ehi
association of the European Heating Industry

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EHI position paper on the use of green gases for heating

This paper presents the views of the European Heating Industry on the role of green gases for heating.

It integrates the '*EHI Vision paper 2030-2050 for the decarbonisation of buildings'* by expanding on a number of aspects such as (1) recent developments in the supply chain of green gas / hydrogen (2) innovation in heating technologies to support the use of green gases, such as hydrogen (3) benefits of using green gases for heating from an energy system point of view, a consumer perspective as well as for the EU climate policy (4) green gas and hydrogen-ready heating technologies.

Finally, it indicates a number of EU policy barriers to be overcome in order to reap the benefits of green gases for heating, including through Ecodesign and Energy Labelling policy.

Key messages

- A **coherent approach between these different policies, including in how ecodesign and energy labelling can best support the overarching policies, is essential to achieve the 2030 and 2050 goals** – this is needed to support a sharp reduction of the heating industry's energy consumption and to support a cut in the use of fossil fuels in the next decades.
- **Electrification of space heating will play a major role in the decarbonisation of heating, however, there will also be a clear role for decarbonised gas and other decarbonised fuels** – none of the EU scenarios foresee an electrification of space heating of more than 34 %.
- **On the supply side, green gas production is being scaled up and, on the infrastructure side, biomethane injections are being increased and on the gas infrastructure side developments are ongoing in preparation of the transition from fossil fuel gas to biomethane, green e-methane, green hydrogen or blends.** The gas grid can be used to store renewable energy when the demand of energy exceeds the electricity demand and will be needed to ensure security of supply.
- **Electrification of heating will not be possible in all buildings from a technical and financial point** – in those cases, converting the gas infrastructure and gas-fuelled space and water heaters to green gases would be cheaper, faster and more efficient.
- **Gas fuelled space and water heaters can already burn 100 % biomethane today and are moving towards a 'green gas readiness' –** this will allow gas burning appliances to convert to any green gas (e-methane, bio-methane, hydrogen or blends with up to 20 % hydrogen) and will avoid a premature end of life of the appliances when local decarbonisation strategies for gas are being decided.
- **There is no one-size fits all solution to decarbonise heating, different efficient and renewable heating solutions will be needed to offer suitable and affordable solutions to all EU citizens -** next to heat pumps, gas burning appliances using decarbonised gases will be needed, examples of such appliances are hybrid heat pumps, micro-CHP, thermally driven heat pumps, but also condensing boilers.
- **Ecodesign and energy label should support green gas readiness** – to remove potential barriers to decarbonise gas and to give Member States and regions maximum flexibility in selecting the most suitable decarbonisation pathway for their local conditions.
- We propose to introduce a **pictogram for products that can operate with green gases on the energy label in 2023**; **a mandatory ecodesign requirement for gas condensing boiler space and**

combination heaters ≤ 70 kW, hybrid heat pump space and combination heaters ≤ 70 kW and thermally driven heat pump space and combination heaters ≤ 70 kW to be a '20% of hydrogen appliance' in 2025; and **mandatory ecodesign requirement for gas condensing boiler space and combination heaters ≤ 70 kW, hybrid heat pump space and combination heaters ≤ 70 kW, micro-CHP space and combination heaters ≤ 70 kW and thermally driven heat pump space and combination heaters ≤ 70 kW are '100% hydrogen-ready appliances' or '100 % hydrogen appliances' in 2029**.

About EHI, the Association of the European Heating Industry

EHI represents 90% of the European market for heat and hot water generation, heating controls and heat emitters, 80% of biomass central heating, as well as 75% of the hydronic heat pump and solar thermal markets. Our Members produce advanced technologies for heating in buildings, including: heating systems, burners, boilers, heat pumps, components and system integrators, radiators, surface heating & cooling and renewable energy systems. In doing so, we employ directly more than 160.000 people in Europe and invest more than 700 million euro a year in energy efficiency.

1. The role of buildings and heating in today's climate policy context

The building sector accounts for 40% of the energy consumption[1] (and 36 % of the greenhouse gas emissions) in the EU, with heating representing the largest share of energy consumed. Indeed, in residential buildings, space and water heating account for 78 %[2] of the final energy consumed and in industrial buildings, space and process heating account for 71 %[3] of the final energy consumed.

