THyGA

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

Market segmentation of domestic and commercial natural gas appliances

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Authors	Mustafa Flayyih[1] Johannes Schaffert[1] Frank Burmeister[1] Rolf Albus[1] Klaus Görner[1] Patrick Milin[2] Stéphane Carpentier[2] Krishnaveni Krishnaramanujam[3] Jörg Endisch[3] Kris de Wit[4] Eric Geerts[4] Jean Schweitzer[5]
Affiliations	[1] Gas- und Wärme-Institut Essen e.V. (GWI), Hafenstraße 101, 45256 Essen, Germany [2] ENGIE, CRIGEN Lab, 4 Rue Joséphine Baker, 93240 Stains, France [3] DVGW-Forschungsstelle am EBI des Karlsruher Instituts für Technologie, Engler-Bunte-Ring 7, 76131 Karlsruhe, Germany [4] Gas.be, Place Masui 15, B-1000, Brussels, Belgium [5] Dansk Gasteknisk Center (DGC), Dr. Neergaards Vej 5B, DK-2970 Hørsholm, Denmark
Corresponding author	Johannes Schaffert (WP2 leader), schaffert@gwi-essen.de

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Partner	Approval (Signature or e-mail reference)
GWI	Manfred Lange (lange@gwi-essen.de)
ENGIE	Patrick Milin (patrick.milin@engie.com)
DGC	Jean Schweitzer (jsc@dgc.dk)

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List of abbreviations

APPLiA	Home Appliance Europe
BSH	BSH Hausgeräte GmbH
CCB	Combustion controlled boiler
CH4	methane
CHP	combined heat and power
CO	carbon monoxide
CO2	carbon dioxide
EN	European Norm
EU	European Union
FS	floor standing or free standing
GHP	gas heat pump
GIWH	Gas Instantaneous Water Heaters
GSWH	Gas Storage Water Heaters
H2	hydrogen
H2NG	hydrogen / natural gas blend
HKI	German Industrial association of House, Heating and Kitchen Technology
HP	heat pump
LPG	Liquefied Petroleum gas
NCV	lower heating value, net calorific value
NG	natural gas
NOx	nitrogen oxide
O2	oxygen
PEM FC	Polymer Exchange Membrane Fuel Cell
Seg	(market) segment
SO FC	Solid Oxide Fuel Cell
SYNEG	French National Union of Large Kitchen Equipment
TC	Technical Committee from the CEN standardization organization
THyGA	Testing Hydrogen Admixture for Gas Applications
UK	United Kingdom
WH	wall hung
WP	work package

1 Introduction, objective and scope

Natural gas is one of the most important primary energy sources in Europe, with combustion processes representing the dominant utilization path. Although natural gas also serves as a feedstock for a wide variety of products in the chemical industry (as well as in some metallurgical applications), the vast majority of the natural gas being distributed today is burned to provide heat, electricity or propulsion across many different sectors, from domestic appliances to industrial furnaces, power plants or in natural gas vehicles. The combustion of natural gas as well as any other hydrocarbon fuel releases carbon dioxide (CO_2), a greenhouse gas. Measures must be taken to drastically reduce the overall impact of gas combustion on the climate. The use of **hydrogen as a non-polluting fuel** which reacts with oxygen to form nothing but water, is an intensely discussed and promising option for all end-use sectors.

While a distribution of pure hydrogen through existing or future gas grids remains a major challenge, **hydrogen admixture or blending** into the natural gas grids is a technically feasible way to partly reduce CO_2 emissions from gas combustion across all sectors quickly.

The investigated appliance types installed within the EU today were designed and optimised for operation with natural gas only. This is also true for larger equipment in industry and power generation. Therefore, the **impact of hydrogen admixture on combustion processes** will be an important criterion to assess the viability of various admixture levels of hydrogen in the natural gas grids on the technical, environmental, economic, political and societal level. The residential and commercial sectors, with an estimated population of more than 228 million appliances in the EU, play a major role in this discussion.

One of the main **goals of the THyGA project** is to enable the wide adoption of hydrogen / natural gas blends (H2NG) by closing knowledge gaps regarding technical impacts on residential and commercial gas appliances. For this purpose, the THyGA project screened the portfolio of technologies (this report, D2.1) and assessed the impact of hydrogen / natural gas admixture on a theoretical basis (THyGA reports [BlBr20, LSCA20, SFLB20]).

The market segmentation reported here is part of work package 2 of the THyGA project and provides a **quantitative segmentation of the gas appliance market** in terms of appliance population numbers. It therefore prepares the project partners to perform the subsequent selection of the most representative product types to be tested in the laboratories of the THyGA partners. The classification is developed to categorise appliances installed in the field, based on available statistics, calculation methods and estimations. As a result, **appliance populations are provided for each technology segment** that draw a representative picture of the installed end-use appliances within the European Union in 2020.

2 Market segmentation

Market segmentation can be defined as the subdividing of a market into distinct subsets, where any subset may be selected as a target for tailored efforts, i.e. in the case of this project, suitable research and testing approaches.

Task 2.1 from Work Package 2 aims to identify a recent detailed market segmentation of the existing natural gas fired appliances in domestic and commercial sectors. Besides literature research, additional information was needed to assess the available data in order to make meaningful deductions. Typical challenges were deviating aggregations of appliance numbers with regard to technologies and segments. In other cases, simplifications or lacking differentiations e.g. between fuel types were encountered. Direct communication with national and international technical associations was sought to allocate the information and validate the deductions. The needed complementary information was gathered as a result of various discussions with experts, partners, associations, manufactures and standardisation committees. This report took into account available segmentation and population assessment approaches from previous projects and ongoing combination with datasets provided by project partners and experts; extrapolations and estimations of the appliance populations per technology segment were done in order to achieve a representative overview.

The analysis of the European market for gas-fired end-user appliances led to the information shown in Table 2-2 sorted by appliance technology categories and burner types and referenced by segment numbers which is used as a reference system in the further course of the THyGA project.

For each of the main appliance categories considered in this project, a suitable method was developed for gathering and assessing available information and to extrapolate historic data to the year 2020. The year 2020 is chosen as a common reference year for all technologies to be studied within the project. The calculation method for estimating the appliance population in 2020 takes market developments into account to the maximum possible extent. The trends are derived from existing publications on sales numbers and lead to shifts between the technology subcategories. As a prominent example, the downward trend of non-condensing boilers in the field in favour of condensing boiler technology is reflected by the chosen approach. The expectation of the future market trends post-2020 is mainly a further continuation of recent developments with accelerated speed during the next two decades of the European energy transition. The market trends will be taken into account in later stages of the project e.g. for the selection of appliances for laboratory testing.

Despite the detailed approach pursued for each appliance category, all calculated results must be considered being estimations, which draw an overview picture of the gas-fired appliance market in the EU. The authors make no claim to completeness or precision of the population numbers resulting from the work presented here.

Amongst other, the presented data will be exploited as a guiding system for the selection of appliances to be tested in the project partners' laboratories in the further course of the THyGA project.

2.1 Classification and population of gas appliances in EU

Classification

The investigation focused on the currently installed portfolio of gas appliances in Europe. The working hypothesis of work package 2 is, that the stock of appliances in the field needs to cope with a new quality of distributed gas, i.e. natural gas with hydrogen blended into it. In this research project, the partners include appliances designed for a broad variety of purposes to draw a complete picture of the overall European natural gas appliance market in the domestic / commercial sector[1]. This report sets out a list of appliance categories that need to be analysed concerning the specific combustion technologies, impact of hydrogen admixture, market size and future market trends to assess their specific relevance to the test programme in the further course of the project.

