1- Introduction: THyGA project in short
2- Experimental tests: what we have done
3- Selection of test results
4- Conclusions

# THyGA Test results

## Presentation for HIPSNET


**Jean Schweitzer**
**DGC - EVIDA**


*June 2023*

**T**esting **Hy**drogen admixture for **G**as **A**pplications


This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 874983. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

THyGA

# 1- Introduction

# 2- Experimental tests: what we have done

# 3- Selection of test results

# 4- Conclusions

**T**esting **Hy**drogen admixture for **G**as **A**pplications

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 874983. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

Clean Hydrogen Partnership

# Scope

**Household >200 million residential and commercial gas appliances**

- Space heating and hot water
- Cooking
- Combined heat and Power production (CHP)
- Etc.

ONLY H GAS

**Not in the scope:**

Power production | Industry | Mobility

**Q: How will the installed European stock of appliances be impacted by an increasing % of H2 injected? → TESTING**

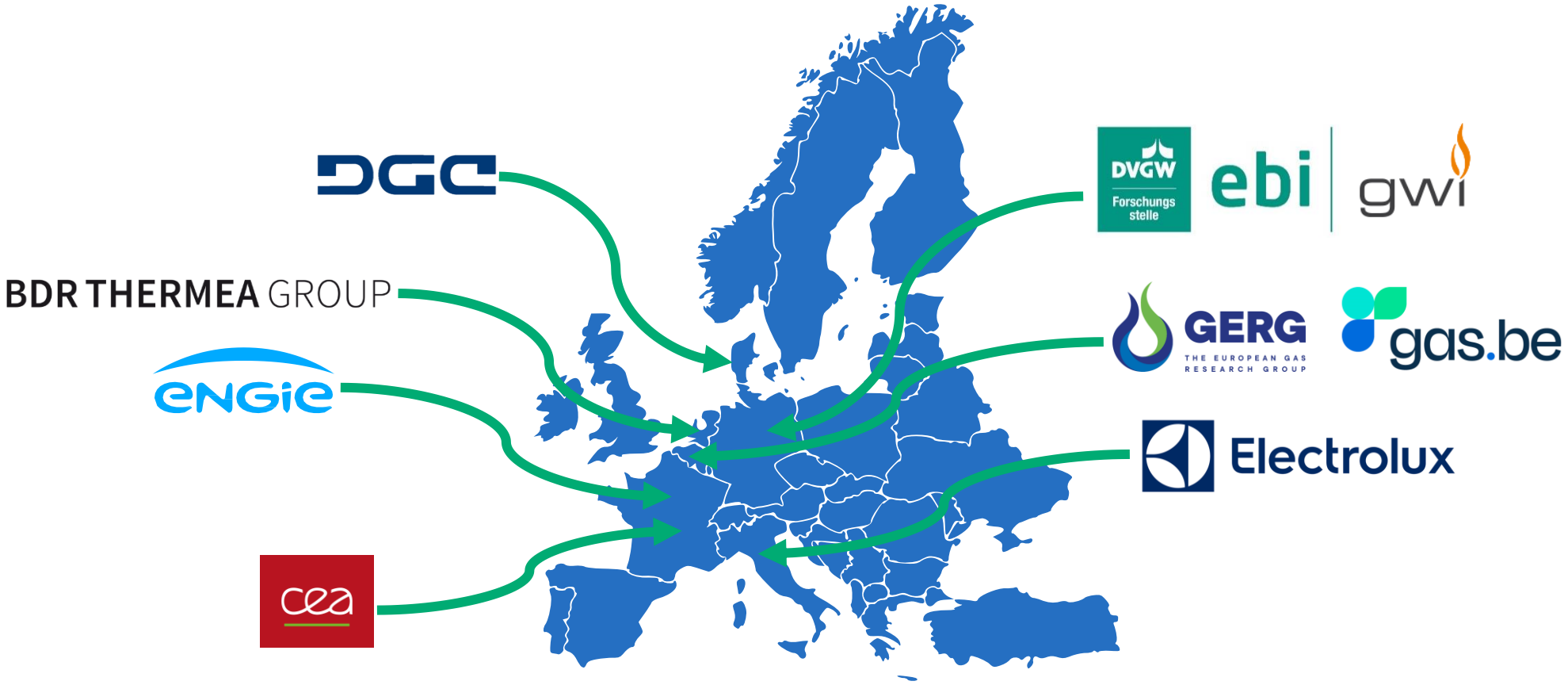

- Safety
- Efficiency
- Emissions
- Operation

**Other tasks:**

- Mitigation solutions?
- Standardisation

# Organization of the THyGA project

Project consortium: 9 partners in response to the Horizon 2020 call FCH-04-3-2019




This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 874983. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research

THyGA

# 1- Introduction

# 2- Experimental tests: what we have done

# 3- Selection of test results

# 4- Conclusions

**T**esting **Hy**drogen admixture for **G**as **A**pplications

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 874983. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

