status of gas utilization technologies

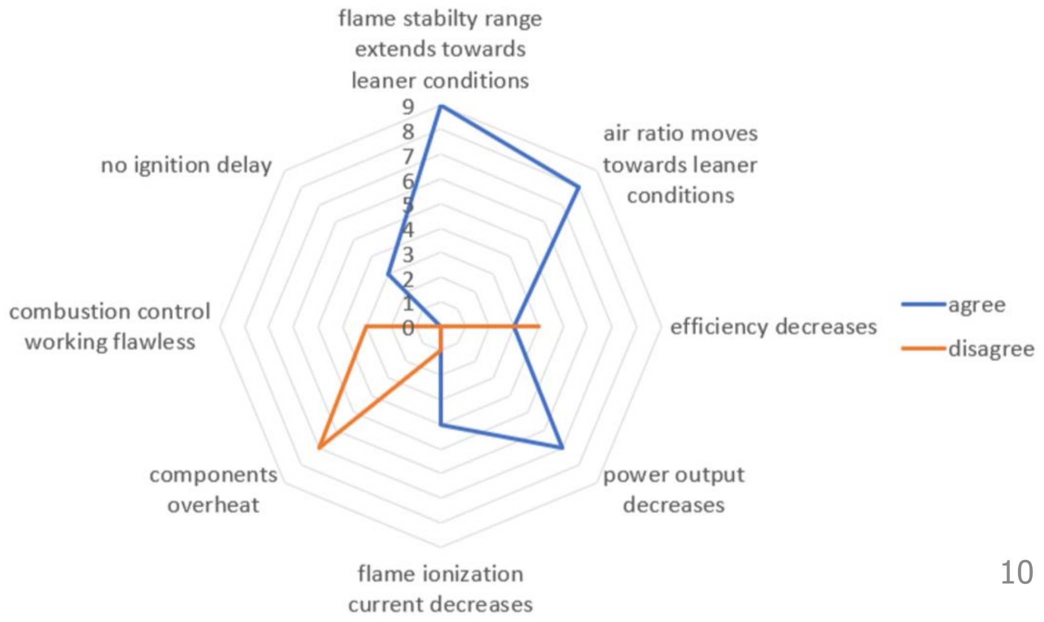
GERG 60 YEARS — THE EUROPEAN GAS RESEARCH GROUP

T2.3

Defining and explaining the variety of studied technologies and publishing **a first assessment of potential hydrogen impacts** based on experts view and literature study.

The study highlighted the differences and incomplete knowledge basis on conclusions and test methods reported in literature, supporting the **strong need for a complete, harmonised lab campaign as the one proposed by THyGA.**





WP3 – Experimental Work

T3.1

Elaboration of the **test protocols** (from T2.5) **and templates**

T3.2

Testing

- 3.2.1: Short term combustion tests - tests for the evaluation of safety, efficiency, environmental performance (NOx, CO, UHC emissions)
- 3.2.2: Long-term combustion test
- 3.2.3: Leakage tests on indoor installation (long term)

T3.3

Data compilation and validation

- 3.3.1: Test results and analysis of **short-term tests**
- 3.3.2: Test results and analysis of **long-term tests**