In order to reach the European Green Deal's ambition to reduce greenhouse gas emissions by 55% by 2030 in comparison to 1990 and be climate-neutral by 2050, it is clear that the heating sector will sharply have to reduce its energy consumption and cut its use of fossil fuels in the next decades.

To steer the market in this direction and to overcome existing barriers, the European Commission is working on several initiatives, including the review of the renewables directive and the energy efficiency directive, the renovation wave and at a later stage the review of the energy performance of buildings directive, the strategies for hydrogen and other 'green' gases, and the review of the ecodesign and energy labelling regulation for space and water heaters. A coherent approach between these different policies, including in how ecodesign and energy labelling can best support the overarching policies, is essential to achieve the 2030 and 2050 goals.

2. A perspective from the energy system: requirement for green gas for space and water heating in addition to electricity

Even with improvements to the building envelope and a change to more efficient heating systems, heating is expected to remain the largest share of energy consumption in buildings in Europe, with high demands on the coldest days of the year.

Although electrification of space and water heating with heat pumps will play a major role in the decarbonisation of heating, not all heat demand can and will be covered by electric heat pumps without putting enormous strains on the electricity grid.

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[1] Communication from the Commission to the European parliament, the Council, the European Economic and Social committee and the committee of the regions - a renovation wave for europe - greening our buildings, creating jobs, improving lives. Brussels, 14.10.2020, com(2020) 662 final. (Renovation wave).

[2] Source: Eurostat - Share of fuels in final energy consumption in the residential sector by type of end-use, 2018

[3] Source: https://ec.europa.eu/energy/topics/energy-efficiency/heating-and-cooling_en

Indeed, the EU scenarios towards a climate neutral 2050 forecast an electrification of space heating in residential buildings of not more than 34%[4,5]. Moreover, these EU scenarios show that of the non-electricity fuel consumption in buildings (only used for space heating, water heating and cooking[6]) a significant proportion[7] will be covered by gas (in a mix of hydrogen, biogas and e-gas, and sometimes low quantities of natural gas, depending on the scenario).[8,9] This confirms that the remaining space heating will need to be generated by non-electric renewable solutions. Even more so, to meet the 2030 and 2050 goals, all renewable options, including solar thermal, biomass boilers, renewable-based, district heating networks and gas-fuelled appliances functioning on 'green' gas (i.e. green e-gas, green hydrogen, bio-gas) will need to be available and developed.[10,11]

These findings are also in line with the joint projections by the electricity and gas infrastructure operators, which also foresee a clear role for gas in residential, commercial and public buildings for space heating.[12]

3. Developments on the supply side and gas infrastructure

The gas grid can be used to store renewable energy when the demand of energy exceeds the electricity demand, this will be needed to ensure security of supply.

To comply with EU CO_2 emission reduction goals, on the supply side, developments are ongoing to scale up the 'green' gas production[13,14]. With the scale up of the production, costs for green gases are expected to drop considerable. For example, it is expected that the price of hydrogen will be competitive to that of the natural gas price in Germany and Scandinavia on an energy-equivalent basis before 2050.[15]

In addition, on the gas infrastructure side, developments are ongoing in preparation of the transition from fossil fuel gas to biomethane, green e-methane, green hydrogen or blends. For biomethane, injections into the gas grid increased in the last decades to a 0,4 % share in the gas grid, this share is expected to increases to 5-8 % (based on European and national targets) by 2030[16]. For hydrogen, today a concentration of 10 % and for some 20 % hydrogen (in very specific conditions, e.g. in

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[4] In-depth analysis in support of the Commission Communication Com(2018) 773 - A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy (In-depth analysis), figure 43, scenarios TECH1.5 and LIFE1.5; the other scenarios do not lead to climate neutrality by 2050, the ELEC scenario, which is the scenario with the highest electrification rate and only leads to 80-90 % reduction of emissions in 2050, forecasts an electrification of 44 %..

[5] Commission staff working document impact assessment accompanying the document communication from the Commission to the European Parliament, the Council, the european economic and social committee and the committee of the regions stepping up europe's 2030 climate ambition investing in a climate-neutral future for the benefit of our people (Impact assessment for the 2030 climate target plan), derived from figure 55.