Clean Hydrogen Partnership

# Starting point: the segmentation

- We defined ~60 appliances type/technologies segments (Boilers, water heaters, cookers, catering, space heaters, CHP, GHP, others)

| THyGA Segment | Type of appliance | Category | Burner type | Standard | Total Appliance Population |
|---|---|---|---|---|---|
| 101 | BOILERS | Open flued (former EN 297) | Partial premix/conv (atmos. & fanned) | EN 15502 | 13 588 |
| 102 | | | Low NOx technology burners | | 2 012 |
| 103 | | | Full premix | | 152 |
| 104 | | Room-sealed (former EN 483) | Partial premix/conv (atmos. & fanned) | | 25 333 |
| 105 | | | Low NOx technology burners | | 1 972 |
| 106 | | | Full premix | | 1 781 |
| 107 | | Condensing boiler (former EN 677) | Partial premix fanned | | 2 920 |
| 108 | | | Full premix (including CCB) | | 56 492 |
| 109 | | Forced-draught / Jet burner boiler (former EN 303-3) | Jet burner | | 1 129 |
| 201 | WATER HEATERS | Instantaneous open flued | Partial premix/atmos | EN 26 | 14 945 |
| 202 | | Instantaneous room-sealed | Partial premix/fanned | | |
| 203 | | Storage open flued | Partial premix/atmos | EN 89 | 3 121 |
| 204 | | Storage room-sealed | Partial premix/fanned | | |
| 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 | 15 |
| 602 | | Internal Combustion Engine | | | 41 |
| 603 | | Micro Gas Turbine | | | 1 |
| 604 | | PEM FC | | | 5 |
| 605 | | SO FC | | | 3 |
| 701 | HP | Engine HP | Heating | EN 16905 | 60 |
| 702 | | Adsorption | | EN 12309 | |
| 703 | | Absorption | | | |

| THyGA Segment | Type of appliance | Category | Burner type | Standard | Total Appliance Population |
|---|---|---|---|---|---|
| 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~~ | |
| 804bis | | Radiant strip | with fan driven burners and recirculation fans | EN 17175 | |
| 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 | 2 |
| 809 | | domestic dryers | | EN 1518 | 2 |
| 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 premix 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 premixed | | 27 712 |
| 310 | | Cavity burner "metal sheet" (ovens, freestanding ranges) | Atmospheric burner | | 13 056 |
| 311 | | | "Venturi" burner | | |
| 312 | | | Partially premixed | | 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 | |
| 404 | | Ovens | Tubular or circular burners | | |
| 405 | | Boiling pans / pasta cookers | Microperforated burner | EN 203-2-3 EN 203-2-11 | |
| 406 | | Fryers | Premix burner | EN 203-2-4 | |
| 407 | | Salamanders / Rotisseries | Ceramic or blue flame burners | EN 203-2-7 | |
| 408 | | Brat pans | multi-ramp tubular slot burners | EN 203-2-8 | |
| 409 | | Covered burners (griddles, solid tops, pancake cookers) | Tubular burner or multi-ramp tubular burner | EN 203-2-9 | |
| 410 | | Barbecues | Chargrill with burner tubes w/ holes on top | EN 203-2-10 | |

Budget for the test of 100 appliances: we had to define priorities based on:
1 The population of the segments - 2 Their sensitivity to H2

# WP3 - Testing protocol and parameters studied

Objective: to understand how appliances react in the short term (few minutes to few hours) with different H2NG blends.

The philosophy of the test in lab is to simulate a situation that is found on the field:
**Gas quality variation with H2 on appliances** that are not modified.

**Parameters to vary =** Operational conditions as in reality:

- % H2 & H2 Rate of change (ROC)
- Natural gas composition
- Pressure
- Adjustment or not. Etc.

**Parameters to measure**

- Combustion/emissions
- Efficiency
- Safety
- Operational aspects (Normal operation of the appliances or not)

- **Testing on 100 appliances under different operation conditions**

**+**

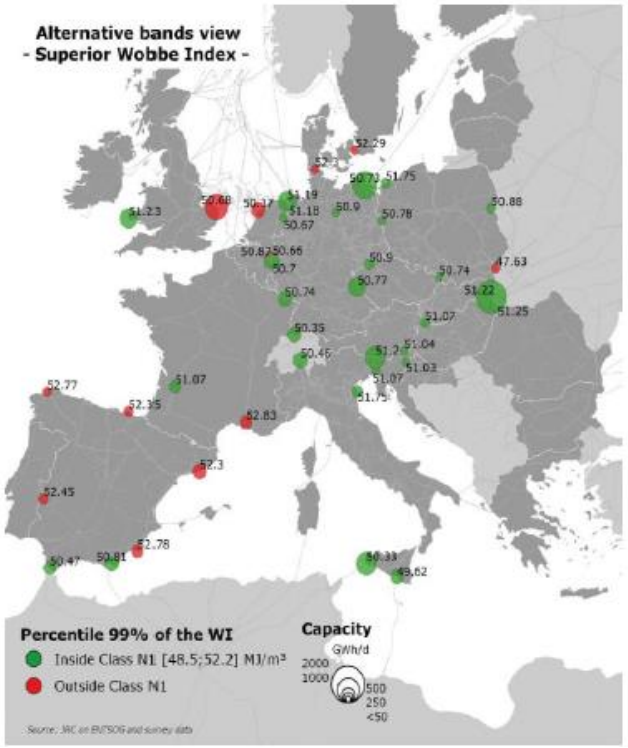
- **Long- term testing on 7 appliances**
- **Tightness check of present indoor installation**