T3.4

Logistics

T3.5

Management and overall analysis of the test results reporting

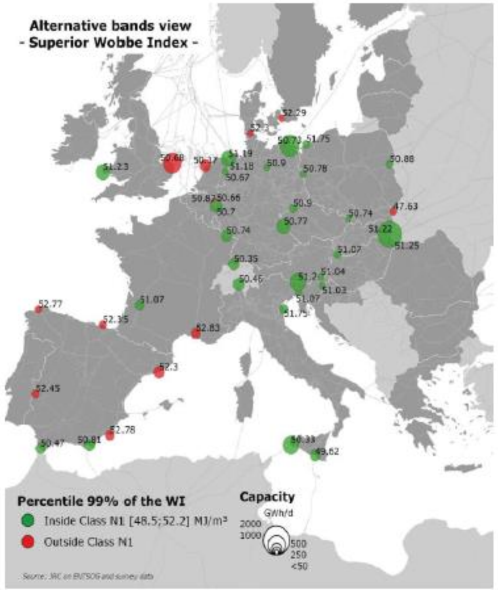
WP3 – Experimental Work

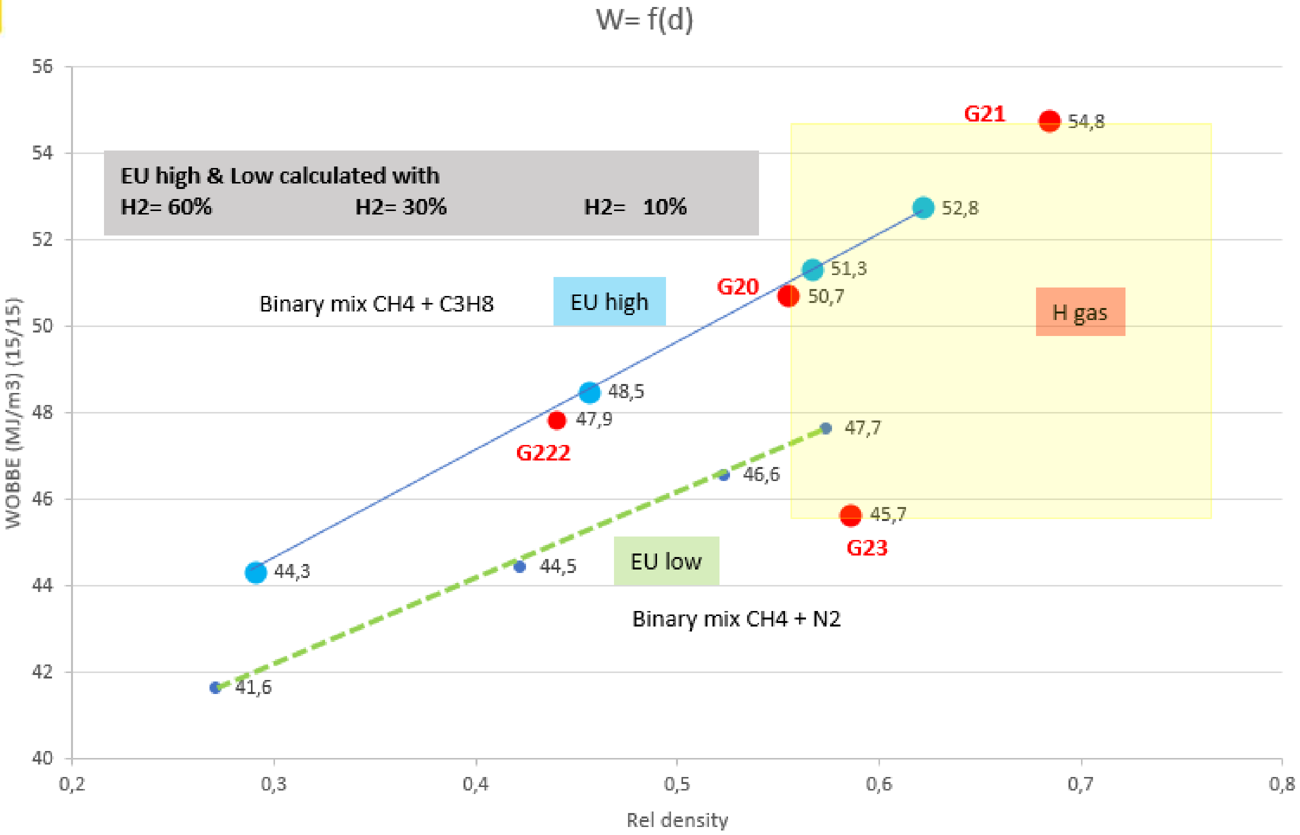
We are not talking about test gases, but distributed gases (EU High and EU Low)

T3.1

Elaboration of the **test protocols** (from T2.5) **and templates**

100% percentile = 47,63 (EU LOW) à 52,78 (EU HIGH) MJ/m3





WP3 – Experimental Work

T3.1

Elaboration of the **test protocols** (from T2.5) **and templates**

FOCUS OF TESTS

SAFETY
- CO
- Flashback
- Overheating

EMISSIONS
- NOx
- CO
- CxHy

EFFICIENCY
- Flue gas Eff.
- electr. consumption

OPERATION
- T(burner)

