Testing **Hy**drogen admixture for **G**as **A**pplications

WP3. Intermediate report on the progress of the long-term tests

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Executive summary

The first WP3 reporting period covers M1 to M20 (January 2020 to June 2021).

The "long-term" tests are to be executed on appliances that are tested before during the "short term" testing. As those appliances will run more or less continuously, laboratories have to prepare their facilities for the monitoring and the surveillance of the test rig so the tests can be done in a safe way.

Delay in implementing the short-term test appliances (covid-19 impact ainly) and delays in the preparation of the test rigs are the reason why the tests have not yet started at M18, but they are expected to start in September/October 2021, and we are looking at ways to catch up to the initial planning and ensure a publication of the results within the project timeframe (M1-M36).

This report gives insight on the project's objectives and methodology of test.

List of abbreviations

GA	Grant Agreement
H_2NG	Hydrogen / Natural Gas blend
MS	Milestone
Qmin	Minimum heat input of an appliance (kW)
Qmax	Maximum heat input of an appliance (kW)
WP	Work Package

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Introduction

Unfortunately, due to delays (mainly lack of availability or of delivery of components for the test rigs, due to covid-19 pandemic, the long-term tests have not yet started at M18, therefore this report does not include results but rather focusses on the testing preparation (objectives and methodology). Results will be published in deliverable D3.9, second semester of 2022.

1. Deliverable situation for WP3

Table 1 summarizes the public deliverables listed in the Grant Agreement for WP3, the present report covers D3.6 "Intermediate report on the progress of the long-term tests".

The deliverable was due in M18, but because of some delays in the realisation of short-term tests and the conception of the test rig (due to covid-19 pandemic, as explained in the introduction), it was decided in accordance with the project officer to postpone this publication to M20. The objective was to have to more time to gather elements and updates on the status of the tests by the Labs in charge (DGC and GWI).

Table 1: List of public deliverables for WP3 in the THyGA project (shaded deliverables will be delivered at the end of the project)

Deliverable number	Deliverable title
D3.4	Intermediate testing on components (new and taken from existing installations)
D3.5	Intermediate segment of technologies by segment report on the impact of the different H_2 concentrations on safety, efficiency, emissions and correct operation
D3.6	Intermediate report on the progress of the long-term tests
D3.7	Testing done on components (new and taken from existing installation) from different countries (at least FR, GE, DK and BE) including statistics on results obtained for the leakage testing
D3.8	Segment of technologies by segment report on the impact of the different H_2 concentrations on safety, efficiency, emissions and correct operation
D3.9	Long term effect of H_2 on appliances tested
D3.10	Compiling of results from all tasks and development of further statistics at EU and country level

2. Work carried out in WP3 – long term test. Working method

2.1 WP3 – Experimental Work

The two following goals come directly from the grant agreement and are relevant to highlight the interest of the long-term testing according to the expectation of the FCH JU:

1. *"To define a detailed test protocol based on WP2 input in order to accurately define the details of the testing and to guarantee the best possible reproducibility of testing and making sure that all elements needed for the analysis are included in the reports*."
2. *"To execute short- and long-term testing on as many appliances as possible to achieve conclusions on sensitivity to H_2 by segments of technologies*."

As the test have not yet started at M20, this report summarizes the methodology and work to define the test protocol[1].

2.2 Elaboration of the protocol

The testing in WP3 is based on a protocol that was developed in the early part of the project, conjointly with WP2 (Task 2.5). The steps of elaboration and interactions with the stakeholders are more precisely described in the public deliverable D3.5 ("Testing programme for hydrogen tolerance tests of domestic and commercial natural gas appliances"). For simplifications sake, we will not repeat the details from this report but will focus on additional aspects that are relevant to long-term testing.

The elaboration of the protocol has included the following phases:

- Phase 1. Preliminary (experimental) protocol (Jan -May 2020)
- Phase 2. Protocol discussion with the stakeholders (May 2020 and later)
- Phase 3. Protocol for real use (June 2020 and later)
- Phase 4. Protocol further improvements (from December 2020)

For long-term test only phases 1 & 2 are relevant as test have not yet started (phases 3 & 4 are still relevant for short-term tests, see public deliverable D3.5 for more details).

In addition to the overall discussion with the stakeholders, THyGA organized a specific and individual discussions with the two manufacturers partners within the THyGA project (BDR Thermea and Electrolux) to exchange views on long-term testing and fine tune the protocol.