[6] In-depth analysis, p 104, Section 4.3.3.2

[7] 50-60% of the non-electric fuel consumption in buildings for the scenarios in the in-depth analysis and 26-29% for the scenarios in the impact assessment for the 2030 climate target plan, noting that in absolute values (Mtoe) the gas consumption is similar in both assessments (ranging from 35 to 45 Mtoe, depending on the scenarios).

[8] In-depth analysis, calculated from figure 43 for scenarios TECH1.5 and LIFE1.5

[9] Impact assessment 2030 climate target plan, calculated from Figure 55 for REG, MIX, CPRICE and ALLBNK

[10] In-depth analysis, section 4.3.1

[11] Impact assessment for the EU 2030 climate target plan, Section 2.2.2.

[12] ENTSO-E and ENTSO-G, Three Storylines to test Europe's gas and electricity infrastructure (2020)

[13] Biomethane production is estimated to grow from around 23 TWh/yr in 2018 to 300-370 TWh/yr by 2030 (Market state and trends in renewable low carbon gases, a gas for climate report, December 2020);

[14] EU industry has developed an ambitious plan to reach 2x40 GW of electrolysers by 2030 (Communication from the Commission to the European Parliament, the Council, the European economic and social committee and the committee of the regions - A hydrogen strategy for a climate-neutral Europe)

[15] Hydrogen economy outlook, 30 March 2020, Bloomberg NEF

[16] Market state and trends in renewable low carbon gases, a gas for climate report, December 2020

dedicated projects and new or very recent gas infrastructures)[17] by volume can be blended into the existing gas grid without any adaptations of the grid. Different scenarios[18] are being investigated for the use of hydrogen in buildings:

- via a dedicated hydrogen infrastructure and storage[19], which can be deployed at any scale and at various distribution levels (e.g. regional, city, a district or even smaller areas);
- by blending hydrogen with natural gas, biomethane, or e-methane delivered in the existing gas grid[20];
- the local production of hydrogen by energy independent buildings to store the excess of electricity produced by PV cells and use it when needed;[21]
- the use of hydrogen for district heating networks.

In most parts of Europe, the gas grid can be adapted fairly quickly[22] to accommodate up to 20% of hydrogen[23] with very limited costs[24]. The total estimated investment for building a European hydrogen network (including 75 % of converted natural gas pipelines and 25% new pipeline) is considered modest[25] in comparison to the foreseen size of the hydrogen market.

The heating market offers a large, easy-to-develop demand market, which can quickly generate investment security for hydrogen producers and bulk consumers, which in turn will support the transformation in all sectors.

As is the case for the optimal heating solution, the optimal decarbonisation solution and the role of green gases will depend on specific local circumstances (e.g. age of building stock, level of insulation, state of the grids, availability of renewable energy sources). This is why different Member States and regions will focus on different solutions ranging from higher shares of renewable gases to higher electrification rates. Also the choice of gas will differ depending on the Member State and region: some Member States might only focus on biomethane (e.g. France), some on hydrogen[26] (e.g. UK) or some on both (e.g. Germany).

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[17] MARCOGAZ, Overview of test results & regulatory limits for hydrogen admission into existing natural gas infrastructure & end use, October 2019. Link: https://www.marcogaz.org/publications-1/documents/

[18] The Round Table of Clean Hydrogen for Buildings will cover four scenarios for hydrogen with a focus on a dedicated hydrogen grid and blends of hydrogen with methane (natural gas, biomethane or e-methane) for which solutions are already being developed for high-scale deployment

[19] 11 gas infrastructure companies have published a vision to build a hydrogen backbone to the gas grid in 10 Member States by 2040: European Hydrogen Backbone, Enagás, Energinet, Fluxys Belgium, Gasunie, GRTgaz, NET4GAS, OGE, ONTRAS, Snam, Swedegas (Nordion Energi), Teréga, and consultancy company Guidehouse July 2020

[20] Research and pilot projects are being set up to investigate the effect of increasing blending levels for hydrogen in the gas infrastructure and plans are being prepared to unroll a dedicated hydrogen infrastructure and storage. Some examples of projects: GRHYD (France), Avacon (Germany), Hydeploy (the UK) – all of them focusing on a variable share of H2 up to 20%, because this would not require a major change to the infrastructure and the appliances.

[21] For one example see https://www.solencopower.com/.

[22] In the short term, hydrogen can be blended in most networks at a rate of 6% in terms of volume; by 2030, operators recommend setting a target capacity for integrating blended hydrogen into the networks of 10%, and 20% thereafter; these rates are achievable with limited changes to the infrastructures.