MOST RELEVANT PARAMETERS

1 GAS
- Initial Natural gas composition
- H2 concentration (up to 60%)
  - o Low = <10% Vol.
  - o Medium = 10-30% Vol.
  - o High = 30-60% Vol. (also 100% if possible)
- Rate of change of H2 concentration

2 APPLIANCES
- Appliance adjustment (for a given gas)
- Qmin / Qmax / On-off
- Used / new appliances

3 TEST CONDITIONS
- Extreme conditions (air temp., overpressure, cold start)
- Long term testing

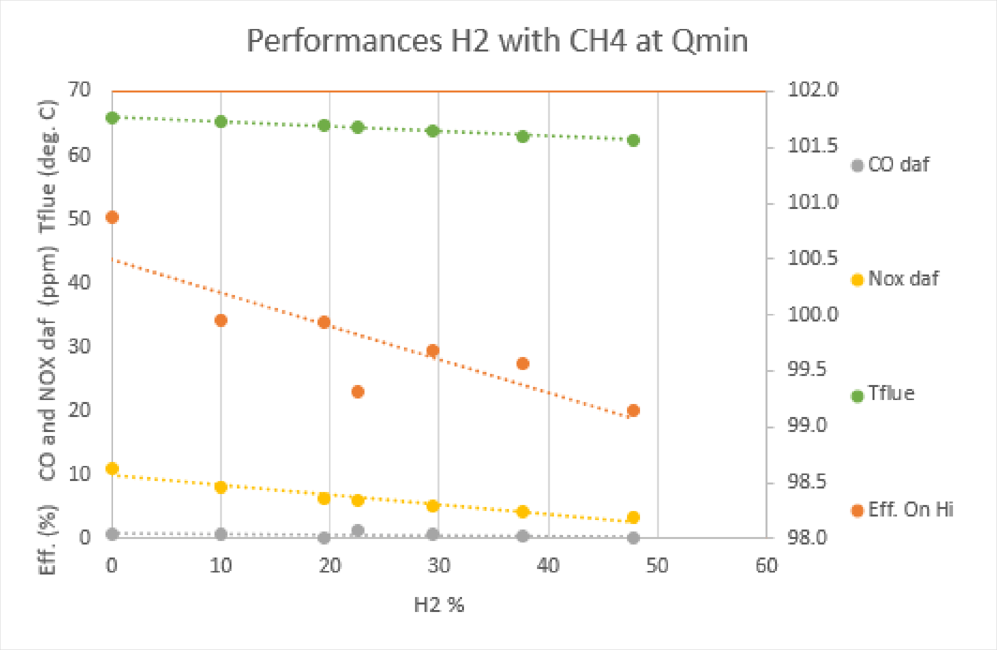
WP3 – Experimental Work

T3.2

3.2.1: Short term combustion tests - tests for the evaluation of safety, efficiency, environmental performance (NOx, CO, UHC emissions)

So far, 30% of the appliances tested: condensing and atmospheric boilers, cooking hobs, ovens, fires, catering

Generally, when H2 % is increasing: Efficiency is not significantly impacted, NOx tend to decrease, CO can or not be impacted



Overview of main results

- **The atmospheric technologies tested so far have been able to cope with 30**% of H_2. Above 30%, potential issues of flashback and high temperature due to a change of combustion properties (cooking hobs).
- The principal reason for issues for the **premix appliances** is the adjustment. If we consider that this can be solved, most appliances will have no problem anymore and **can burn gas with at least 40% H_2**.