The classification of the gas-fired appliances according to the relevant EN classifications can be a first approach. However, the EN classifications do not always segment the market with sufficient technical detail to cover all the variables that need to be taken into consideration. In most cases it was necessary to sub-segment the EN classifications in order to make sure that critical variables are not mistreated.

This section presents an overview of installed gas-fired end-user appliance technologies classified by type including the results of the calculations and estimations of the related populations for residential and commercial applications, in the field in the EU 2020. The data sources, calculation methods and explanations market segment by market segment are treated individually in sections 2.2 to 2.9.

The following eight main segments were chosen for a rough division of the market.

(1) Boilers
(2) Water Heaters
(3) Cooking appliances
(4) Catering equipment
(5) Space Heaters
(6) Combined Heat and Power appliances
(7) Gas Heat Pumps
(8) Other appliance types

The classification becomes finer when considering:

- various product standards for each category
- different burner technologies including flue type and types of combustion controls
    - Conv. (conventional)
    - Atmos (atmospheric)
    - Pre-mix (premixed)
    - Full pre-mix (full premixed)
    - Open flued and room sealed
    - CCB (combustion Controlled Boilers)

As a result, the market segments and sub-segments presented in Table 2-2 were defined for the appliance classification implemented in this project.

[1] Large-scale application of natural gas, i.e. industrial-scale combustion is not within the scope of this project.

Even deeper technical levels of sub-segmentations could be developed, however, some grouping of rather similar appliances is necessary to find a compromise between technological details and exploitable, applicable and communicable results.

As the key result of this task, the stock of existing / installed appliances in the field is represented based on the list presented in Table 2-2 and Figure 2.1.

Another level of details to the appliance populations country by country in each segmentation for boilers, water heaters, cookers, catering, space heaters and others were taken in the investigations according GASQUAL [Fern10] and Ecodesign [HoKE19, KeEC19] projects. The appliance populations per country are not represented for this WP but summarized on EU level. The main reason is to avoid very rough estimations or lack of data in some cases, this estimation on national level may be used in D 6.5 ("Green Hydrogen" for Europe roadmap).

Exchange & communication with manufacturers and associations

In addition to the dataset collections, interviews and workshops with manufactures and associations were done in parallel. Table 2-1 shows a list of organisations that have been contacted for the market study. In the first public THyGA Workshop on 6th of May, 2020, a preliminary market segmentation was presented to the audience as a basis for further discussion and development.

For the clarification of open points concerning the market segments of boilers and water heaters the authors communicated with the associations and consultants EHI[2], BRG[3], VHK[4] on current boiler and water heater developments as well as stock and market sales numbers. In case of space heaters and other appliances the communication was mainly based on the feedback from VHK. Moreover, the interviews with JRC, APPLiA, BSH, SYNEG, Electrolux Professional and Electrolux helped to achieve the final cookers and catering segmentations. Delta-EE[5] provided a significant feedback to the CHP segmentation and validation of the estimated population. In case of heat pumps the data were mainly based on Ecodesign [HoKE19, KeEC19] analyses.

[2] http://www.ehi.eu/
[3] http://www.brgbuildingsolutions.com/
[4] https://www.vhk.nl/
[5] https://www.delta-ee.com/

Table 2-1 Communication of the project partners with external stakeholders concerning the market segmentation of gas-fired appliance technology in Europe.

Manufacturers / Associations	Discussed topics
JRC[6]	Consultation concerning Ecodesign reports - segmentation domestic cooking
BSH[7]	Segmentation for domestic cooking appliances
Electrolux[8]	Segmentation for domestic cooking appliances
Electrolux Professional[9]	Segmentation for commercial catering equipment
APPLiA[10]	Segmentation for domestic cooking appliances
CEFACD[11]	Segmentation space heaters
HKI[12]	Segmentation boilers and water heaters
SYNEG[13]	Segmentation for commercial catering equipment
Deta_EE[14]	Segmentation CHP
BRG[15]	Segmentation Boilers
EHI[16]	Segmentation Boilers
VHK[17]	Consultation concerning Ecodesign - Segmentation boilers, space heaters and water heaters

As a result of task 2.1 in WP 2 the following market segments were defined for next steps in the project. The final list is presented in Table 2-2. An overview of the market shares of the head categories is visualised in the pie chart in Figure 2.1.

[6] https://www.eubuero.de/jrc.htm
[7] https://www.bsh-group.com/de/
[8] https://www.electroluxgroup.com/en/
[9] https://www.electroluxprofessional.com/fr/equipement-cuisine/
[10] https://www.applia-europe.eu/
[11] https://www.cefacd.eu/
[12] Industrieverband Haus-, Heiz und Küchentechnik
[13] https://syneg.org/
[14] https://www.delta-ee.com
[15] http://www.brgbuildingsolutions.com/
[16] http://www.ehi.eu/
[17] https://www.vhk.nl/

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**

Appliance population

The goal of the THyGA market study within WP2 is to quantify the population of domestic and commercial gas-fired appliances. The data for the appliance park installed in the European Union will be presented segment by segment in the following sections of this chapter. The **results** of the data research, extrapolations and estimations as summarised in Table 2-2 **indicate a total stock of approximately 228 million domestic and commercial natural gas appliances in the field in 2020**. The stock of gas- fired catering equipment comes on top of this number but could not be quantified.

The distribution of appliance types in the different European member states is strongly inhomogeneous. This work however focusses on the total population size of each individual appliance type rather than a country-by-country analysis. Thus, even if for some technologies historic data on the national shares is available and have been used for some projections by generating weighting factors resembling the national development of technology shares, just the EU-wide sums are presented in this report.

For the above presented market segments of Table 2-2, workflows were established to determine the approximate populations of the appliance categories in the EU. The data on stock of appliances and current market developments at the EU level were gathered from two main sources as a starting point: reports with respect to the Ecodesign Directive [HKEW19, HoKE19, KeEC19, KeEl19, RSVH19] and the database from the detailed market analysis conducted during the project GASQUAL [Dgc11a, Fern10]. These sources were especially applied to assess the appliance park for boilers (section 2.2), water heaters (section 2.3), cookers (section 2.4) and space heaters (section 2.6).

The available information did not cover all parts of the market segmentation chosen for analysis in the THyGA project. Via communication with external stakeholders, it was possible to complement some of the data sources with additional information. The database was checked for representability and homogeneity. For this data validation step, additional sources, such as partial information from literature were used for assessing the data quality for some market segments.

In order to implement the acquired knowledge about the market developments, an evolution scenario was used to calculate progression factor (% p.a.) for specific technologies during a specific period of time. The length of this period is the difference between the publication year of the available data points and the year 2020, which is chosen the reference year for the market analysis of the THyGA project. Wherever possible, the technology-specific share of sales numbers as well as the percentage of annual stock changes are implemented in the upscaling process. Also, an estimation of appliances replacements by new products from the same market segment has been taken into account. The latter leads to a more realistic, yet slightly slower exchange of older appliance technologies by newer ones. With this third stage, the authors defined the THyGA appliance stock in 2020 from extrapolation of development. This methodology was mainly implemented in case of boilers and water heaters, where the data availability proved to be comparably high.

