

Work Package 2

Status of gas utilisation technologies – impact of hydrogen admixture and design of testing programme for devices

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



Task 2.1: Market segmentation of domestic and commercial natural gas appliances

Work Package 2

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OVERVIEW AND OBJECTIVES

The segmentation and inventory of the gas utilization is critical

- To identify the types of appliances with different combustion criteria and design, in order to identify which will be impacted by X% of hydrogen
- Prognoses of degrading or developing the number of each technology
- What is their representativity on the market and how it will evolve to prioritize the segments of appliances to test

WP2 – Status of gas utilization technologies

Segmentation and inventory of the gas utilization technologies in Europe

X

Impact of hydrogen admixture on combustion processes in theory + practice

→

Test program & Selection of the appliances to be tested

WP3 – Experimental work

Testing gas applications
Generic test protocol (safety, emissions, operation, efficiency)
Tests on ~100 appliances for domestic and commercial end use (short term and long term)

WP4 – Standardization

Overview of current framework of standards with regards to H2 injection
Development of test procedures including definition of test gases
Validation through tests

WP5 – Recommendation for mitigation measures

How can we increase the acceptable H2 rate?
Identification of mitigation measures to increase H2 rate
Validation through tests

WP6 – Communication, dissemination and exploitation

Communication with stakeholders, public, workshops
H2 admixture roadmap from the end-user point of view

WP2 PARTNERS

Work Package Lead	GW
Task 2.1 – Market Segmentation	GW, ENGIE, DGC, GAS.BE, DVGW-EBI
Task 2.2 – Impact of H2 in Theory	GW, ENGIE
Task 2.3 – Impact of H2 in Practice (& Projects)	GW, ENGIE, DGC, GAS.BE, DVGW-EBI
Task 2.4 – Embrittlement and Tightness	CEA
Task 2.5 – Development of Testing Programme	GW, ENGIE, DGC, GAS.BE, DVGW-EBI, CEA, BDR, ELECTROLUX
Task 2.6 – Selection of Appliances to Test	GW, ENGIE, DGC, DVGW-EBI, GAS.BE, CEA

METHOD

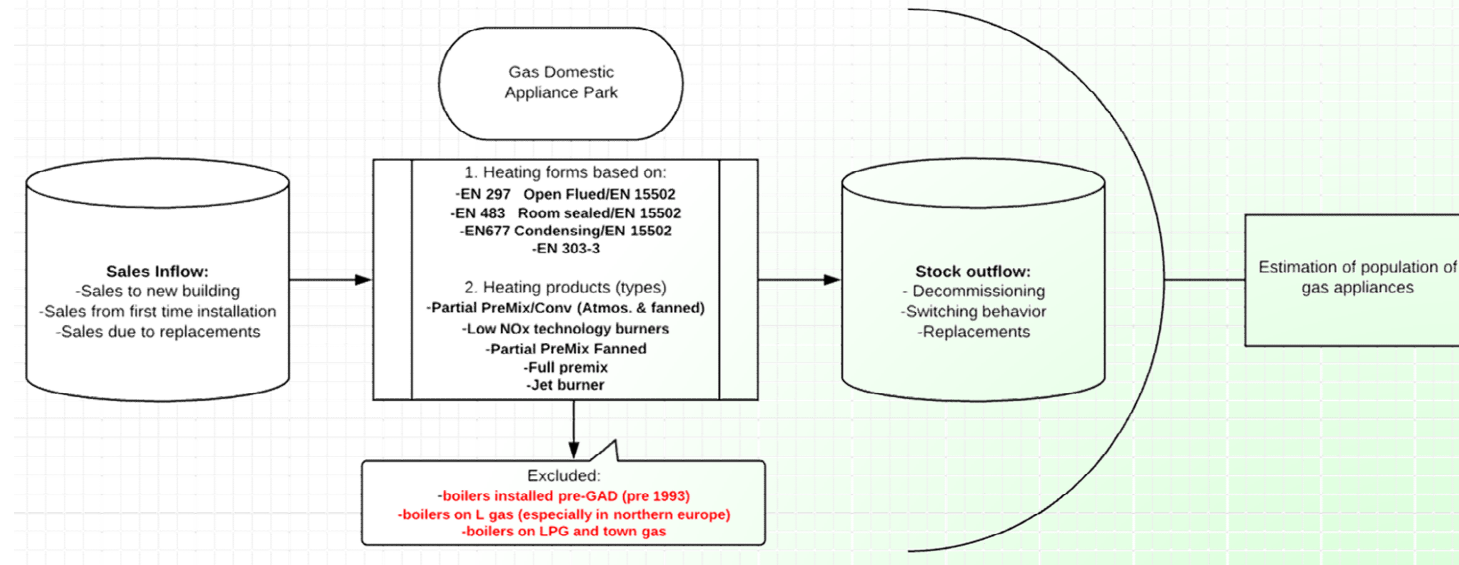
Boilers:

The aim is to cover all installed gas appliances due to screening types and numbers on market but also a prognoses will be used to achieve a good weighting approach.