2.3 Content of the protocol & test program

2.3.1 Introduction

Long-term test will be carried out to observe possible appliances alterations (performances or physical alteration) in the long-term (few month) with given H_2NG blend. The idea with the long-term testing is

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[1] Private deliverables D3.1 (Test protocol for all appliances to be tested – M10) and D1.7 (Periodic Technical Report – Part B – M20) already report detailed explanation to the European Commission and the FCH JU.

to simulate a real situation in accelerating the testing time, several indicators will also be continuously monitored to identify possible alterations.

The project decided to **realize short-term tests before and after the long-term test to have a complete vision** of the impact of the hydrogen presence on functionalities and components, as described on Figure 1.
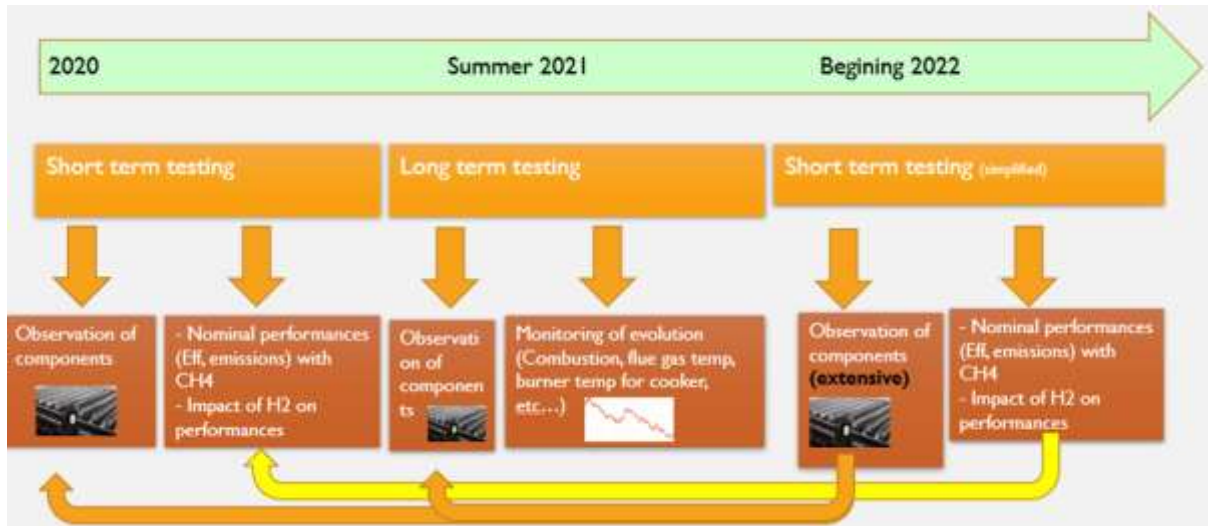

Figure 1: Organization of the long-term tests

The first short-term tests were performed by DGC and GWI (the 2 Labs in charge of the long-term tests) on **5 boilers and 2 cooking hobs**.

- The long-term tests are planned to last 30 weeks for a total of 2520 hours of operation with a 30 % H_2 admixture in the natural gas.
- The operating hours will be a mix of nominal and minimal load durations with breaks (no systematic runs in weekend and holidays).

The long-term test protocol was discussed with the two manufacturers (boiler and cooker) who are members of the consortium. A specific protocol was designed for cookers and another for boilers. The initial protocols were amended to take the manufacturers point of view into account.

The evaluation will be based on the following elements:

- Visual evaluation of the components (mainly burner) based on photos, taken before and after the test.
- Follow up on the evolution of the measurement of data during testing (temperatures, flue gas composition, etc.).
- Re-assessment of the appliances at the end with a simplified short-term test to check possible alteration of performances, emissions, or safety.

2.3.2 Main point of the testing programme

Test gases for long-term testing will be done with natural gas (G20 is used for short-term tests) with addition of H_2, for costs reasons.

1.   Introduction

Long-term testing procedure is inspired by the project GASQUAL where appliances were subjected over long periods to "extreme" gases (but without hydrogen). The test protocol was elaborated with the support of manufacturers having experience in such exercise. The test programme is taking the contractual specification of the THyGA agreement into account. **Tests are done with 30 % H_2**.

2.   Test chronology for long-term

Appliances for long-term tests are appliances which have been through short-term testing before being tested for a long period. They have been assessed according to the test programme described and their condition, before and after the short-term test, is documented through photography etc. as described in the previous sections.