Market Segmentation of gas-fired appliances in EU 2020 (x1,000)

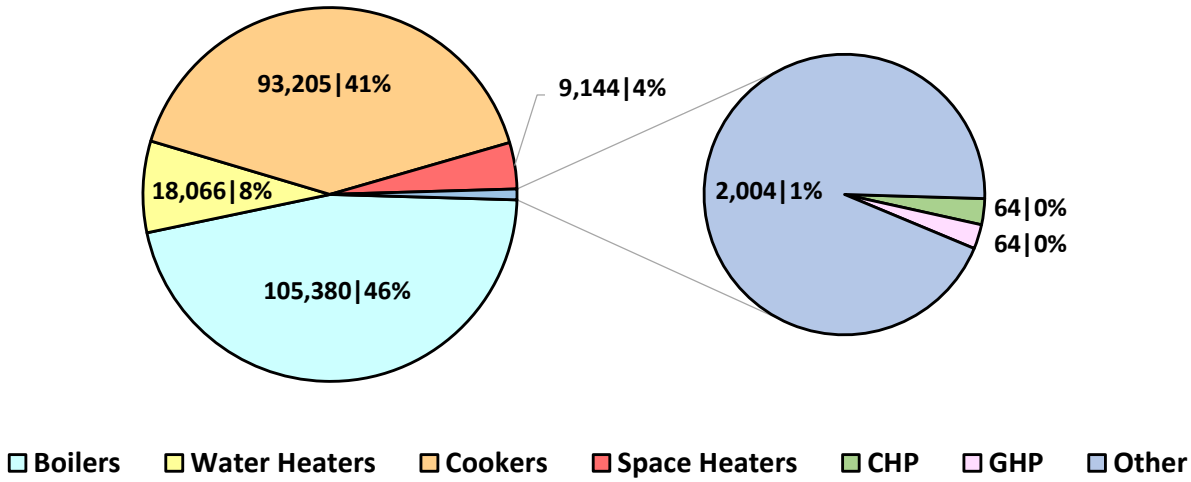

Figure 2.1 Approximate population of gas-fired appliances in the EU, 2020. Catering equipment not shown due to lack of data.

The data sources and extrapolation methods are described in the following subchapters for each appliance type category in detail.

2.2 Boilers

The total estimated park of the boilers across the EU exceeds 100 million appliances, Table 2-2. These boilers typically provide central heating for a single dwelling. The current use of the terms 'commercial' and 'domestic'[18] boilers has been reviewed to not be consistent with how products are used and to create room for interpretation of the scope of the regulation. This means, that the classification between the domestic and non-domestic installation of boilers was considered unimportant for this analysis.

Open flued boilers

The technology category of open flued boilers (non-condensing) contains partial premix designs in both, atmospheric as well as fanned design (Seg 101). Full premix burners form the segment 103. In addition, low NOx technology (Seg 102) burners belong to this category. All open flued boiler burner types are regulated by the EN 15502 [En1512] (former EN 297 and EN 656).

Room sealed boilers

Category room sealed boilers (non-condensing) contains partial premix / conventional burners (both atmospheric and fanned; Seg 104) as well as low NOx technology burners (Seg 105) and full premix burners (Seg 106). All of them are regulated by the EN 15502 [En1512] (former EN 483 and EN 656).

[18] nominal heat output below 70 kW [Dgc11a, Fern10]

Condensing boilers

In this category the authors group fanned partial premix burners (Seg 107) as well as full premix burners (Seg 108). Here again, standard EN 15502 is applicable [En1512]. In the past, the former EN 677 next to EN 297, EN 483 or EN 656.were applied.

Forced-draught / Jet burner boilers

"Forced-draught" or "Jet burner" boilers (non-condensing and condensing) form the market segment 109. Formally these were standardised with EN 676 for the burners, EN 303-3 for the combination of a boiler body with a forced draught burner and EN 303-7 for boilers equipped with forced draught burners and this technology is now also regulated by EN 15502 [En1512].

EU stock of installed boilers

To quantify the current boilers park for the THyGA segment 101 – 108, two projects were taken as a reference: GASQUAL [Dgc11a, Fern10], 2007 and Ecodesign [HoKE19], 2015-2017. The aim is to represent the installed end-use appliances within the European Union for the year 2020, the period between the used population datasets of these two projects is eight years; 2007 to 2015. Even if the Ecodesign data were more recent in comparison to GASQUAL, it was not possible to use this available information directly since the Ecodesign database contains different categories/classifications, which are generally differently structured and do not match the sub-segmentation done in THyGA project as show in Table 2-4. Nevertheless, the dataset from Ecodesign was very useful and necessary to identify the total numbers e.g. of non-condensing vs. condensing boilers and to calculate progression factors for the latest market developments. The progression factors were used to update the historic data from GASQUAL to find values for 2020. The factors are a function of the average difference of population datasets 2015 to 2017 [19]. The value of the factor can be positive (increased market share) or negative (reduced market share) and reflects the percentage of average annual progression of the installed appliances per segment. These values are shown in Table 2-3.

Table 2-3 : Installed stock of boilers (<400 kW) in the EU [HoKE19, p.29]

EU installed stock of gas boilers from 2015 to 2017			
Year	**Non-condensing**	**Condensing**	**Total**
2015 (x 1,000)	56,017	37,388	93,405
2017 (x 1,000)	50,055	45,697	95,752
Progression or degression (% p.a.)	-0.053	0.11	0.012

In addition to solely sales-related shifts in the appliance stock calculated with progression factors regarding to the data from Table 2-3, correction factors was applied in order to consider both a replacement[20] of appliances by new appliances of the same type (estimated 8 %) and a general annual stock increase of 1 % of gas-fired boilers, resulting in a modified factor which reflects approximately

[19] The Ecodesign regulation is applicable since 2016 and has impacted the market by decline the number of selling non-condensing boilers.

[20] This effect in the realistic market and leads to a slightly slower change of appliance types in stock regarding the transition of non-condensing to condensing.

the actual appliance stock in 2020. The modified factor was used to define the growth of numbers of appliances starting from the data from the GASQUAL technology segments as a starting point.

The resulted values for the modified annual progression factor are equal to 0.860 % for the non-condensing boilers and 1.339 % for the condensing boiler. Finally, the calculated annual change was validated according the Ecodesign [HoKE19] market data analysis, which discusses in detail the installed stock and the sales trend for each segment from 1990 to 2016.

Depending on the methodology described above, the population of the boilers (excluding forced draught burner boilers) is shown in Table 2-4.