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WP3 – Experimental Work

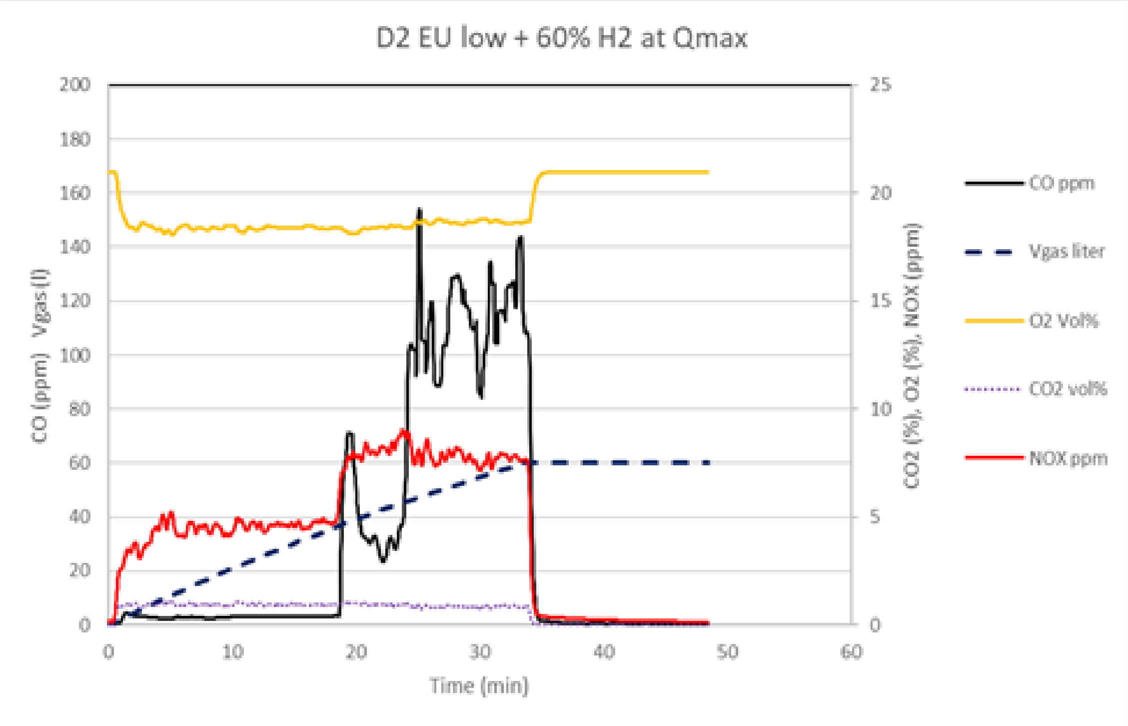
T3.2

3.2.1: Short term combustion tests - tests for the evaluation of safety, efficiency, environmental performance (NOx, CO, UHC emissions)

Present procedures for flash back is not adapted to H2NG → the THyGA results are already shared and discussed for CEN testing.

Test showing FB under following test conditions, Qmax, Pnom, CH4 = 40% H2 = 60%

Picture burner after Flash back. The small burner (tested here) is comapred to a large one (not tested). Change in color is noticable, but there is also a deformation of the burner.



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WP3 – Experimental Work

Adjustment is an issue for premix appliances

T3.2

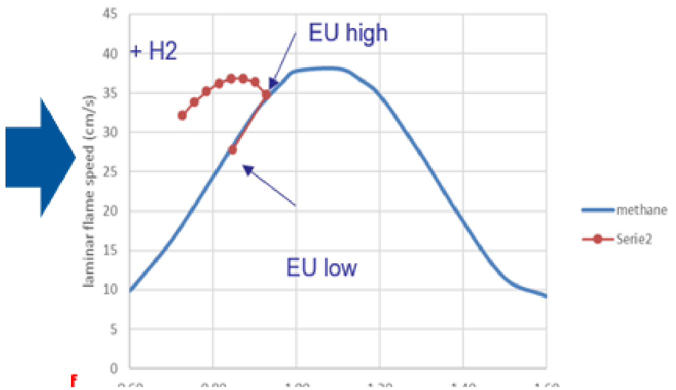
3.2.1: Short term combustion tests - tests for the evaluation of safety, efficiency, environmental performance (NOx, CO, UHC emissions)