[23] MARCOGAZ, Overview of test results & regulatory limits for hydrogen admission into existing natural gas infrastructure & end use, October 2019. Link: https://www.marcogaz.org/publications-1/documents/

[24] French TSOs and DSOs, Final report, Technical and economic conditions for injecting hydrogen into natural gas networks, June 2019. Link: http://www.grtgaz.com/fileadmin/plaquettes/en/2019/Technical-economic-conditions-for-injecting-hydrogen-into-natural-gas-networks-report2019.pdf

[25] 27 to 64 billion euros according to the European Hydrogen Backbone report

[26] According to the EU hydrogen strategy, 100 % hydrogen in the EU will only be foreseen for space heating in residential and commercial buildings, in case of hydrogen clusters and potentially hard-to-decarbonise commercial and industrial buildings

4. Decarbonisation of buildings

New buildings today can include high-performance thermal insulation. However, these buildings will only represent 10-25% of the buildings stock in 2050 and to achieve the ambitious climate goals, also the remaining buildings will need to be decarbonised.[27]

Buildings are different across Europe and so are heating needs, due to different climates, energy infrastructure, available renewable energy resources at local level, individual preferences and economic resources. There is no one-size-fits-all solution.

Thermal insulation of the building envelope and replacement of windows, will be key to reduce the heating demand in the building and to decarbonise buildings. However, these types of renovations take time and are characterised by high financing requirements and long payback periods. These high upfront investments might not be affordable for many consumers, even with funding programs and low capital market rates. Moreover, the potential of thermal insulation is not unlimited as a substantial part of the building stock cannot be fully insulated[28]. When the level of thermal insulation doesn't reach a certain threshold, low temperature space heating systems (e.g. energy efficient heat pumps) will not be able to cover the heating demand at the rated efficiency of the appliance.

In addition to the financing requirements for the improvement of the building envelope, the existing heating appliance and hydronic system will need to be replaced; and aside from possible affordability issue, there might be limitations in existing buildings due to the size of this hydronic system (larger radiators, larger diameter piping, the need for domestic hot water storage) when installing low temperature heating systems.

In these cases, electrification is not the optimal solution to decarbonise the heating system[29]. Instead, converting the gas infrastructure and gas-fuelled space and water heating appliances to 'green' gases, would be cheaper[30], faster[31] and more efficient.

5. Gas-fuelled space and water heaters and 'green' gases

Gas-fuelled space and water heaters (i.e. condensing boilers, micro-cogeneration including fuel cells, gas fired heat pumps and hybrid heat pumps) today typically burn fossil fuels, this is due to the fact that today there is not enough renewable gas available (e.g. green hydrogen, biomethane, green e-gas) that can be injected into the gas grid. This situation is similar to that of electricity two decades ago. Since then, the renewables share in electricity production has grown significantly, the same is expected to happen for gas in the next decades (see Section 3).

In response, gas-fuelled space heaters are moving towards a 'green' gas readiness so they are able to burn green gas, i.e. biomethane, e-methane, green hydrogen in blended and pure form. Gas fuelled space and water heaters on the market today are already capable of working with up to 100% bio-

[27] In-depth analysis, section 4.3.1

[28] According to BPI Buildings Performance Institute Europe ("Long-Term Renovation Strategies: How the building sector can contribute to climate neutrality in the EU », Policy Brief January 2020. Link: https://www.bpie.eu/wp-content/uploads/2020/01/EUCalc_PB_no3_Buildings.pdf) 37 % of the existing building stock needs to be demolished by 2050 to meet the goals in a scenario where only 4 % gas is considered in the fuel mix of decentral heat and district heat generation in 2050

[29] Heat pumps at higher temperatures are not as efficient as at lower temperatures, the high purchase price remains

[30] As an example, a hydrogen boiler and a thermally driven heat pump become competitive versus an electric heat pump in old buildings at around 4 USD/kg and 5.6 USD/kg respectively. Path to hydrogen competitiveness. Calculated from A cost perspective, 20 January 2020, published by the Hydrogen Council with analytical support from McKinsey & Company and for selected areas E4tech.