Table 2-4 : Estimated park of EU installed boilers and developing trend until 2020 (excluding forced draught burner boilers)

Boilers						
THyGA Segment	**Category**	**Stock in 2007 from GASQUAL (x 1,000)**	**Calculated stock in reference year using GASQUAL and EHI data (x 1,000)**	**Reference year**	**Progression of the appliances numbers (% p.a.)**	**Resulting stock in 2020 (x 1,000)**
101	**Open flued**	14,429	15,796	2017	-5.32	13,588
102		2,137	2,339	2017	-5.32	2,012
103		161	176	2017	-5.32	151
104	**Room-sealed**	26,901	29,450	2017	-5.32	25,333
105		2,094	2,292	2017	-5.32	1,971
106		305	1,330	2017	11.11	1,781
107	**Condensing boiler[21]**	500	2,180	2017	11.11	2,919
108		9,674	42,186	2017	11.11	56,492

In the case of the ***forced draught burner boilers*** (also often referred to as 'jet burner boilers') a different method had to be chosen because of missing / incomplete data. The main data used in the calculations were taken from Ecodesign [KeEC19]. The analyses done in the literature [KeEC19] of the total stock of installed jet burner units in EU was combined for both oil and gas jet burners. There is mentioned that 85 – 90 % of the total number of jet burners were oil-fired boilers. Now, taking the assumption of a share of 90 % oil-fired and 10 % gas-fired jet burner boiler stock into account, it is possible to calculate the progression factor for gas jet burners from 2010 to 2020. The trends show a strong decline of the total[22] jet burner boiler sales, but this is mainly because the jet burner numbers include the oil- and gas-fired boilers. In case of gas jet burners, the sales increased slightly by an average of 1.8 % p.a. comparing to the reference year 2010, as shown in Table 2-5. By comparing the total gas-fired jet burner units in stock from 2010 to 2020, an estimated 18 % of increase in sales has occurred. This means that in 2020 the total number is equal to 1,070,000 units (including 118 % of increase on 907,000 units).

[21] This segment also includes hybrid boilers appliances, combination of a condensing boiler and an electric heat pump, with specific control unit. The justification is that, in term of combustion with regards to the H2NG admixtures, the behaviour of the appliances in directly driven by the condensing boiler.
[22] Both condensing and non-condensing burners.

Table 2-5 : Estimated EU stock of forced-draught burners / jet burners with the assumption 90 % oil-fired and 10 % gas-fired appliance stock, based on [HKEW19, p.40]

Installed stock of Jet Burners oil and gas < 400 kW	2010	2015	2020	change per year 2010 – 2015	change per year 2015 – 2020	change per year 2010 – 2020
non-condensing	22,141	17,780	15,467	-4.9%	-3.0%	-4.3%
condensing	521	1,230	2,056	11.5%	8.0%	7.5%
non-cond. oil	19,927	16,002	13,920	-4.9%	-3.0%	-4.3%
cond. oil	469	1,107	1,850	11.5%	8.0%	7.5%
total oil jet burners	20,396	17,109	15,771	-3.8%	-1.7%	**-2.9%**
non-cond. gas	2,214	2,393	2,575	1.5%	1.4%	1.4%
cond. gas	52	123	206	11.5%	8.0%	7.5%
total gas jet burners	2,266	2,516	2,780	2.0%	1.9%	**1.8%**

The estimated stock of forced-draught burners resulted from the calculation described above can be shown in Table 2-6.

Table 2-6 : Estimated EU stock in 2020 of forced-draught burners / jet burners used in THyGA project

THyGA Segment	Category	Stock in 2007 from GASQUAL (x 1,000)	Calculated stock in reference year using GASQUAL (x 1,000)	Reference year	Progression of the appliances numbers (% p.a.)	Resulting stock in 2020 (x 1,000)
109	**Forced-draught burners / jet burners**	907	954	2010	1.8	1,129

Table 2-7 summarises the numbers from Table 2-4 and Table 2-6 including the classification used in this project for the boiler segmentation 101 to 109.

Table 2-7 Boiler market segments and estimated appliance population in EU, 2020

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
Total					**105,380**

The pie chart in Figure 2.2 shows the share of the sub-segments for the boiler market and the estimated population in EU.

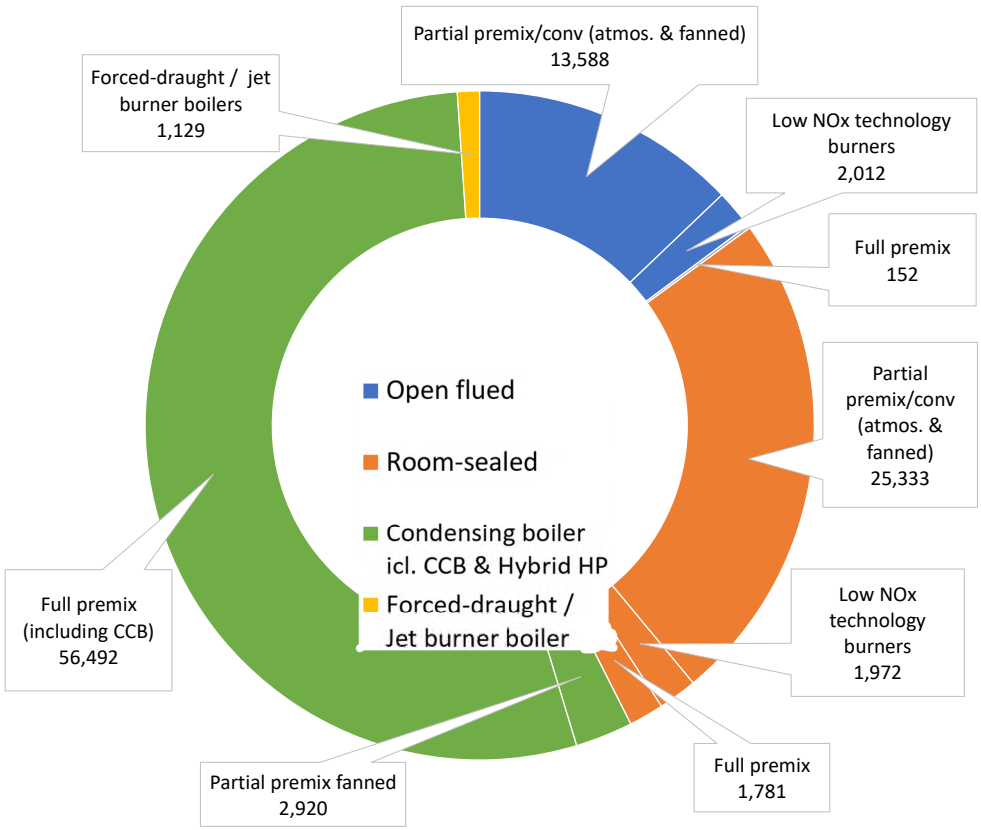

Figure 2.2 Overview of the market segmentation and estimated population of appliances from the boiler segment. Main categories are represented by the colour-code, populations given in x 1,000 units.

2.3 Water heaters

Gas Instantaneous Water Heater (GIWH), also called tankless water heaters and Gas Storage Water Heaters (GSWH) are widely installed technologies in Europe even if they suffer a continuous decline in stock of appliances on the residential market (2004-2014, GIWH stock decreased from 19.1M to 17.2M installed appliances and GSWH from 3.8M to 3.6M installed appliances). Technologically, the base product for the commercial sector is practically same as residential water heaters but figures on stocks are not available. As a reference, in 2016, 1.2M GIWH and 0.025M GSWH (including 0.012M condensing appliances) were sold [KeEl19].

Technologies are generally segmented in the following ways:

- Burner type: non-premixed, partially premixed and fully premixed
- Flue type: open flued and room sealed (with or without fan)

A gas water heater is fundamentally similar to a gas boiler, therefore, the working principles are basically the same. Explanations and technical details can be found in [SFLB20].

Instantaneous open flued

The first category of water heaters is designed for instant hot water supply, fired by an open flued (atmospheric) burner (Seg. 201). Instantaneous open flued are regulated by the EN 26 [Dine00a, p.2015].