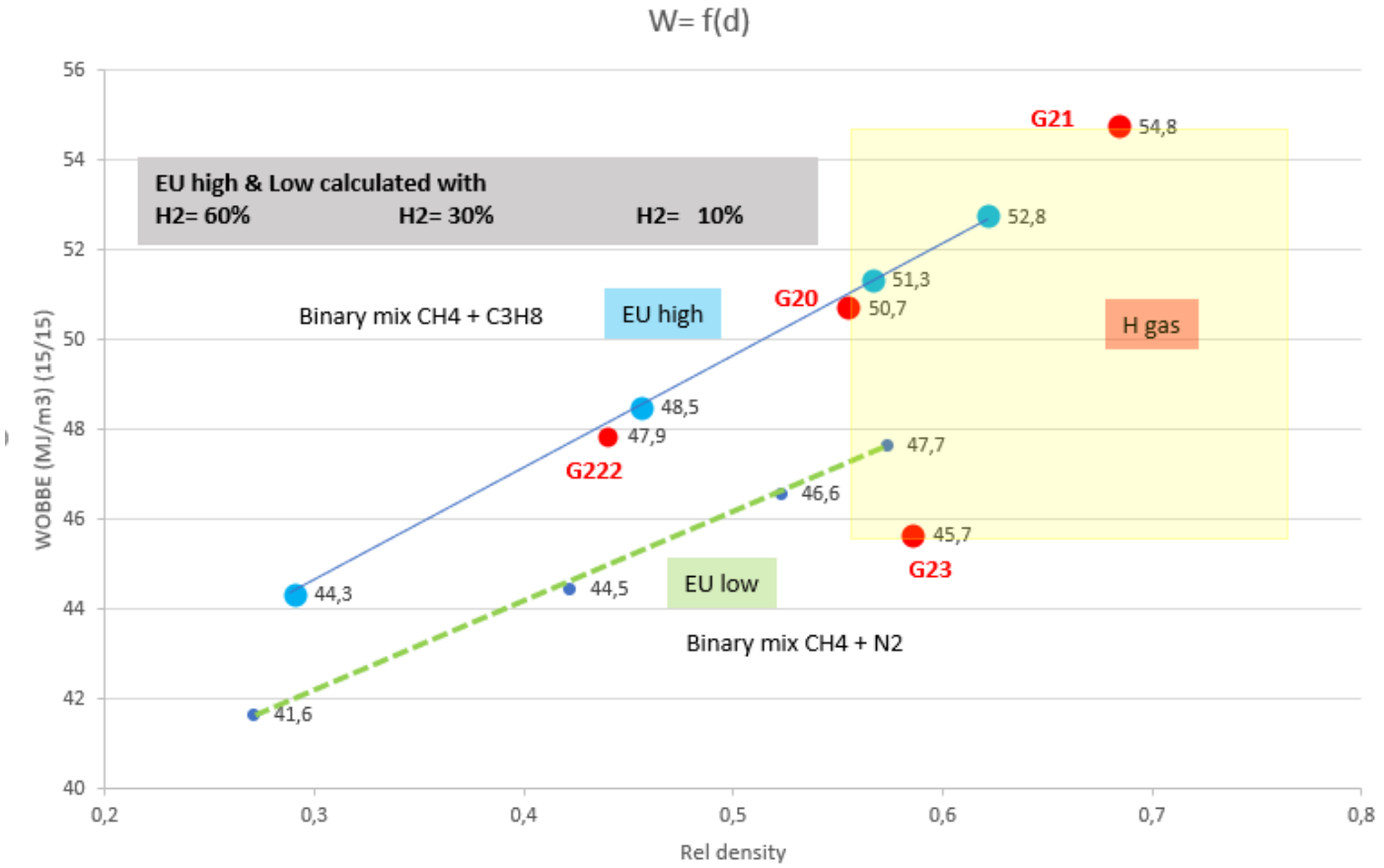
# WP3 - Testing protocol and parameters studied

## Specification of the gases used for the testing

Based on real distributed gases (EU High and EU Low)

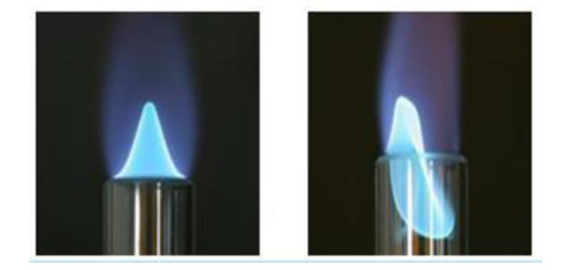
100% percentile = 47,63 (EU LOW) à 52,78 (EU HIGH) MJ/m3