[31] In comparison, upgrading buildings to work with low temperature heating systems such as heat pumps, require an upgrade of the electricity grid, i.e. a additional electricity generation, transportation and ddistribution capacities plus a renovation of the building envelope, this will take much more time than relying on the gas grid

and e-methane and some condensing boilers can already accommodate a variable share of hydrogen of up to 20%. In addition, there are fuel cells[32] on the market today that are already capable of functioning with 100 % hydrogen. Boilers and micro-cogeneration units that function with 100% hydrogen are under development and in the field-test phase.

In addition, as the local decarbonisation strategies for the gas grids are still undecided, manufacturers of heating systems are considering developing 100 % hydrogen ready appliances, which by means of hydrogen conversion kits would be fully convertible to a 100 % hydrogen appliance. These appliances would be able to function with any type of green gas (e.g. e-methane, bio-methane, hydrogen or blends with up to 20 % hydrogen), the conversion kits would be supplied to the consumer if a region, city or part of a city would convert to 100 % hydrogen and would avoid that gas-fuelled space and water heating appliances in these areas would prematurely reach their end of life.

6. There is no one-size fits all solution to decarbonise heating, different efficient and renewable heating solutions will be needed to offer suitable and affordable solutions to all EU citizens

There are 65 million old and inefficient heaters installed in Europe, with an average age of 25 years and average efficiency of 60 to 70 %. To reach the 2030 targets, these units will need to be replaced relatively quickly by energy efficient alternatives[33].

The optimal choice of space and water heating system will depend on specific local circumstances such as the availability of local renewable sources, the availability and feasibility of the energy infrastructures, the building's properties, technical building systems and their link with the energy system. However, individual preferences (of the consumer or installer) and economic resources will also play an important role.

It is clear that electrification of space and water heating with low temperature heating systems, such as heat pumps, in combination with thermal insulation of the building envelope and replacement of windows[34], will be key in the decarbonisation of heating and EHI fully supports this. However, as shown in the Sections 2 and 4, full electrification would put enormous strains on the electricity grid and not all buildings can be insulated sufficiently to accommodate low temperature heating systems.

In these cases, alternative solutions, such as adding a heat pump to an already existing condensing boiler, hybrid heat pumps (combination heat pump and boiler), thermally-driven heat pumps and micro-CHP can be a good alternative, as they bring already today significant reductions in CO_2 emissions. They efficiently work in buildings that are not well-insulated and work with -in the future-decarbonised gases.

However, there are still some barriers for the market uptake of the above solutions, which are difficult to overcome in the short term. Some examples are: the lack of upskilled installers, the price of electricity versus the price of gas and the suitability of the electricity system.

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[32] Solid oxide fuel cells (SOFC) have an overall efficiency of more than 85% (electricity and heat) and work by combining hydrogen produced from the fuel and oxygen from the air to generate power, water, and heat. These systems can be used in cities, factories, trade and commerce, data centers, critical infrastructure (e.g. telecommunications, hospitals) and electric vehicle charging infrastructure.

[33] The impact assessment for the EU 2030 climate target plan and renovation wave indicate a 4 % replacement rate for heating appliances, however, this is already today's replacement rate. As such, to reach the climate goals this should be increased to at least 6 %.

[34] Heat pumps will reach their highest efficiency levels when used in new and renovated well-insulated buildings, equipped with low temperature radiators / underfloor heating

In these cases, condensing boilers are the next most efficient solution. Condensing gas boilers, today, cost least of all the high-efficiency space heating technologies in terms of life cycle cost; and although they are closely followed by air source heat pumps, condensing gas boilers are at least 3.3 times cheaper[35] in terms of purchase price than any of the more efficient alternative space heating technologies. In addition, the payback period for replacing a non-condensing gas boiler with a condensing gas boiler is also at least 7 %[36] lower than that of any of the other more efficient appliances. As such, until the price of alternative solutions and/or electricity drops considerably, condensing boilers will remain the most affordable solution for many households in many EU Member States, and especially for energy-poverty conditions.

In addition, a quick calculation with the data of the review study of Ecodesign, indicates that if the stock of non-condensing gas boilers would be replaced by new gas condensing boilers, the energy savings would be as much as 463 PJ/a and the savings in greenhouse gas emissions would be as much as 23 Mt CO_2 eq./a[37]. At such, they can significantly contribute to the 2030 goal to reduce 55 % CO2 emissions (translating in 77 Mt CO_2 eq/a).[38]

There is no one-size-fits-all-solution: therefore, it is important to keep all solutions available and promote all efficient solutions, including condensing boilers.