Instantaneous room-sealed

The second category of water heaters is designed for instant hot water supply as well, but fired by a room sealed burner (Seg. 202). Air required for the combustion process is fanned into the combustion chamber. Instantaneous room sealed water heaters are also regulated by the EN 26 [Dine00a].

Storage open flued

The third category of water heater appliances is dedicated to hot water storage products that are fired by an open flued (atmospheric) burner (Seg. 203). Storage open flued are regulated by EN 89 [Dine00b].

Storage room-sealed

The fourth and last category of water heater appliances is composed of hot water storage products fired by room sealed burners (Seg. 204). Air required for the combustion process is fanned into the combustion chamber. Storage room sealed are regulated by EN 89 [Dine00b].

EU Water heaters stock

In the case of the segment water heaters, a similar methodology to estimate the boilers park in EU was implemented for this segment. The main difference relates to the input parameters. The water heaters (segments 201 – 204) stock in EU is based on only Ecodesign [KeEl19, p.11] datasets, 2010-2014. The dataset from Ecodesign was necessary to identify the installed stocks of gas water heaters in 2014 and to calculate progression factors for the later market developments until 2020. The progression factors were used to update the data from 2014 to find values for 2020. The factors are a function of the average difference of population datasets 2010 to 2014 as shown in Table 2-8. The value of the factor

can be positive (increased market share) or negative (reduced market share) and reflects the percentage of average annual progression of the installed appliances per segment.

Table 2-8 : Installed stock of water heaters in the EU [KeEl19, p.11] and the calculated progression factors to show the trend to 2020.

EU installed stock of gas fired water heaters from 2010 to 2014			
Year	**GIWH**	**GSWH**	**Total**
2010 (x 1,000)	19,069	3,769	22,838
2014 (x 1,000)	17,172	3,586	20,758
Progression or degression (% p.a.)	-0.0248	-0.0121	-0.0227

In addition to solely sales-related shifts in the appliance stock calculated with progression factors regarding to the data from Table 2-8, correction factors were applied in order to consider both a replacement[23] of appliances by new appliances of the same type (estimated 8 %) and a general annual stock increase of 1 % of gas-fired boilers, resulting in a modified factor which reflects approximately the actual appliance stock in 2020. Consequently, the resulted values for the modified annual progression factor are equal to 0.870 % for the GIWH and 0.934 % for the GSWH. Consequently, the progression factor [24] of the appliance numbers 2014-2020 after correction is -0.13 % for GIWH and -0.01 % for GSWH. the Depending on the methodology described above, the population of the water heaters is shown in Table 2-9. Table 2-9 shows the numbers included in Table 2-8 including the classification used in this project for the water heater segments 201 to 204.

Table 2-9 : Estimated park of EU installed water heaters and developing trend until 2020. GIWH includes segments 201 and 202. GSWH includes segments 203 and 204.

THyGA Segment	**Category**	**Calculated stock 2014 year using BRG data (x 1,000)**	**Progression of the appliance numbers 2014-2020 (% p.a.)**	**Resulting stock in 2020 (x 1,000)**
201	instantaneous open flued	17,172	-0.13	14,945
202	instantaneous room sealed, fanned			
203	storage, open flued	3,586	-0.01	3,121
204	storage, room-sealed, fanned			

[23] This effect is realistic on the market and leads to a slightly slower change of appliance types in stock regarding the transition of non-condensing to condensing.
[24]The progression per year = 1- corrected progression factor

Table 2-10 Market segment of gas-fired water heaters including sub-segments, relevant standards and estimated installed appliance population in the EU 2020. GIWH includes segment 201 and 202. GSWH includes segment 203 and 204.

THyGA Segment	Type of appliance	Category	Burner type	Standard	Estimation of Total EU Appliance Population 2020 (x 1,000)
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		
Total					**18,066**

Figure 2.3 shows the share of the four sub-segments for the water heaters market including the estimated population in EU. GIWH includes segments 201 and 202. GSWH includes segments 203 and 204.

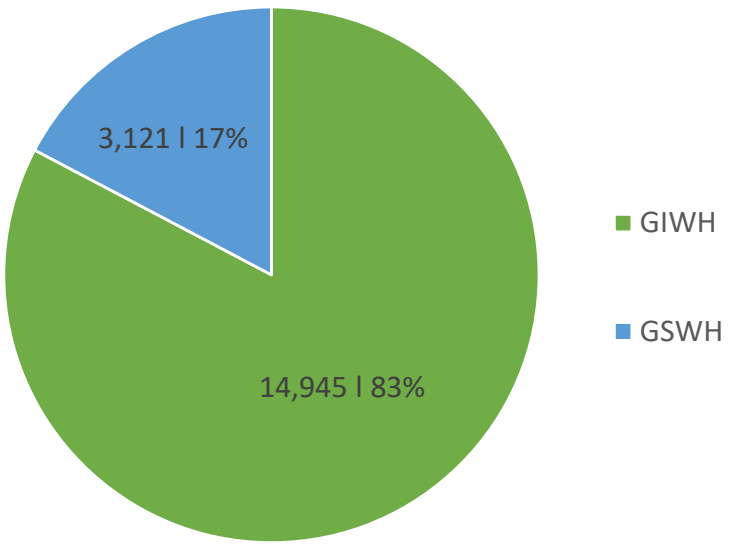

Figure 2.3 Overview of the market segmentation and estimated population of appliances from the water heater segment. Main categories are represented by the colour-code, populations given in x 1,000 units

2.4 Cookers

The starting point of the segmentation for cookers was taken from GASQUAL [Fern10] study, this was mainly based on categories from standard EN30 [Dine00c, Dine00d, Dine00e, Dine00f, Dine00g].

In order to update this vision to the actual 2020 market and technologies, several exchanges have been initiated with:

- JRC[25] (Joint Research Center, member of THyGA's Advisory Panel Group), in charge of the revision of lots 22 and 23 for the Ecodesign directive. The goal was to actualize market figures from the market analysis of the preparatory study. Due to different points of view regarding segmentation (usage in Ecodesign / Technology in THyGA) and different time constraints (planning and deadlines), the actualization of market figures was not be able to undertaken directly on Ecodesign (which rather served as reference for global figures)

- APPLiA (Home Appliance Europe Association, member of THyGA's Advisory Panel Group) represents most cooking appliances manufacturers in Europe and was able to provide the THyGA project with a global vision from the industry on our first proposal (9th of June 2020) and a different segmentation proposal.

- Finally, bilateral exchanges with manufacturers BSH[26] (member of THyGA's Advisory Panel Group) and Electrolux (partner of the THyGA project) allowed to clarify definitions of particular technologies as well as links between current standards and the previous studies, GASQUAL [Dgc11a, Fern10]. The descriptions given for each category are those provided in a listing submitted by APPLiA. Both suggested to have a single category for both the single ring and single crown burner since they describe the same technology. For clarity (stakeholders may be used to one name or another), it was decided to keep them as different segments anyways, the appliances that will be tested under 301/302/303 or 304/305/306 are generally included in one cooktop equipped with several burners (this is why one market figure is given for the 3 sub-segments).

The results are presented in Table 2-11. Descriptions given for each row and the respective technologies within each sub-segment are based on the personal interviews conducted with the above-mentioned stakeholders and experts knowledge from inside and outside the project consortium. Especially a listing provided by APPLiA [Appl20] was used as a guideline.

Some current sales numbers including forecast and annual growth rates for free standing cookers and mixed cookers are shown in Table 2-12.