# Few definitions

## Flashback



*Flame with Flash back (picture THyGA application)*

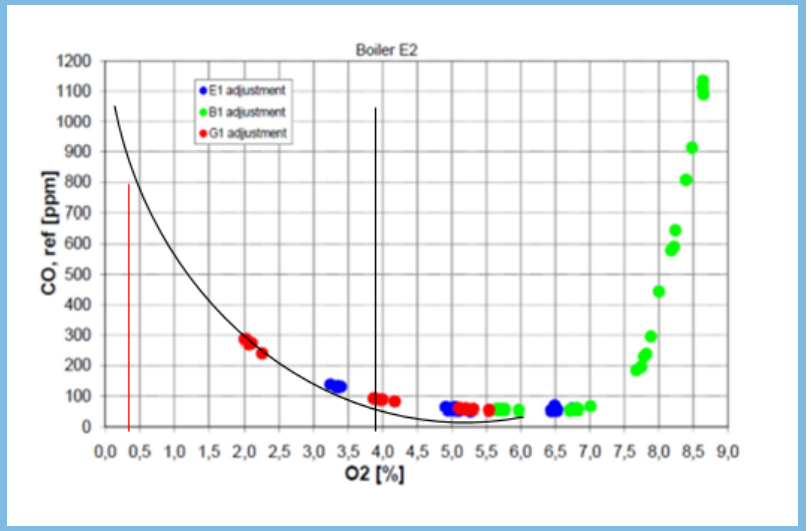

*Flame with partial flash back on a cooker hob (picture THyGA test DGC)*

## Adjustment

**Adjustment =** the operation of adjustment to reach a certain **air** excess according the **O2 or CO2 value** that is given by the boiler manufacturer.

Usually, appliances are adjusted to an air excess that is a **compromise** to achieve the best possible efficiency with the lowest possible emissions.

Most of appliances in the category H (High calorific gas – widely distributed in the EU) **are adjusted by the manufacturers with CH4** before being sold on the market.




Some appliances are also re-adjusted **on the field (**commissioning or after a service or a reparation). **This is generally done with the gas distributed locally and not CH4**.

THyGA

# 1- Introduction

# 2- Experimental tests: what we have done

# 3- Selection of test results

# 4- Conclusions

**T**esting **Hy**drogen admixture for **G**as **A**pplications

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 874983. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

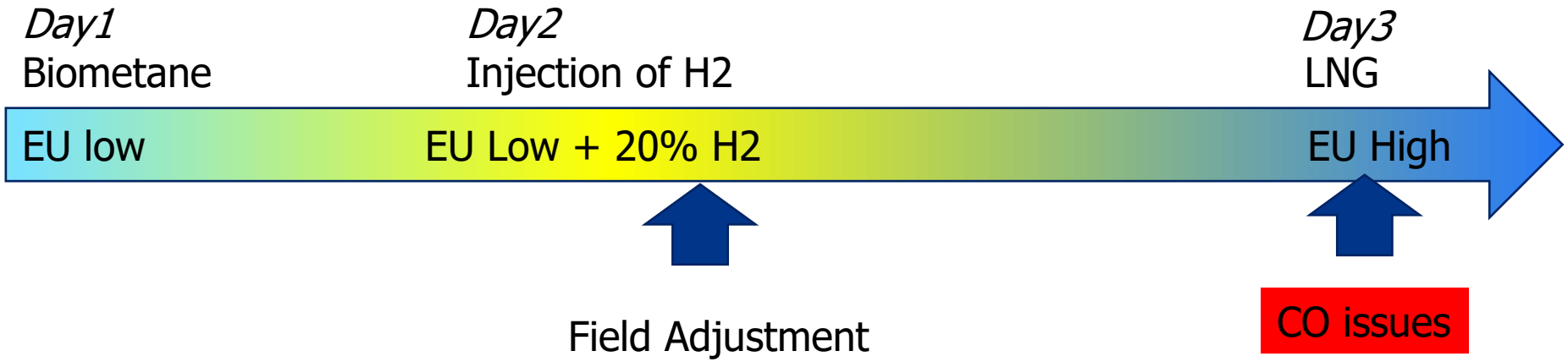
Clean Hydrogen Partnership

# Segment 100a Boilers fully premix: **Adjustment issue**

Exemple 1 Boilers

Main issue = adjustment with a low Wobbe gas containing H2

**Example of a real situation:**






1. Possible issue already **at 20% H2 if adjustment is still allowed when H2 in the grid and present procedure is not changed** (= same CO2% or O2% as for NG).
2. Adjusting with O2 instead of CO2 may solve a great part of the issue