7. Why should Ecodesign and energy labelling support 'green' gas readiness

Action at EU level will ensure that potential barriers to decarbonise gas, which as shown in the previous sections will have a significant role, are removed. If gas-fuelled space and water heating appliances are 'green' gas ready, Member States and regions will have maximum flexibility in selecting the most suitable decarbonisation pathway for their local conditions.

Gas-fuelled space and water heaters that are sold today, are on the market for an average of 15 to 24 years[39]. This means that if no action at EU level in ecodesign and energy labelling is taken in this review (which will at least apply until 2030), consumers will end up with stranded investments, because their gas-fuelled space heating appliances will not be compatible with the decarbonised gas grid.

8. How should European policies ecodesign and energy labelling support this?

8.1. Ecodesign and energy labelling

8.1.1. Proposed ecodesign and energy labelling measures

In 2023: to introduce a pictogram on the energy label indicating the capability of the gas burning appliances to use 1) biomethane, e-methane, bio LPG, 2) a variable share of hydrogen of up to 20 % by volume (in combination with biomethane or natural gas) and 3) 100 % hydrogen.

In 2025: to introduce a mandatory ecodesign requirement for a gas condensing boiler space and combi heaters ≤ 70 kW, hybrid heat pump space and combi heaters ≤ 70 kW, micro-cogeneration space and

[35] Space and combination heaters, ecodesign and energy labelling review study (Review study), task 5 – comparison of a condensing gas boiler ≤ 70 kW with an air to water heat pump; comparing with a hybrid ≤ 70 kW, would be 4.1 times cheaper
[36] Review study – comparison of the payback period of a condensing gas boiler ≤ 70 kW with an air to water heat pump, the payback period was calculated by dividing the purchase price and installation cost of the new appliance by the difference in annual costs for maintenance cost for maintenance, repair and energy of the new appliance in comparison to those a non-condensing boiler; the payback period of a condensing gas boiler ≤ 70 kW vs that of a hybrid ≤ 70 kW, would be 61 % shorter
[37] Calculated from Tables 10 and 15 of the Review study – using the stock base case for condensing and non-condensing boilers ≤ 70 kW, ≤70 and > 400 kW and > 400 kW
[38] This is calculated for natural gas, not for green gas
[39] Review study, task 5

combination heaters ≤ 70 kW and thermally driven heat pump space and combi heaters ≤ 70 kW to be a ‘20% hydrogen appliance’.

In 2029: hydrogen readiness, i.e. make sure that gas condensing boiler space and combi heaters ≤ 70 kW, hybrid heat pump space and combi heaters ≤ 70 kW, micro-cogeneration space and combination heaters ≤ 70 kW and thermally driven heat pump space and combi heaters ≤ 70 kW are ‘100 % hydrogen-ready appliances’ or ‘100 % hydrogen appliances’.

8.1.2. Definitions

‘20% hydrogen appliance’ means a gas appliance that is designed and approved to operate safely and efficiently without conversion using a gas that has a fluctuating hydrogen content of between 0 and 20 % by volume.

‘100 % hydrogen appliance’ means a gas appliance that is designed and approved to operate safely and efficiently without conversion using 100 % hydrogen.

‘100 % hydrogen-ready appliance’ means a gas appliance that is designed and approved to be installed and to operate on natural gas and, following a conversion and re-commissioning process in situ, can then operate safely and efficiently using 100 % hydrogen’.

8.1.3. Ecodesign and safety requirements

100% hydrogen-ready boiler, hybrid heat pump, micro-cogeneration and thermally driven heat pump space and combination heaters are not on the market today, so, their energy efficiency and emissions are difficult to determine at this stage. As such, for the moment we propose that the 20 % hydrogen boiler, hybrid heat pump, micro-cogeneration and thermally driven heat pump space and combination heaters and the 100 % hydrogen-ready boiler, hybrid heat pump, micro-cogeneration and thermally driven heat pump space and combination heaters shall meet the ecodesign and energy labelling requirements for gas-fired space heaters or combination heaters tested with a nominal methane content of 100%[40].

Regarding safety, all gas appliances suitable for green gas shall meet the safety requirements laid down in the Gas Appliances Regulation (EU) 2016/426 for those gases, and be independently tested by a notified body. The hydrogen conversion kits shall be approved by the notified body under the Gas Appliances Regulation including completion of the risk assessment. EN 15502-1 already describes the requirements for developing kits for any gas type.