[25] https://ec.europa.eu/info/departments/joint-research-centre_en
[26] https://www.bsh-group.com/us/

Table 2-11 Market segmentation of cookers appliances including gas hobs (Seg. 301-306) and ovens (Seg. 307-312), description of combustion technologies and relevant standards.

THyGA Segment	Type of appliance	Category	Burner type	Standard	Estimation of Total EU Appliance Population 2020 (x 1,000)
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
Total					**93,205**

Table 2-12 Forecasts on the sale of domestic ovens in the EU-27 from 2007 to 2025 [MTHA11, p.22]

	FS gas cooker		FS mixed cooker		TOTAL
	Sales	Annual growth	Sales	Annual growth	Sales
2007	2,183,426		1,476,157		12,650,668
2010	2,105,762	-1.2%	1,476,157	0.0%	12,739,542
2015	1,982,413	-1.2%	1,476,157	0.0%	12,913,606
2020	1,866,289	-1.2%	1,454,148	-0.3%	13,111,412
2025	1,756,967	-1.2%	1,432,466	-0.3%	13,348,849

2.5 Catering

Compared to the previous project GASQUAL, the market segmentation in THyGA takes into account many additional appliance technology segments. In particular, the sector of the catering appliances is included in detail with the aim to accordingly represent catering appliances in the subsequent laboratory tests on hydrogen tolerance as well. In the previous project GASQUAL an estimation for this segment were done in [Dgc11a]. The estimation was not possible to use it in this WP because of the different classification and because of the missing information to the progression rate from 2007 until 2020.

The knowledge on the appliance sub-segments within the market of catering equipment was gained via cooperation with the French association for catering equipment SYNEG [Syne20]. The information was reviewed via discussions between THyGA partners and several manufacturers (see Table 2-1). The technology segments defined here try to correctly represent the diverse market of catering appliances with its many sub-segments.

The project faced several issues to get an estimate of the stock of appliances in Europe since the market proves to be quite different from boiler or the domestic cooking markets with respect to the availability of publicly available statistical data. Indeed, there are many different manufacturers with a multiplicity of sub-segments of categories of catering equipment across Europe, which makes it complicated to access aggregated numbers.

- Deliverable D6.2 from the GASQUAL project focuses on non-domestic appliances [Dgc11a] and reports some quantitative data, the only figures available for EU27, which reports
    - **200 000 gas hobs for commercial use, in 2007**

  and forecasts
    - **~73,000 Gas combi-steamers in 2020.**
- Exchanges with the JRC (advisory panel member of the THyGA project and also in charge of the revision or the ECO design studies for LOT22 & LOT23, in 2020) gave the same feedback on the unavailability of figures on the stock of appliances with catering at the European level.
- Through a discussion with the UK HyReady project, the THyGA team got the same feedback, that even on National level (UK, in that case), the stock of catering equipment was not available.
- This conclusion was shared with catering equipment associations in Germany (HKI) and France (SYNEG), contacted by the project partners. As a result, annual sales numbers were available, but it remained impossible to extrapolate these numbers to the appliance stock in the field given the high lifetime of many appliances and the multiple technical segments available.

Therefore, the catering equipment population column could not be filled in the following Table 2-13. The precise population segmentation of millions of appliances across the European Union remains unknown to the authors, however, this will not be a deciding factor in the appliances selection for the test programme in the following tasks of the THyGA project.

Table 2-13 Market segmentation of catering appliances including sub-segments, description of combustion technologies and relevant standards.

THyGA Segment	Type of appliance	Category	Burner type	Standard	Estimation of Total EU Appliance Population 2020
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
Total					**unknown**

2.6 Space heaters

This segment includes only fixed residential space heaters. It does not include:

- mobile space heaters that are generally not designed for use with natural gas, but with LPG;
- non-residential space heaters like infrared radiant heaters (considered in the following chapter) and air heaters (considered chapter 2.9), which are a technologically very different application.

The market segmentation used in the THyGA project is based on the related EN product standards as developed by CEN/TC62 (for more information and examples, see also [SFLB20]:

Independent convection space heaters (EN 613, [Tech04])

These products are independent convection space heaters:

- of type B or type C → in the THyGA project they have been divided into a different market segment as some risks are specific to the type;
- that are wall mounted, free-standing or built-in;
- that have a nominal heat input not exceeding 20 kW (NCV);
- that are or are not live fuel effect appliances.

Open fronted independent space heaters (EN 13278, [Cent13])

These products are open fronted independent space heaters:

- of type B;
- that have a nominal heat input not exceeding 20 kW (NCV);
- that are delivered with the gas carrying components, burner(s), combustion chamber and heat exchanger fully assembled;
- that are or are not live fuel effect appliances.

Decorative fuel-effect appliances (EN 509, [Cent99])

These products are decorative fuel-effect appliances

- of type B and more specifically type B_{AS} which are appliances equipped with an oxygen depletion device;
- that have a nominal heat input not exceeding 20 kW (NCV);
- that are designed to simulate a solid fuel fire;
- that are designed for decorative purposes only and not for heating;
- that are designed to be installed within a non-combustible builder's opening or a non-combustible fireplace recess.

Independent flueless space heater (EN 14829, [Plng08])

These products are independent flueless space heaters of 'type A_{AS}'. In contrast to 'type A' flueless appliances, 'type A_{AS}' concerns flueless appliances equipped with a safety device which will shut-off the gas supply in case of insufficient oxygen in the room in which it is installed. The safety device is more specifically called an oxygen depletion device. The scope of the EN 14829 is specifically limited to 'type A_{AS}' appliances [Plng08].

The estimated appliance population for the four sub-segments is presented in Table 2-14. The estimation of the EU park of the local space heaters in THyGA project was based on the review study on local space heaters [RSVH19, pp.113 and 117].

Sales are generally expected to be stable for electric heaters and to decrease for gas- and liquid-fired heaters over the coming years. Electric local space heaters form the product group with the highest sales numbers.

Generally, all electrical products develop towards more refined controls and an increased number of control functions with more and more products being inter-connected e.g. via Wi-Fi. For the local fixed electrical heaters a shift is also seen away from convector heaters towards radiators and towel rail heaters. For gas- and liquid-fired heaters, the sales numbers are significantly lower than for electric appliances, and the market shares of different product types fluctuates somewhat from year to year [RSVH19].

Table 2-14 Market segmentation of local space heaters including the estimated EU park represented in THyGA project

THyGA Segment	Type of appliance	Category	Burner type	Standard	Estimation of Total EU Appliance Population 2020 (x 1,000)
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
Total					**9,144**

The pie chart in Figure 2.4 shows the market split of the four sub-segments defined for the local space heater market including the estimated population in EU.