# WP3 – Results for the short-term tests

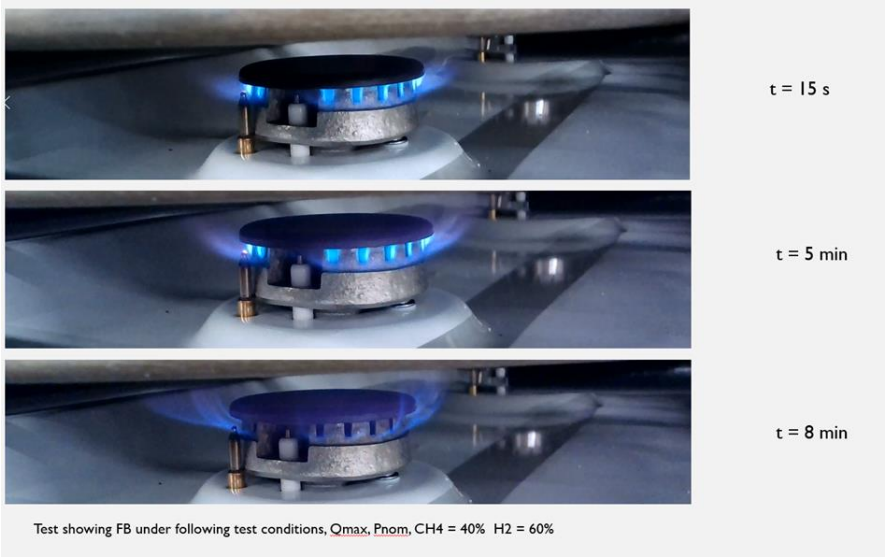
## Segment 300a cookers domestic.

Exemple2 Cookers

Flashback:

- Flashback was observed on many cookers hobs for in general H2 >= 30%

and especially during long running time of the cookers.




# WP3 – Results for the short-term tests

## Segment 300a cookers domestic: flame aspects and other observations

Exemple3 Cookers

**Water condensates that create partial extinction**

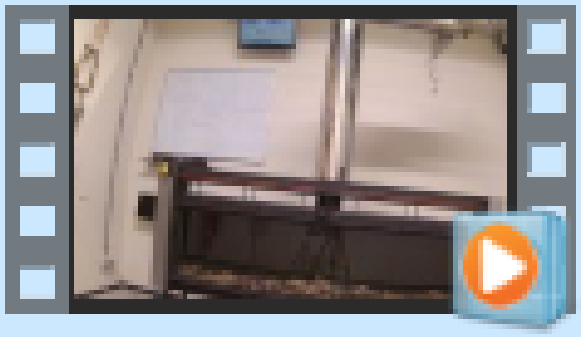
- With hydrogen and cold water in the pan, **condensation appears on the bottom of the pan**.
- When the droplets hits the burner, it causes a partial extinction of the flame. The flame turns orange for a few seconds and becomes blue again when water has fully evaporated.

*EN12 burner under normal operation and with water falling into the flame*

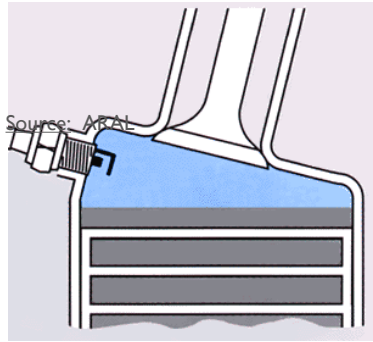
# DELAYED IGNITION
# WP3 – Results for the short-term tests
## Decorative Space heaters : delayed ignition

Exemple4 Space heaters

Delayed ignition test on decorative space heater



FHD0006-60-40
%H2 45sec NOK



THyGA

# 1- Introduction

# 2- Experimental tests: what we have done

# 3- Selection of test results

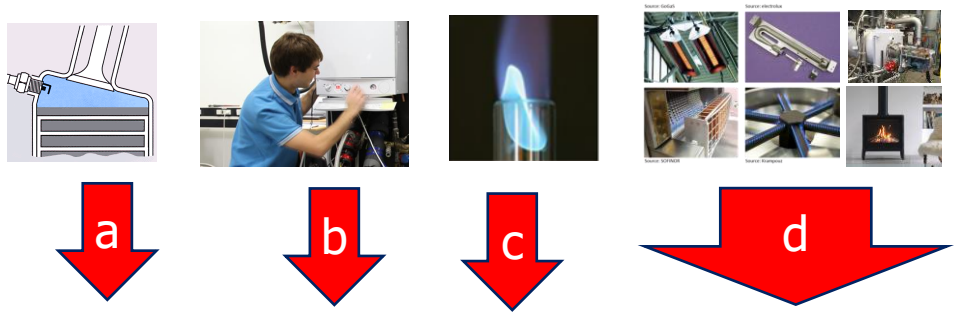
# 4- Conclusions

**T**esting **Hy**drogen admixture for **G**as **A**pplications

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 874983. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

Clean Hydrogen Partnership

# Overall impact when increasing H2 %




a) The first issue observed is a limited number of appliances whose design makes them sensitive to **delayed ignition.**

b) The second issue that may happen starting from 20% or maybe below, is high CO emissions with premix appliances that can be **adjusted on-site.**

c) The third issue is **Flashback**. It generally occurs for 30% H2 or more, appearing first on partially premix appliances when increasing the H2 %.

d) Most of other appliances will be subject to issues from 40% H2.