Currently, European standards are under development to integrate hydrogen blends and at a later stage pure hydrogen. To define the test gases the EN 437 (CEN TC238 WG1 ad hoc group H2) and for the safety and performance of boilers the EN 15502-1 (TC 109 WG 1, ad hoc group H2)) are being reviewed. These updates will be based on ongoing testing programmes and the PAS 4444 used in UK for 100 % hydrogen gas appliances certification and the framework of HyDeploy, which is field testing a 20 % hydrogen blend. Furthermore, the German Notified Body under the Gas Appliance Regulation, DVGWcert, has recently introduced a certification scheme – ZP 3100 – for appliances according EN 15502 for blends of 20 % H2 and therefore these appliances can be CE-marked for the free movement in Europe. Additional certification schemes for other gas appliances and other hydrogen blends are under development.

[40] According to the EN 437

8.1.4. Clarification of the scope of the requirements

After the review study, manufacturers started evaluating the possibility and cost of making appliances hydrogen ready. They started this evaluation by first evaluating the most common appliances for the renovation market and hence, by making these products future proof first, the biggest impact on consumers due to stranded investments would be avoided.

The results of this evaluation show that the proposed requirements for are a no-regret option from a cost-benefit point of view with limited effect on the purchase price and least life cost.

For water heaters and non-condensing boilers, more technical analysis will be needed before confirming the requirements.

Hydrogen readiness for larger outputs > 70 kW would also be feasible, making gaseous fuel appliances with larger output future-proof with similar technical considerations. However, the route-to-market, the conformity assessment and the maintenance of these larger appliances are often different.

EHI is further assessing the technical and economic aspects related to this and will come back with more information once it is available.

8.1.5. Purchase price of a 100 % hydrogen-ready appliance versus the regular gas-burning appliance

8.1.5.1. Condensing boiler space heater ≤ 70 kW

The following is a rough estimation of the purchase price of the 100 % hydrogen-ready gas condensing boiler space heater ≤ 70 kW (before conversion) and the purchase price of the hydrogen kit for such a boiler. The estimation is an average based on various independent inputs received from EHI members. The values are given as the increase of the purchase price and least life cycle cost in comparison to the purchase price and least life cycle cost of the base case for a condensing boiler space heater ≤ 70 kW (from the ecodesign and energy labelling review study for space heaters and combination heaters (Task 5, Table 10)), expressed in percentage.

HYDROGEN READY BOILER INFORMATION	**ESTIMATION [a]**	**INCREASE IN LIFE CYCLE COST(LLC)[a]**
Increased purchase price of the hydrogen ready boiler compared to a natural gas boiler	16.9 %	1.1 %
Price of hydrogen conversion kit from natural gas to 100% hydrogen as a percentage of the natural gas boiler purchase price	12.8%	0.8 %
Time for conversion using the hydrogen conversion kit and commissioning	1-2 h	
Other costs related to the installation of the appliance	Same as normal installation/ possible quality check/chimney sweeper	
[a] Increase in comparison to condensing boiler space heater ≤ 70 kW (from the ecodesign and energy labelling review study for space heaters and combination heaters (Task 5, Table 10))		

As the price of hydrogen will be competitive in between 2030 and 2050, no increase in fuel price has been taken into account.

The cost of the hydrogen kit and hydrogen ready boiler will be depend on the number of sales. They provide a unique opportunity for low-cost decarbonisation, as long as they have substantial volume. It is essential therefore that national transitions to hydrogen-ready are orchestrated by governments, not left to market forces and not restricted to small regions. With a similar numerical scale of boiler manufacturer and market as that of todays (2021) "methane" gas boilers then 100% hydrogen-ready gas condensing boilers should be competitively priced (close to same price) in today's terms. By definition this does not allow for future inflation.

The above does not include the consumer investment cost saving from avoiding the stranding of products and a premature end of life of the product. This principle is also consistent with the EU material efficiency initiatives.