Sources: Ecodesign survey, GasQual project, Manufacturers, Partners, Literature research ...

The methodology of calculating a population for boilers, cookers, GHP or CHP... is to investigate the sales inflow throughout various methods. This Data will be then categorized to many sub entities for a detailed analysis.

The information is available now? What is next to do? Categorizing the appliances into sub entities by reference to type, e.g. partial premix, fully premix ,...



Finally, a population data will be concluded and these will be ready to be investigated and go one step further by using weighting factors and sensitivity factor to reach an approximate approach for the future numbers of appliance. Finally, the tested devices could be defined according this information.

METHOD

A similar approach will be used for other segments.

Domestic Water Heaters:

Source: Ecodesign, GasQual, Manufactures, Partner, Literature search ...

Cookers:

Source:

GasQual

Manufacturers

EUROSTAT time series

IGU Database

Literature search ...

Gas Fires and heaters:

GasQual

Manufacturers

Literature search ...

N° segment	Type of appliance	Category	Comments	Standard	GASQUAL SEGMENT - Ranking across all appliance types
1	BOILERS	Open Fired (based on retracted EN 297)	Partial PreMix/Conv (Atmos. & fanned)	EN 15502	11
2			Low NOx technology burners*		3
3			Full premix		12
4		Room sealed (based on retracted EN 483)	Partial PreMix/Conv (Atmos. & fanned)		7
5			Low NOx technology burners*		5
6			Full premix		8
7		Condensing boiler (based on retracted EN 677)	Partial PreMix Fanned		24
8			Full premix		1
9		Jet burner (based on retracted EN 303-3)	Jet burner	EN 303-3	4
10	WATER HEATERS	Instantaneous Open Fired	Partial PreMix/Atmos	EN 26	9
11		Instantaneous Room Sealed	Partial PreMix/Fanned	EN 89	20
12		Storage Open Fired	Partial PreMix/Atmos		19
13		Storage Room Sealed	Partial PreMix/Fanned		28
14	COOKERS	Open burners - vertical	Atmospheric, partially aerated ; Single- and Multi- rings	EN 303-3	2
15		Open burners - horizontal			18
16		Oven – free standing + built-in	Partially Aerated		16
17		EN 30 Free-Standing Cooker	Partially Aerated		10
18		Surface combustion	Partially Aerated		6
19	CA TERING	Ribbon burners	Partially Aerated	EN 203-2-1 EN 203-2-2 EN 203-2-3 ; EN 203-2-4 EN 203-2-7 EN 203-2-8, -9, -10	15
20		Open burners and wok burners			
21		Ovens			
22		Boiling pans and Fryers			
23		Salamanders and rotisseries			
24	FIRES	Pans, grill, griddles			
25		Radiant Gas Fires	Heating & Decorative	EN 613	15
26		Live Fuel Effect Gas Fires Type B	Heating & Decorative		22
27		Live Fuel Effect Gas Fires Type C	Heating & Decorative		13
28		Live Fuel Effect Gas Fires	Heating & Decorative	EN 13278	26
29		Decorative Gas Fires	Decorative	EN 509	17
30		Flueless Gas Fires	Heating & Decorative	EN 14829	23
31		Room Heaters Floorstanding	Heating & Decorative	EN 613	25
32		Wall Heaters	Convectors		21
33	CHP	Air Heaters <70kW	Ducted	EN 778	27
34		Stirling Engines	Heating & Electricity	EN 50465	
35		Internal Combustion Engine			
36		Turbine			
37		PEM FC			
38		SO FC			
39	GHP	Ad-sorption HP		EN 15502, EN 12309, EN 16905 Gas Heat Pump	
40		Ab-sorption HP			
41		Engine HP			
42	OTHER	Dryers			29
43		Infrared Radiant Heaters			

CONCLUSIONS

Boiler, Fires and Water Heaters segmentation is well documented in literature, and the technology variations are described.

Segmentation of **Cookers and Catering** are supported by interviews of manufacturers and associations. Few data are collected on commercial catering equipment markets. Consequence: feedback needed from OEM and associations. Personal contact is ongoing, JRC, OEM, associations etc.

Within the category "**other**", dryers and patio heaters are categorised. Feedback needed for this segment.

In case of **CHP** the internal combustion engine (ICE) and fuel cell (FC) were added. The FC category includes PEM and SOFC.

GHP & Hybrid HP are segmented together. The next step is to take Hybrid HP separately. The prognoses to this technology shows due to *Ecodesign* (2019) project and literature that the number and of sales numbers will be ascending in the future.