# WP3 – Results for the short-term tests

## PERFORMANCES

In general, under the conditions of the THyGA testing (= copy the reality of the field):

- **H2 has no or only small impact on efficiency** but for boilers where we see a slight increase of efficiency on Hi due to higher heat recuperation on condensation with the testing conditions used.
- **Heat output decreases with H2 injection** which could prove to bring comfort issue for domestic hot water or cooking appliances
- **NOx is decreasing** with H2 (*)
- **CO is decreasing** with H2 (*)

*(*) only when considering the value in ppm calculated with no air excess. Results in mg/kWH may be different.*

| Overall Impact of H2 on | | | | | |
|---|---|---|---|---|---|
| SEGMENT | | Efficiency | NOX | CO | CH4 |
| 100a | Boiler premix | + | - | - | |
| 100b | Boiler NOT premix | 0 | - | - | |
| 200 | Water heater | 0 | - | - | |
| 300 | Cooker dom | 0 | - (*) | - | |
| 400a | Catering premix | NM | - | - | |
| 400b | Catering NOT premix | unclear | - | - | |
| 500 | Space heaters | 0 | - | unclear | |
| 600 | CHP | 0 | unclear | unclear | |
| 700 | GHP | 0 | - | - | |
| 800 | Radiant heater & commercial air heaters | - | unclear | - | |

(*) can suddenly increase for H2 >40%

# Other (positive) results

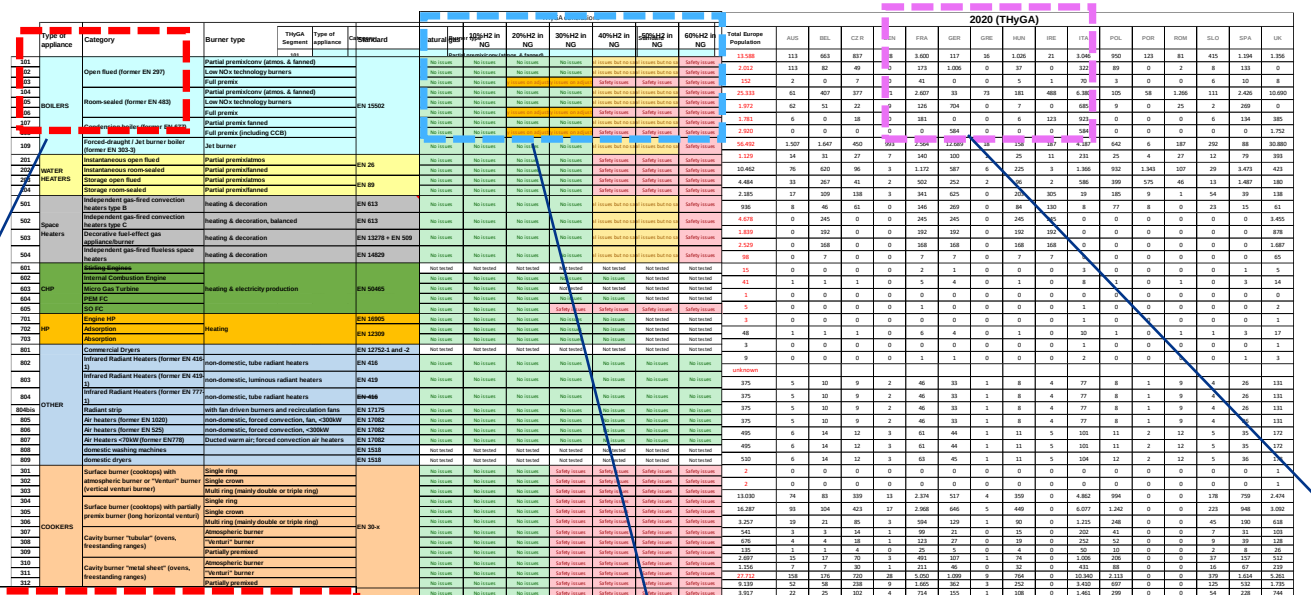
- Most of the appliances tested have **flame supervision systems based on flame ionisation** currents. For most of them, the ionisation signal remains quite high and above the threshold.
- Both impacts of "**low air temperature (- 10 °C)**" and "**Flue gas pipe length**" have been tested on few appliances (boilers) and the results from the test done show no impact of hydrogen.
- **ROC (PLUG FLOW)** is generally not showing issue (generally variation from 0 to 40% H2 and the other way round).
- **Long term test** on 7 appliances with 30% H2 have not shown issues.
- Leaks from existing **used indoor components** tested are within the regulations limits

*DGC's long term test rig is especially designed to monitor gas appliances performances over testing periods of several weeks or months.*