8.1.5.2. Hybrid heat pump space heater ≤ 70 kW

The following is a rough estimation of the purchase price of the 100 % hydrogen-ready hybrid heat pump ≤ 70 kW (before conversion) and the purchase price of the hydrogen kit for such a unit. The estimation is an average based on various independent inputs received from EHI members. The values are given as the increase of the purchase price and least life cycle cost in comparison to the purchase price and least life cycle cost of the base case for a hybrid heat pump ≤ 70 kW (from the ecodesign and energy labelling review study for space heaters and combination heaters (Task 5, Table 10)), expressed in percentage.

HYDROGEN READY HYBRID HEAT PUMP INFORMATION	**ESTIMATION [a]**	**INCREASE IN LIFE CYCLE COST(LLC)[a]**
Increased purchase price of the hydrogen ready hybrid heat pump compared to a natural gas hybrid heat pump	4.5 %	0.8 %
Price of hydrogen conversion kit from natural gas to 100% hydrogen as a percentage of the natural gas hybrid heat pump purchase price	3.4 %	0.6 %
Time for conversion using the hydrogen conversion kit and commissioning	1-2 h	
Other costs related to the installation of the appliance	Same as normal installation/ possible quality check/chimney sweeper	
[a] Increase in comparison to hybrid heat pump space heater ≤ 70 kW (from the ecodesign and energy labelling review study for space heaters and combination heaters (Task 5, Table 10))		

8.1.5.3. Thermally driven heat pump space heater ≤ 70 kW

The following is a rough estimation of the purchase price of the 100 % hydrogen-ready thermally driven heat pump space heater ≤ 70 kW (before conversion) and the purchase price of the hydrogen kit for such a thermally driven heat pump. The same approach and assumptions were taken as for the 100 % hydrogen-ready gas condensing boiler space heater ≤ 70 kW and its conversion kit. The values are given as the increase of the purchase price and least life cycle cost in comparison to the purchase price and least life cycle cost of the base case gas sorption heat pump ≤ 70 kW (from the ecodesign and energy labelling review study for space heaters and combination heaters (Task 5, Table 10)), expressed in percentage.

HYDROGEN READY TDHP INFORMATION	**ESTIMATION [a]**	**INCREASE IN LIFE CYCLE COST(LLC)[a]**
Increased purchase price of the hydrogen ready TDHP compared to a natural gas TDHP	3.3 %	0.6 %
Price of hydrogen conversion kit from natural gas to 100% hydrogen as a percentage of the natural gas TDHP purchase price	2.5 %	0.5%

Time for conversion using the hydrogen conversion kit and commissioning	1-2 h
Other costs related to the installation of the appliance	Same as normal installation/ possible quality check/chimney sweeper
[a] Increase in comparison gas sorption HP space heater ≤ 70 kW (from the ecodesign and energy labelling review study for space heaters and combination heaters (Task 5, Table 10))	

8.1.6. Purchase price of a 100 % hydrogen appliance

8.1.6.1. Condensing boiler space heater ≤ 70 kW

The following is a rough estimation of the purchase price of the 100 % hydrogen condensing boiler space heater ≤ 70 kW. The estimation is an average based on various independent inputs received from EHI members. The values are given as the increase of the purchase price and least life cycle cost in comparison to the purchase price and least life cycle cost of the base case for a condensing boiler space heater ≤ 70 kW (from the ecodesign and energy labelling review study for space heaters and combination heaters (Task 5, Table 10)), expressed in percentage.

100 % HYDROGEN BOILER INFORMATION	**ESTIMATION [a]**	**INCREASE IN LIFE CYCLE COST(LLC)[a]**
Increased purchase price of the hydrogen ready boiler compared to a natural gas boiler	Data collection ongoing	Data collection ongoing
[a] Increase in comparison to condensing boiler space heater ≤ 70 kW (from the ecodesign and energy labelling review study for space heaters and combination heaters (Task 5, Table 10))		

8.1.6.2. Other 100% hydrogen appliances

These appliances are not being developed yet, as such, an estimation of the purchase price is difficult at this point.

8.1.7. Items that are currently still under investigation

The following items are still under investigations and we hope we will be able to deliver these items during the further process of the review:

- Relevance of including products other than gas boiler, hybrid heat pump and TDHP space and combi heaters ≤ 70 kW (e.g. from a purchase price and a life cycle cost perspective, from a cost-benefit point of view)
- Possible requirements for the conversion kit (e.g. duration of the availability, responsibility, easy installation)
- Typical examples of the composition of a conversion kit (e.g. burner, restrictor, code plug, data label)