Work in progress: first vision on the representativity of segments

	Standard	Burner type	Other	Suposed Sensitivity to H2	Can be adjusted	Coefficient to take into account the gas consumption by type of appliance (ARBITRARY)	Existing experience	obsolete technologies	Total EU Appliance Population 2020 (in .000)
BOILERS	EN 297 Open Flued/EN 15502	Partial PreMix/Conv (Atmos. & fanned)		(0) (1 low (premix), 2 medium (partial premix); 3 high (atm. + no info on burner))	(1) or not (0) (will increase sensitivity to H2). CHECK THIS COLUMN (actual situation for GASQUAL TEST only 2 segments could be adjusted!)	(2) Arbitrary weighting factor? (eg 4 for boiler, 2 for water heaters; 1 for cookers, 10 for commercial etc...)	Reduction factor due to number of (useful) test from previous projects	Reduction Factor for	
		Low NOx technology burners including partial premix with cooling rods and fully or highly premixed with and without water cooling							
		Full premix							
	EN 483 Room sealed/EN 15502	Partial PreMix/Conv (Atmos. & fanned)							
		Low NOx technology burners including partial premix with cooling rods and fully or highly premixed with and without water cooling							
		Full premix							
WATER HEATERS	EN677 Condensing/EN 15502	Partial PreMix Fanned							
	EN 303-3	Full premix							
		Jet burner							
COOKERS	EN 26 Instantaneous Open Flued	Partial PreMix/Atmos							
	EN89 Storage Open Flued								
	EN26 Instantaneous Room Sealed	Partial PreMix/Fanned							
	EN89 Storage Room Sealed								
CATERING	EN 30 Built-in Hob	Atmospheric Partially Aerated– Single Ring	Deep Inset & close to surface						
	EN 30 Built-in Oven	Atmospheric Partially Aerated– Multi-Ring							
	EN 30 Free-Standing Cooker	Partially Aerated Oven Burner	Convection Fan						
		Partially Aerated Surface Combustion	Part of free-standing cooker						
FIRES	EN 30 Free-Standing Cooker	Partially Aerated Ribbon Burner	Built-in Grill - Part of free-standing cooker						
	EN203-2-1 Open burners and wok burners								
	EN203-2-2 Ovens								
	EN203-2-3 Boiling pans; EN203-2-4 Fryers;								
	EN203-2-7 Salamanders and rotisseries;								
OTHER	EN203-2-8, -9, -10, Pans, grill, griddles								
	EN 613 Radiant Gas Fires	Heating	Type B open						
	EN 613 Live Fuel Effect Gas Fires	Heating & Decorative	Type C balanced						
	EN 13278 Live Fuel Effect Gas Fires		Type B open						
	EN 509 Decorative Gas Fires	Decorative	Type C fanned						
	EN 14829 Flueless Gas Fires	Heating & Decorative	Type B open						
	EN 613 Room Heaters Floorstanding	Heating	Type A						
	EN 613 Wall Heaters	Convector	Type B open						
CHP ICE	EN 778 Air Heaters <70kW	Ducted warm air	Type C balanced						
		Dryers	Types B&C						
		Infrared Radiant Heaters							
CHP PEM	EN 50465 Micro CHP	Heating & Electricity							
CHP SOFC									
GHP	EN 15502, EN 12309, EN 16905 Gas Heat Pump	Heating							