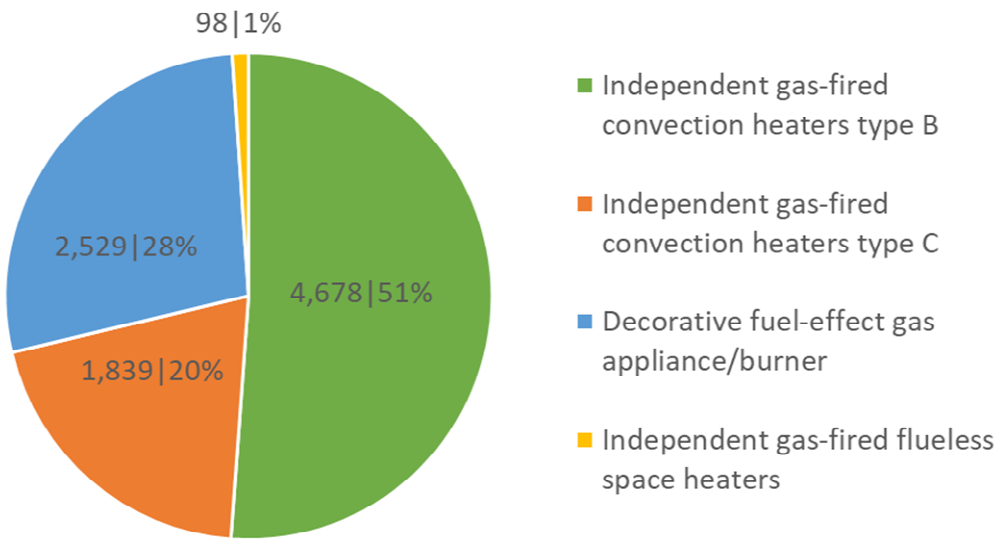

Figure 2.4 Overview of the market segmentation and estimated population of appliances from the space heater segment. Main categories are represented by the colour-code, populations given in x 1,000 units

2.7 Combined heat and power

The three most prominent combined heat and power (CHP) technologies for small scale decentralised applications are 1) reciprocating engines, 2) micro gas turbines and 3) fuel cells. For the case of the engines, the Stirling engine was tried for decentralised applications, but remains an almost negligible niche market while the internal combustion engine / Otto engine, as known from the automotive sector recently dominates the engine-based micro CHP market. For micro gas turbines a few appliances are on the market or in development. For the case of the fuel cells, the PEM FC and the SO FC both gain unbroken attention.

Based on communication with Delta-EE[27] and due to the information provided through the previous and ongoing projects like ene.field[28] and PACE[29], the gap of market data was filled. The communication with the Delta-EE supported the authors of this report to develop the classification in this market segment as shown in Table 2-2 and Table 2-15.

Table 2-15 Market segmentation of combined heat and power (CHP) appliances

THyGA Segment	Type of appliance	Category	Burner type	Standard	Estimation of Total EU Appliance Population 2020 (x 1,000)
601	CHP	Stirling engines	heating & electricity production	EN 50465	14.8
602		Internal Combustion Engine			40.8
603		turbine			0.5
604		PEM FC			5
605		SO FC			2.7
Total					**63.3**

The pie chart in Figure 2.5 shows the share of the five sub-segments for the CHP market including the estimated population in EU.

[27] Delta-EE provided information, analyses, insights and advice about emerging distributed energy markets. The data on micro-CHP were provided from the Delta-EE gas heating service.

https://www.delta-ee.com/

[28] http://enefield.eu/

[29] https://pace-energy.eu/

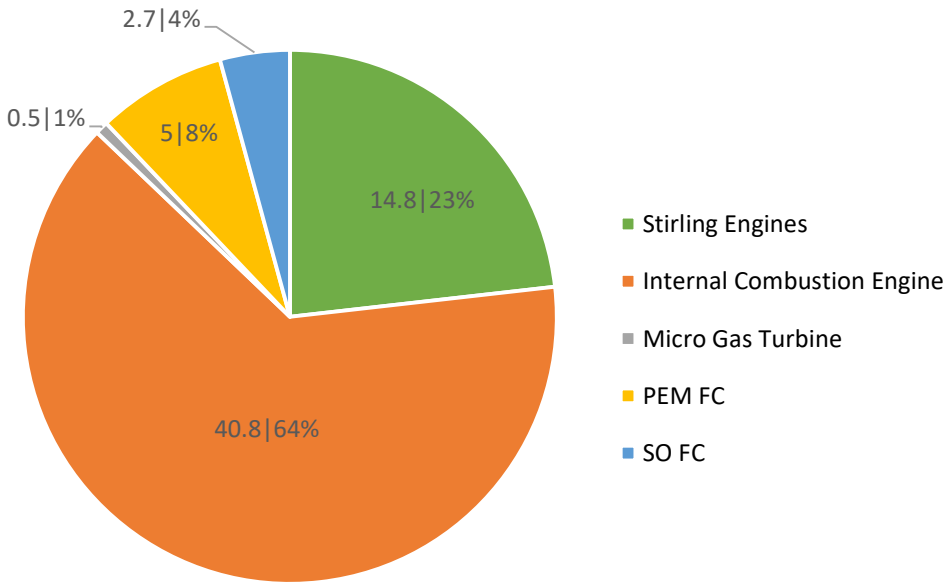

Figure 2.5 Overview of the market segmentation and estimated population of appliances from the CHP segment. Main categories are represented by the colour-code, populations given in x 1,000 units

2.8 Gas heat pumps

In the Ecodesign analysis, an extensive inventory of the currently installed (electrical) heat pumps (HP) as well as sales numbers can be found in a detailed country by country data sets [HKEW19, KeEC19]. In total, the report estimated 373,000 units sold in 2016, almost all of which electrical HPs. The hybrid heat pump technology is a growing market, and it may develop towards a considerable market share of the total heating technology market in the future. Hybrid heating systems, comprising an electric heat pump and a gas-fired (condensing) boiler, are treated as condensing boilers in the respective chapter of this work. **This chapter reports on the estimated number of gas heat pumps, only**.

In total, three gas heat pump (GHP) technologies were taken into account for the THyGA project, engine HP, adsorption and absorption HPs. More information on the various technologies from this report and the expected response to hydrogen admixture can be found in [SFLB20] as well as the Ecodesign documents, e.g. [HKEW19].

The available stock number however, is a total for all gas heat pumps and stems from the VHK report done for Ecodesign (see Table 2-16 and Table 2-17). It accounts for 60,000 units for EU28 in 2020. The business as usual scenario without special market roll-out measures or additional regulations was chosen here. For the future, VHK expects a strong increase, almost up to the ten-fold HP stock in 2050 (see Table 2-16, [HKEW19]).

Table 2-16 EU-28 stock per base case for the BAU0-scenario (without existing regulations), source: VHK, p. 40 in [HKEW19]

STOCK BAU0, 000 units	1990	2010	2015	2020	2025	2030	2035	2040	2045	2050
Gas non-cond	47,237	68,112	57,798	46,010	35,009	31,780	29,134	25,985	23,538	21,198
Gas cond	643	27,317	42,485	57,845	70,731	77,043	81,287	83,296	85,911	87,777
Jet non-cond	25,845	22,141	17,780	13,411	9,300	5,417	3,414	3,012	2,791	2,588
Jet cond	0	521	1,230	2,056	2,969	3,934	4,511	4,901	5,323	5,733
Elec Joule	729	942	1,035	1,177	1,255	1,219	1,171	1,058	968	877
Hybrid	17	25	40	69	120	200	330	539	883	1,445
Elec HP	349	2,506	3,746	5,142	6,565	7,522	8,722	9,929	11,436	13,157
Gas HP	5	25	38	60	94	137	197	280	399	569
mCHP	11	39	48	65	95	137	197	280	399	569
Solar combi (16 m2)	270	437	500	566	629	658	674	676	689	700
Boiler >400 kW	524	545	552	558	564	565	554	543	543	543
Total Central Heating boiler, Space Heating	75,630	122,611	125,252	126,960	127,331	128,614	130,192	130,498	132,878	135,157

Table 2-17 Market segment of gas heat pumps based on Ecodesign analysis [HKEW19]

THyGA Segment	Type of appliance	Category	Burner type	Standard	Estimation of Total EU Appliance Population 2020 (x 1,000)
701	Gas HP	engine HP	heating	EN 16905	60
702		adsorption		EN 12309	
703		absorption			
Total					60

2.9 Other appliance types

This section includes both domestic and the commercial appliances. Some technologies such as gas-fired washing machines, tumble dryers, etc. can be considered to exhibit very small population numbers in the field in EU. About the exact population of installed systems from category 'other', very little is known.