a) ADJUSTMENT EU HIGH -> Gas used= EU LOW + H2

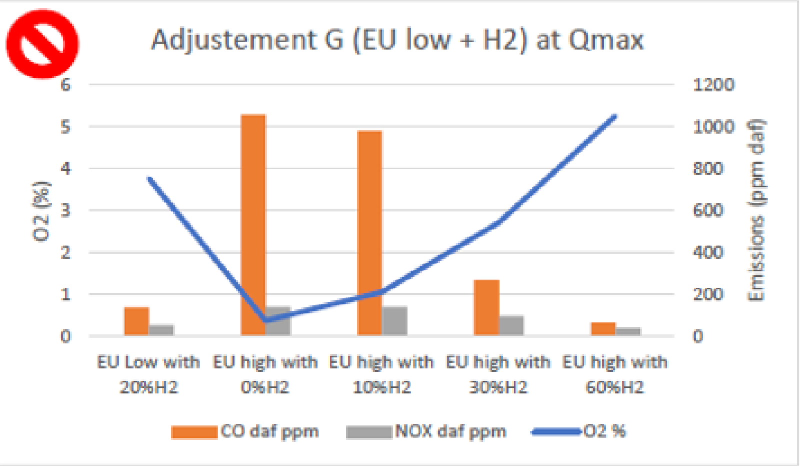
b) ADJUSTMENT EU LOW -> Gas used= EU HIGH + H2 (this test is the most critical for appliances that can be adjusted)

c) ADJUSTMENT EU LOW + 20% H2 -> Gas used= EU HIGH + H2

d) ADJUSTMENT EU High + 20% H2 -> Gas used= EU low + H2



CASE	EULOW + 10, 20, 30% H2	EU low +0 to 60% H2	CH4	EU high + 20% H2	EU high + 0 to 60% H2
G	Adjusted	→	→	→	Used



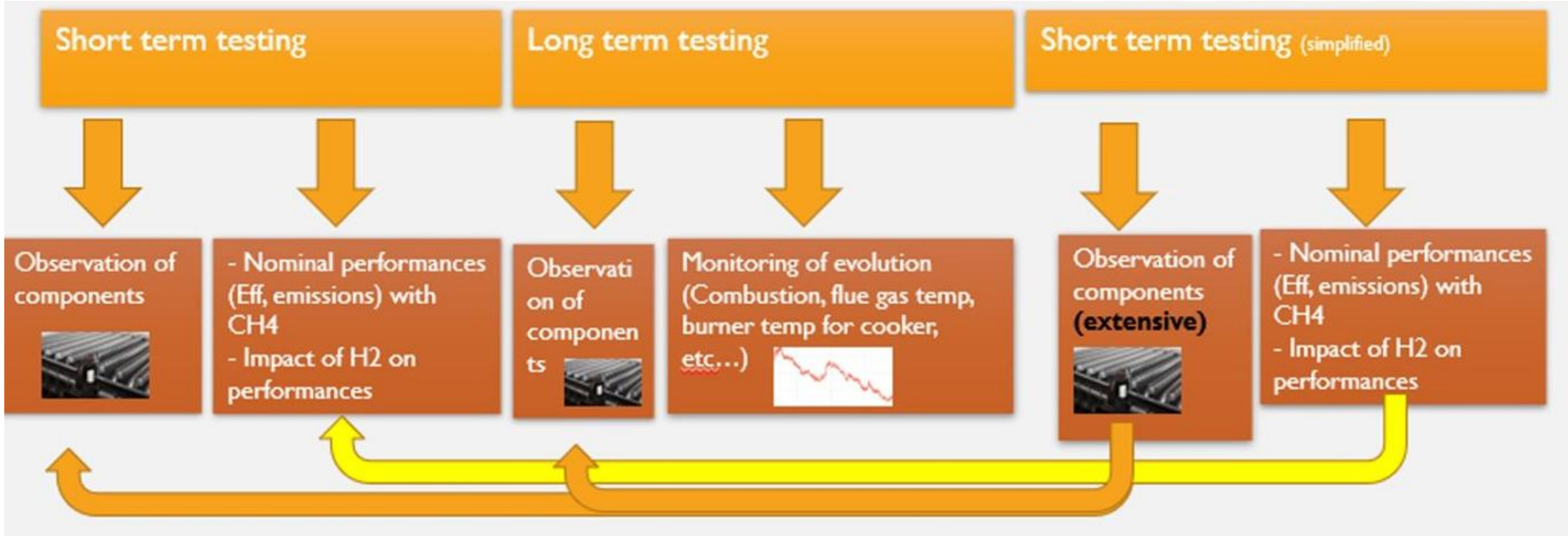
Workshop with boiler, air heaters, catering manufacturers allowed to identify leads to work on, within WP4 or WP5

WP3 – Experimental Work

T3.2

3.2.2: Long-term combustion test

Long term: to observe possible appliances alterations (performances or physical alteration) in the long term (few month) with given H2/NG mix.