The visual documentation of the condition of the appliances after the long-term test should be done in the same way as for the short-term test, respecting as much as possible the instructions given for photography to make the comparison before/after straightforward.

3.   Continuous measurement of combustion parameters during long-term test

The following parameters have to be measured:

- Gas quality (hourly or daily depending on stability)
- Flue gas composition (O_2, CO_2) (sampling < 1 minute)
- Flue gas temperature
- Emissions (CO, NOx) (sampling < 1 minute)
- Test conditions (Ambient temperature, atmospheric pressure, Humidity)

If there are important and sudden variations of a given parameter, the lab has to stop the test and examine the appliance; possibly discuss with the manufacturers and decide if the test can be continued under safe conditions.

Example of followed parameters:

- Daily averages
- Hourly (or min) average in case of sudden variation of one of the combustion parameters

2.3.3 Test plan for boilers. Updates on test protocol after discussion with the manufacturers

The initial protocols have been updated after discussion with the manufacturers, confidentiality of the information regarding the appliance to be tested will be maintained. One important point is that short-term tests will be done systematically before and after the long-term tests.
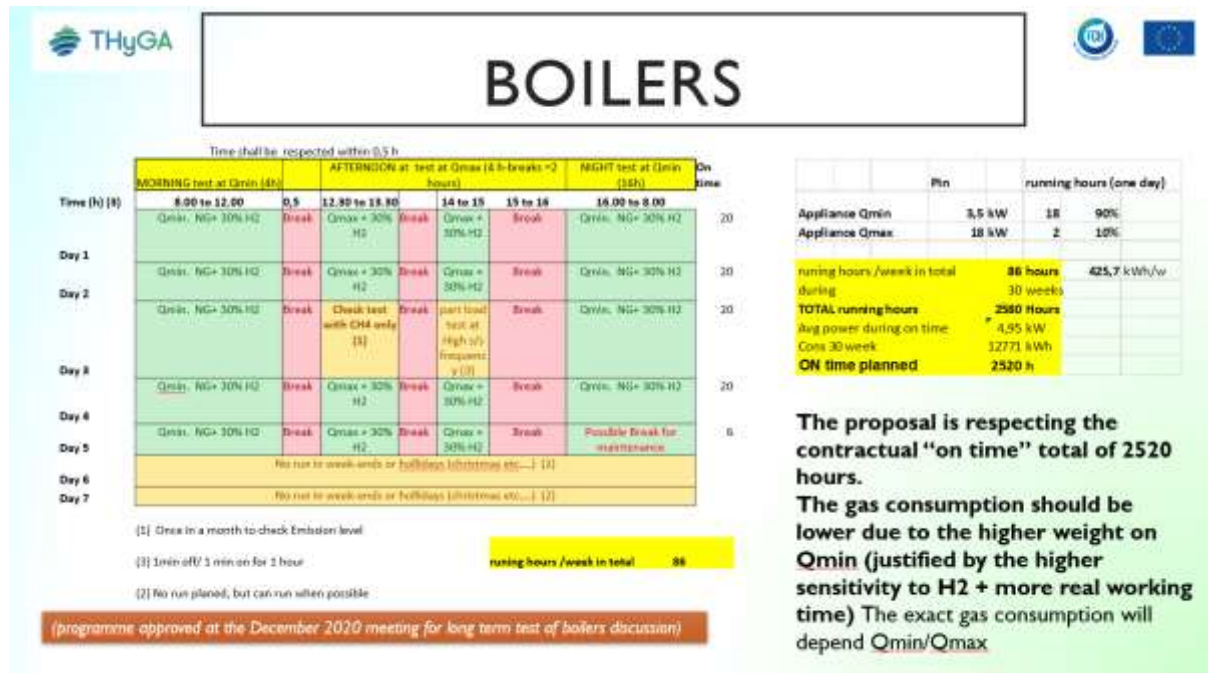

Figure 2: Adapted programme for the boilers, (figure taken from "THY_WP3_024_Test protocol instructions to labs_V07f jn 2021")

As shown on Figure 2, the boilers will be running for 5 days with only a few breaks and, for safety reasons, will not operate during the weekend. However, to catch up with the delay we are considering the options of having test performed at weekends as well (weekend breaks are not based on technical reasons).

A few checks will be done from time to time with pure CH_4 in order to detect possible evolution (as natural gas specification may vary depending on the supply, changes measured may be due to changes in gas composition, making test with CH_4 once in a while will therefore show whether there is a real evolution or not).