It is assumed, that **gas-fired commercial dryers** have a very small market share compared to electric-driven dryers with continuously reducing numbers. Reliable information was not available to the authors of this report. The number of this appliance type in the field is set to 'unknown'. However, it is expected to be almost negligible (possibly few thousand or few ten thousand units). This does not a priori exclude the appliance technology from further studies within this project, i.e. the experimental part of the THyGA project, since for the selection of appliances additional criteria apply.

For the case of **radiant heaters / air heaters** the available information used here originate from GASQUAL and Ecodesign (Data for segments 802-804 are based on [RSVH19, p.117]). The sum of these

segments is expected to account for approximately 1,000,000 units. For segments 805-807 the numbers are based on telephone interviews with experts and on the reports from the GASQUAL [Dgc11b] project. Due to their relevance in large-scale rooms especially in commercial buildings, the heater segments are the most relevant technologies among the "other appliances" market segment. Some technical information can be found in [SFLB20].

For the market segments of **domestic gas-fired washing machines and dryers** similar assumptions as for the commercial dryers concerning small market penetration apply. Both appliance types were considered less extensively for this report since the numbers are very small; less than 10,000 appliances and a strong decreasing trend [MIGS19].

The following Table 2-18 summarises the segments defined, and the estimations made for the total appliance population in EU in 2020.

Table 2-18 Market segmentation of "other" gas-fired appliances incl. estimate of the total appliance population in EU, 2020

THyGA Segment	Type of appliance	Category	Burner type	Standard	Estimation of Total EU Appliance Population 2020 (x 1,000)
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	Ducted warm air; forced convection air heaters (former EN778)	EN 17082	
808		domestic washing machine		EN 1518	<10
809		domestic dryers		EN 1518	<10
Total					**approx. 2,000**

3 Conclusion

The **aim of this study** was to perform a screening to the portfolio of technologies in the domestic and commercial gas-appliance stock in Europe. Besides the necessity to acquire the latest available data and to consider current developments in the appliance market, the THyGA project also included significantly more appliance technologies compared to the earlier project Gasqual, for example, in order to draw a more consistent and complete picture of the gas-fired appliance market and adding new segments such as the catering equipment. In addition, technologies which have been established in the market in the last years were added as well. The standards show a development towards more aggregating view on the market. However, for technical reasons, i.e. crucial differences in the expected impact of hydrogen admixture the authors decided in many cases not to follow this simplification trend but to split appliance segments into more detailed sub-segments.

In total, **56 THyGA segments were defined** and will serve as a reference system for the further course of the project and upcoming reports. Table 2-2 summarises the results. In total, more than 228 Million gas-fired appliances are estimated to be installed in the field plus an unknown number of appliances from the catering equipment market.

4 Outlook

In general, the distribution of hydrogen-natural gas blends is a viable option to decarbonise the combustion processes in the very heterogeneous natural gas sector to a certain extent. The broad portfolio of technologies and their respective market penetrations must be taken into account when developing hydrogen admixture scenarios for the European natural gas distribution. A deep understanding of suitable equipment technology as well as the necessary developments of rules and standards for hydrogen / natural gas blends need to set the basis for the implementation of hydrogen admixture in the field. Typical technologies installed at the end-users may be suitable up to certain hydrogen admixture level without causing safety risks, while other technologies may have to be replaced, especially when reaching high hydrogen concentrations.

The quantitative assessment of the existing stock of the various gas-fired end-user appliance segments performed in **task 2.1 of the THyGA project** and presented in this report will be exploited in the further course of the project in the following way.

The market segmentation results will set the basis for **task 2.5** and the respective report D2.5 in order to develop a test programme that covers as many as possible technologies from relevant market segments for subsequent laboratory testing. The testing programme will not solely rely on the appliance population numbers from this report. Instead, other criteria are being developed to assess the most urgent research needs concerning the impacts of hydrogen admixture for all addressed market segments. These additional criteria will be implemented in terms of weighting factors to determine a priority list for each market category (boilers, water heaters, cooking appliances, catering equipment, local space heaters, combined heat and power systems, heat pumps, other) based on the knowledge of the experts for each technology within the THyGA consortium and through exchange with advisory panel stakeholders. The resulting prioritisation of technologies to be studied serves as input for the following project step.

The final selection of specific appliances for the tests is realised in **task 2.6** as the final step of work package 2. This final selection chooses precisely those technologies and technology combinations that were identified in terms of expected technical impact of hydrogen admixture and as a result the impact on the appliance market and standardisation needs in general. In this final step, the suitable appliances from the market are chosen and a process of communication with manufacturers and THyGA laboratories is started with the aim to acquire the selected test objects and assign them to the testing laboratories that are prepared to perform the pre-defined tests. Testing capacities, laboratory conditions, test protocols, definition of test gases, etc. are prepared in beforehand within work packages 2 and 3 among all involved THyGA laboratories.

Detailed insight into the experimental findings on the various appliance technologies will be given in the future reports from the THyGA project[30].

[30] Please visit https://thyga-project.eu/

5 Acknowledgments

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6 Appendix

6.1 List of technical committees contacted during THyGA project

The following technical committees (TC) from the CEN initiative, the European Committee for Standardization, were contacted by the THyGA consortium with the aim to receive as many expert feedbacks as possible for integration in the ongoing work:

- TC48 (Domestic gas-fired water heaters)
- TC49 (cooking appliances)
- TC58 (combustion control)
- TC62 (independent room heater)
- TC106 (catering)
- TC109 (central heating boilers)
- TC131 (forced draught burners)
- TC238 (test gases, appliance categories, etc.)

With TC238 an official liaison with the THyGA consortium was agreed, through WP4 of the project.

6.2 List of advisory panel members in contact with the THyGA project

The THyGA project gathers the support and challenge from a large European and International panel of stakeholders (manufacturers, associations, research centres). The philosophy of THyGA being to be as transparent as possible with the sector, participation to the advisory panel group will be opened throughout the lifetime of the project.

- AFECOR
- BDH
- Applia
- CEFACD
- CogenEurope
- EFCEM
- EHI
- ELVHYS
- Eurogas
- Heating and Hot water Industry council (HHIC)
- Industrial & Commercial Energy Association (ICOM)
- Marcogaz
- SYNEG
- Tokyo Gas
- Cadent
- GRDF
- AristonThermo
- Atlantic
- Bosch
- Broetje

- BSH
- ebm-papst
- Electrolux Professionnal
- EC Power
- Immergas
- MEMS
- Wolf
- Kiwa
- Hydrogen Aragon
- GTI
- JRC
- Canadian Gas Association
- ARPA-E
- SFG-Utilization
- Japan Gas Association
- Uniclima
- Enagas

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