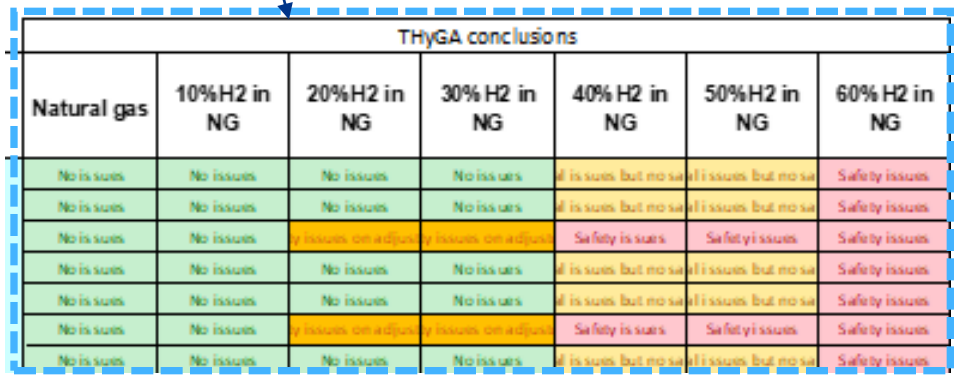
# Quantification of the issues at country level

**Test results appliances segments**

**Stock of installed appliances**



| THyGA Segment | Type of appliance | Category |
|---|---|---|
| 101 | BOILERS | Open flued (former EN 297) |
| 102 | | |
| 103 | | |
| 104 | | Room-sealed (former EN 483) |
| 105 | | |
| 106 | | |



| THyGA conclusions | | | | | | |
|---|---|---|---|---|---|---|
| Natural gas | 10%H2 in NG | 20%H2 in NG | 30% H2 in NG | 40% H2 in NG | 50%H2 in NG | 60% H2 in NG |
| No issues | No issues | No issues | No issues | All issues but no safety issues | All issues but no safety issues | Safety issues |
| No issues | No issues | No issues | No issues | All issues but no safety issues | All issues but no safety issues | Safety issues |
| No issues | No issues | Safety issues on adjustability | Safety issues on adjustability | Safety issues | Safety issues | Safety issues |
| No issues | No issues | No issues | No issues | All issues but no safety issues | All issues but no safety issues | Safety issues |
| No issues | No issues | No issues | No issues | All issues but no safety issues | All issues but no safety issues | Safety issues |
| No issues | No issues | Safety issues on adjustability | Safety issues on adjustability | Safety issues | Safety issues | Safety issues |
| No issues | No issues | No issues | No issues | All issues but no safety issues | All issues but no safety issues | Safety issues |

**2020 (THyGA)**

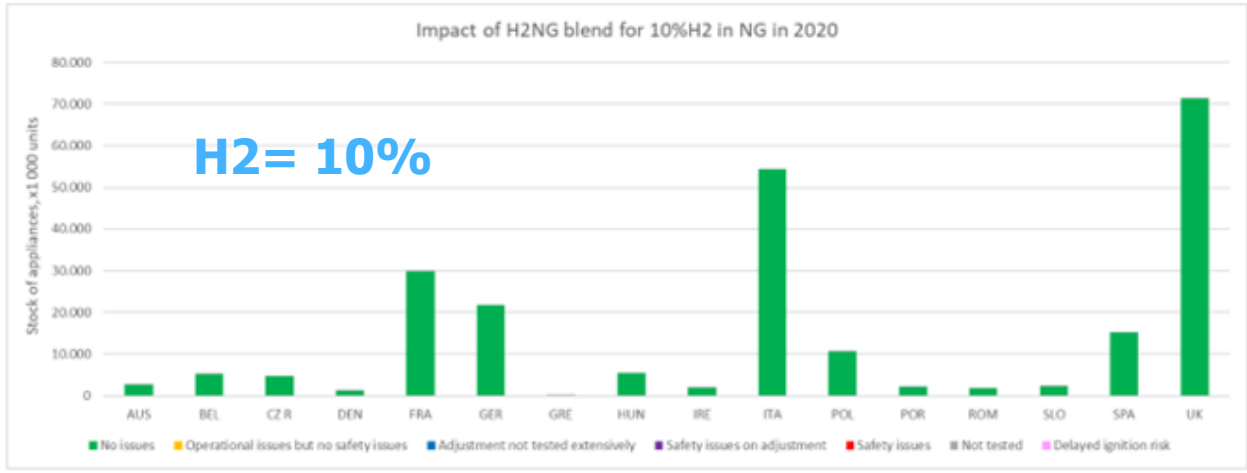
| DEN | FRA | GER | GRE | HUN | IRE |
|---|---|---|---|---|---|
| 28 | 3.600 | 117 | 16 | 1.026 | 21 |
| 0 | 173 | 1.006 | 0 | 37 | 0 |
| 0 | 41 | 0 | 0 | 5 | 1 |
| 71 | 2.607 | 33 | 73 | 181 | 488 |
| 9 | 126 | 704 | 0 | 7 | 0 |
| 0 | 181 | 0 | 0 | 6 | 123 |
| 0 | 0 | 584 | 0 | 0 | 0 |