Another test that will be performed from time to time is a part-load test at high (start-stop) frequency.

As shown in Figure 2, the test will alternate maximal load (Qmax) and minimal load (Qmin). During the night period, the boiler will run at Qmin which has more severe condition than Qmax for flame stability (flame closer to burner surface). It also emulates real situations, appliances are most of the time working closer to Qmin, Qmax is generally for house heating up after night set back (space heating) or for sanitary hot water production (combi boilers).

2.3.4 Test plan for cookers. Updates on test protocol after discussions with the manufacturers

The test programme from 2.3.3 has been adapted for cookers, they are few differences but we have added a number of variations: in particular, the tests will be done on one side with the pot filled with water and on the other side with metal plate designed to "simulate" a pot in an easy way. A system will guarantee that the pot is always filled with water.

Figure 3: Initial programme for the boilers, (figure are from "THY_WP3_024_Test protocol instructions to labs_V07f jan 2021")

2.3.5 Details on measured parameters

The measurement will be performed on the 5 appliances to be tested at DGC in a way that all appliances are checked for a period of 9 minutes every hour. There will be a continuous measurement of 9 minutes each hour on each appliance. The data acquisition system will be used to monitor and record the main data as shown on Figure 4.

For the test at GWI, the setting could be different.

The initial setup presented above may be changed and adapted to the results observed.
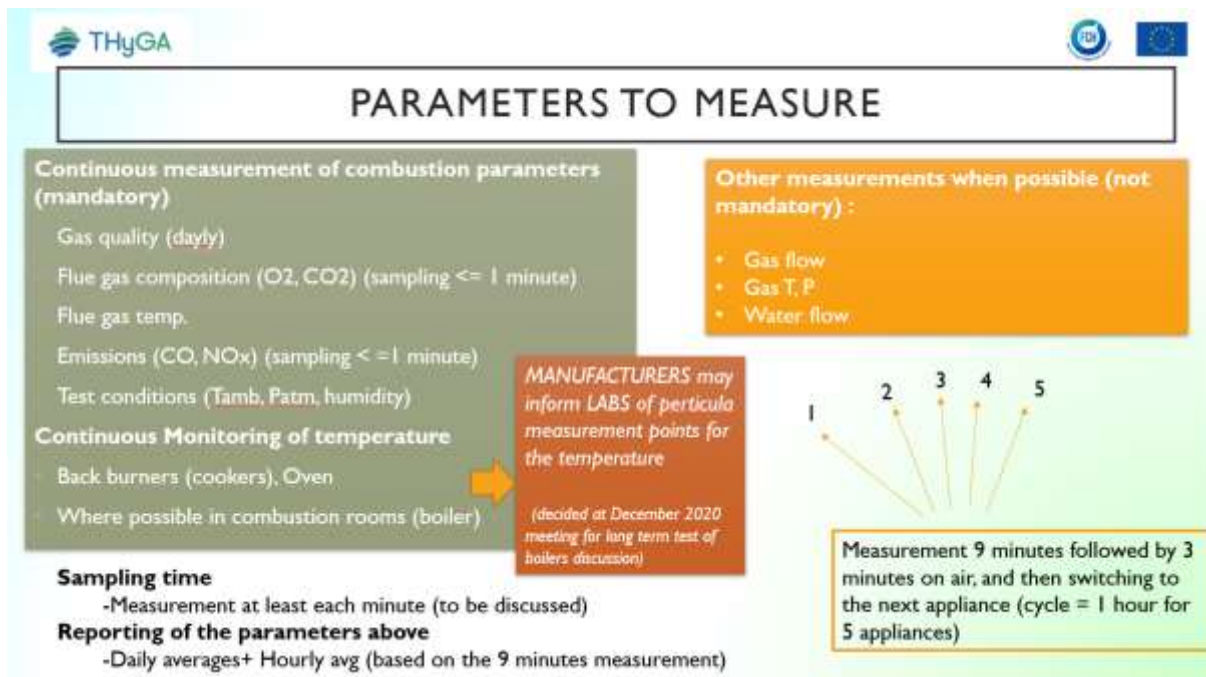
Figure 4: Parameters to measure (figure from "THY_WP3_024_Test protocol instructions to labs_V07f jan 2021")

2.4 Monitoring method

The measurement and monitoring will be the main activities during the long-term test. The main objective is to spot any deviation of performance that could indicate hydrogen impact on the operation of one or more appliances. What we may expect is a deterioration of a burner leading to modification of performances (emissions especially) and flame instability. This may be a sudden or a slow process.