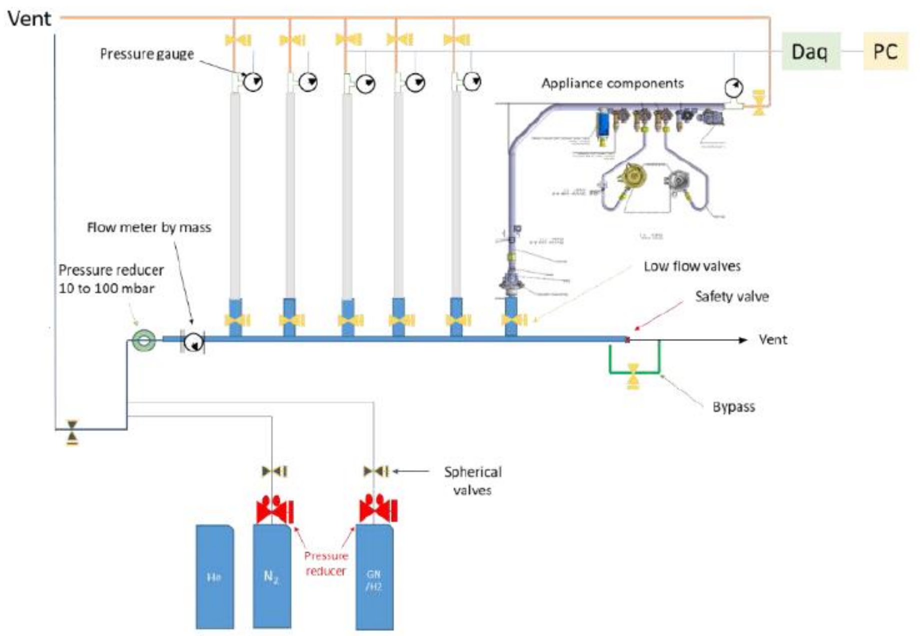
WP3 – Experimental Work

Gas line elements have been gathered from 6 European countries, the impact of H2NG blends compared to NG, on leakage rates

T3.2

3.2.3: Leakage tests on indoor installation (long term)

Much more complex tests than expected, at our levels of pressure (strong uncertainty due to temperature, for example)



T2.4

Studying the hydrogen impacts on materials – focus on **hydrogen embrittlement**.

Fast moving environment

- CEN TCs starting to work on "H2 ready" certification
- "H2 ready" concept discussed in regulation for Energy-related Products (ErP): Ecodesign & Labelling
- Manufacturers H2 roadmaps pushed by the "Primemovers" initiative
- DSO / TSO clearer about possible H2% in the gas grid (up to 20 - 30%)

Example of consequences for the project

➔ **READJUSTING THyGA testing to give the best value to the industry (focus on 0 to 30% H2)**

➔ **ADAPTATION of the content and objective of the WP4 to best suit the needs of the stakeholders**

A wealth of information available on the project website

- **6 Public deliverables** (4 more to come by December 2021)
- Newsletters (subscribe!) and articles

- Replays of several workshops
  - ✓ **Kick off of the THyGA project**
  - ✓ **Impact of hydrogen admixture on combustion processes**
  - ✓ **Materials science – impacts of hydrogen blends**
  - ✓ **Standardization and certification of gas appliances in view of H2NG supply**

- 15th of December 2021: **General THyGA Workshop, showcasing the interim test results**

Register for the Workshop!

Find Us Online

VISIT THE THyGA WEBSITE

All public presentations and deliverables of the project will be available on the project website

thyga-project.eu

GERG LINKEDIN & WEBSITE

For regular updates, you can also follow the GERG LinkedIn page and website

CONTACT EMAIL

Do not hesitate to contact us by email at contact_thyga@engie.com

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THE EUROPEAN GAS RESEARCH GROUP

THANK YOU FOR YOUR ATTENTION