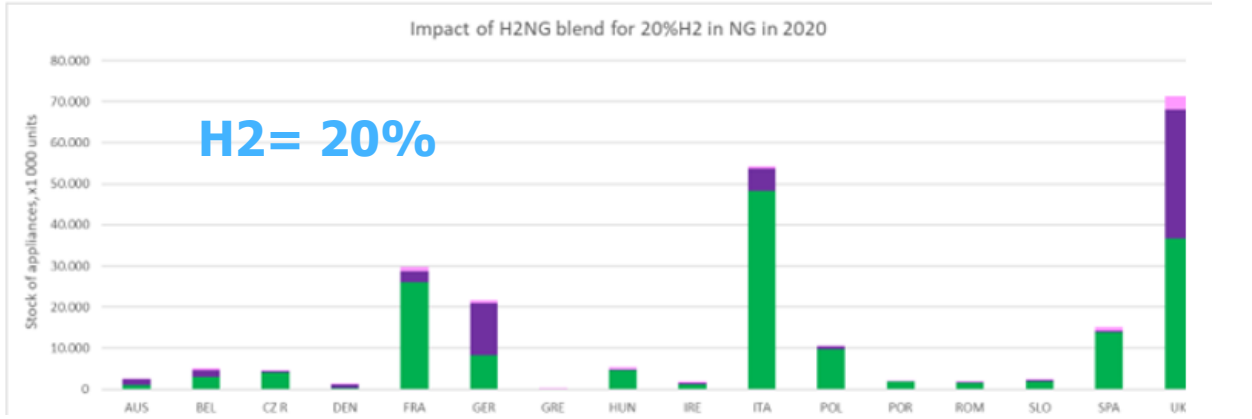
# Scenarios of H2 blend in NG

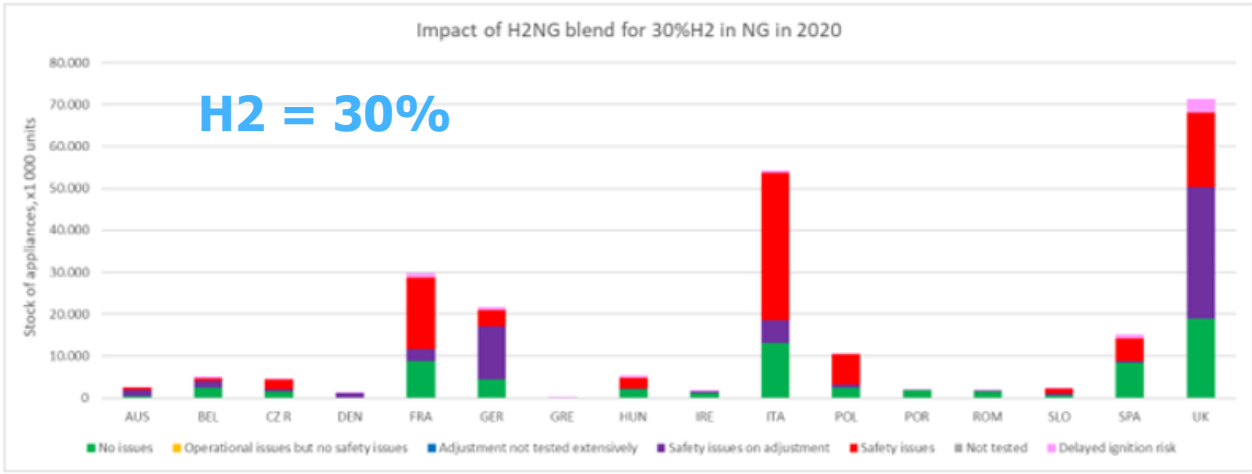
**H2 = 20%**
**Delayed ignition (4%)**
**Adjustment (25%) (*)**

**H2 = 30%**
**Delayed ignition (4%)**
**Adjustment (25%) (*)**
**Flashback (40 %)**

(*) can be solved with simple measures (O2)



# H2 Blends: the 3 main challenges and solutions

## 1- Adjustment of fully premix appliances (As condensing boilers)

**Ban CO2 Adjustment** and use **O2 instead**

**Ban Adjustment totally**

**Adjust with the knowledge of H2 and / or Wobbe.**
Need for portable "cheap" instruments.

## 2- Delayed ignition

**More test are needed. especially appliances without ventilators shall be examined more extensively.**

**Appliances to be removed from the areas where H2 is injected in the grid**

## 3- Liability.

Appliances presently on the market are NOT certified for the use of H2 blends.
Who is responsible liable if issues?

**To be discussed with national safety authorities, manufacturers, DSOs etc.**

**Part of the solution could be to update the definition of "natural gas"** (but this would probably not be for more than few %)

# 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

GERG
THE EUROPEAN GAS RESEARCH GROUP

## CONTACT EMAIL

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