Due to the hardware configuration explained in 2.3.5, we have to accept to have a delay of up to 1 hour in case of a sudden change on one of the appliances.

In case of an issue with one appliance we plan to get in touch with the manufacturer (this is at least valid for 4 out of 5 tests at DGC and the 2 tests at GWI).

- One of the appliances tested at DGC was bought in a shop, and we have for now no contact with the manufacturer, therefore there is an uncertainty about the manufacturer being interested in a dialog with us in case there is such a need.
- The other manufacturers will be informed of the evolution of the work during the course of the testing.

Figure 5: Monitoring (figure from "THY_WP3_024_Test protocol instructions to labs_V07f jan 2021")

2.5 Reporting

The reporting will include the following elements:

- Data showing evolution of key parameters during the long-term test
- Visuals on the main accessible components of the appliances (before/after long term test)

Figure 6: Reporting: (figure from "THY_WP3_024_Test protocol instructions to labs_V07f jan 2021")
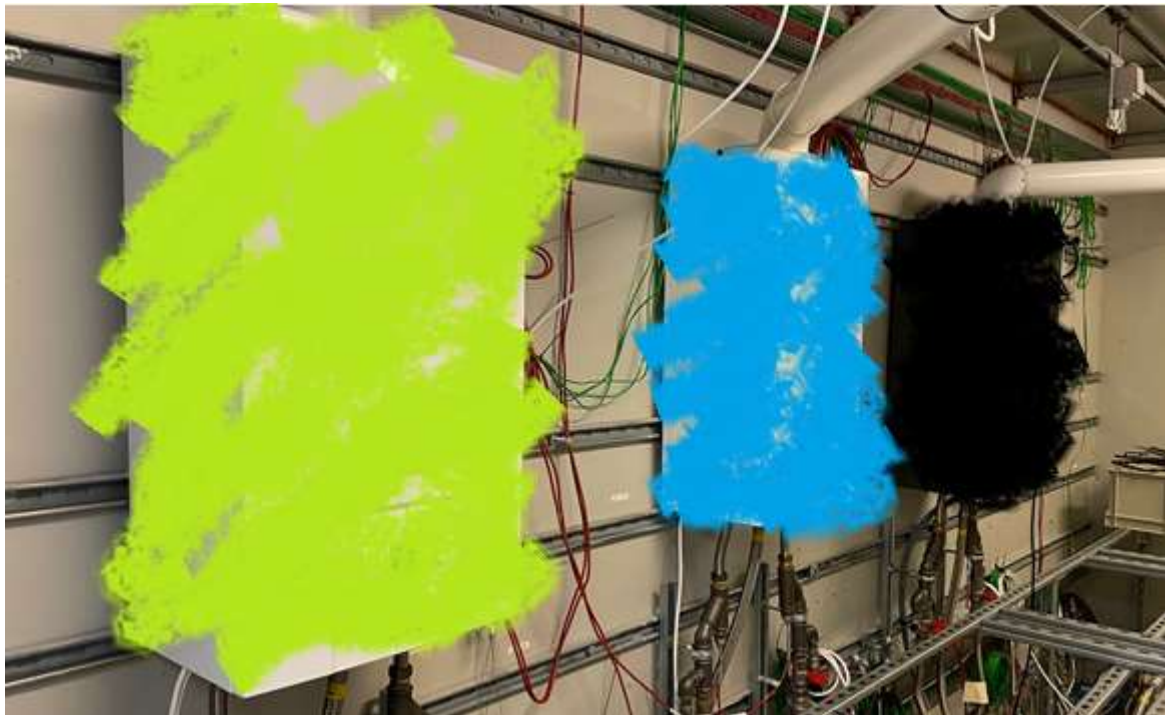
2.6　Set up for the test at DGC

Figure 7: The three boilers ready for the test (anonymized

Figure 8: Instruments for the measure of the appliances (here a gas meter for boiler 1)

Figure 9: Details of the gas mixing station

Figure 10: Detail of the sampling system

Figure 11: Outside the long test room, gas appliances water supply etc.

3. Conclusion

The long-term tests are not yet started (at M20), but will very soon, the project expect to catch up and deliver the results within the time allocated to the project although the impact of unscheduled events (failure on components of the tested equipment, for example) may prove complicated to manage (if there is some time before getting a new part, the test plan could finish after M36).