	Standard	Burner type	Other	Total Appliance Population	AUS	BEL	CZ R	DEN	FRA	GER	GRE	HUN	IRE	ITA	POL	POR	ROM	SLO	SPA	UK	Ranking (within the family of product)
BOILERS	EN 297 Open Fired	Partial PreMix/Conv (Atmos. & fanned)		14978	126	740	934	32	4016	130	18	1145	23	3399	1060	138	90	463	1332	1332	7
BOILERS		Low NOx technology burners including partial premix with cooling rods and fully or highly premixed with and without water cooling		4431	126	91	55	0	193	3160	0	41	0	359	99	0	2	8	148	148	2
BOILERS	EN 483 Room sealed	Full premix		172	2	0	7	0	46	0	0	5	1	78	3	0	0	6	12	12	8
BOILERS		Partial PreMix/Conv (Atmos. & fanned)		19041	68	454	420	79	2908	37	81	202	544	7117	118	65	1412	124	2706	2706	5
BOILERS		Low NOx technology burners including partial premix with cooling rods and fully or highly premixed with and without water cooling		2500	69	57	24	11	141	786	0	7	0	764	11	0	28	2	300	300	4
BOILERS		Full premix		1117	4	0	13	0	132	0	0	4	90	674	0	0	0	4	98	98	6
BOILERS	EN677 Condensing	Partial PreMix Fanned		853	0	0	0	0	0	426	0	0	0	426	0	0	0	0	0	0	9
BOILERS		Full premix		18763	1100	1202	328	725	1872	9264	13	115	136	3057	469	4	136	213	64	64	1
BOILERS	EN 303-3	Jet burner		918	1	24	9	40	277	291	18	0	0	140	63	3	28	0	12	12	3
WATER HEATERS	EN 28 Instantaneous Open Fired	Partial PreMix/Atmos		23999	135	1102	171	5	2082	1042	11	399	6	2427	1656	2385	190	52	6168	6168	1
WATER HEATERS	EN28 Instantaneous Room Sealed	Partial PreMix/Fanned		9765	55	450	70	4	846	425	4	161	4	989	674	970	77	22	2508	2508	3
WATER HEATERS	EN89 Storage Open Fired	Partial PreMix/Atmos		2213	18	116	146	3	362	663	0	215	324	20	196	10	1	57	41	41	2
WATER HEATERS	EN89 Storage Room Sealed	Partial PreMix/Fanned		425	4	22	29	0	70	128	0	40	62	4	37	4	0	11	7	7	4
COOKERS	EN 30 Built-in Hob	Atmospheric Partially Aerated – Single Ring	Deep Inset & close to surface	32574	191	213	869	34	8407	585	11	922	0	13480	2549	0	0	457	2429	2429	3
COOKERS		Atmospheric Partially Aerated – Multi-Ring	Deep Inset & close to surface	1352	8	9	37	1	349	24	0	39	0	560	107	0	0	19	99	99	16
COOKERS	EN 30 Built-in Oven	Partially Aerated Oven Burner	Convection Fan	3853	25	28	115	5	970	68	1	122	0	1555	338	0	0	61	282	282	13
COOKERS	EN 30 Free-Standing Cooker	Partially Aerated Oven Burner	Part of free-standing cooker	27712	194	217	884	35	4917	1790	11	938	0	12227	2595	0	0	465	1720	1720	7
COOKERS		Partially Aerated Surface Combustion	Built-in Grill - Part of free-standing cooker	13056	68	76	310	12	2458	895	4	328	0	6114	906	0	0	163	860	860	5
COOKERS		Partially Aerated Ribbon Burner	Built-in Grill - Part of free-standing cooker	14658	126	141	575	23	2458	895	7	610	0	6114	1687	0	0	303	860	860	10
FIRES	EN 613 Radiant Gas Fires	Heating	Type B open	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
FIRES	EN 613 Live Fuel Effect Gas Fires	Heating & Decorative	Type C balanced	984	0	197	0	0	197	197	0	197	0	0	0	0	0	0	0	0	5
FIRES		Heating & Decorative	Type B open	1308	0	262	0	0	262	262	0	262	0	0	0	0	0	0	0	0	1
FIRES	EN 13278 Live Fuel Effect Gas Fires	Heating & Decorative	Type C fanned	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
FIRES	EN 509 Decorative Gas Fires	Decorative	Type B open	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
FIRES	EN 14529 Flueless Gas Fires	Heating & Decorative	Type A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
FIRES	EN 613 Room Heaters Floorstanding	Heating	Type B open	569	0	0	0	0	0	569	0	0	0	0	0	0	0	0	0	0	7
FIRES	EN 613 Wall Heaters	Convectors	Type C balanced	5138	0	253	0	0	253	398	0	3983	252	0	0	0	0	0	0	0	4
FIRES	EN 778 Air Heaters <70kW	Ducted warm air	Types B&C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
OTHER		Dryers		150	0	0	0	0	0	0	0	0	0	0	57	0	0	0	57	57	
OTHER		Patio heaters		26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	11	1	
CHP/ICE	EN 50465 Micro CHP	Heating & Electricity		20	2	0	0	0	1	10	7	0	0	0	0	0	0	0	0	0	1
CHP/PEM	EN 50465 Micro CHP	Heating & Electricity		20	2	0	0	0	1	10	7	0	0	0	0	0	0	0	0	0	1
CHP/SOFC	EN 50465 Micro CHP	Heating & Electricity		20	2	0	0	0	1	10	7	0	0	0	0	0	0	0	0	0	1
GHP	EN 15502, EN 1230W, EN 16905 Gas	Heating		371	50	10	10	50	100	150	0	0	0	0	0	0	0	0	0	1	
Overall total				=	200989	2379	5663	5007	1057	33319	22216	200	9737	1901	58559	12569	3580	1966	2433	19715	19706
BOILERS	TOTALS			52773	1457	2568	1790	886	3585	14094	130	1520	794	16013	1822	210	1697	821	4672	4672	
WATER HEATERS	TOTALS			34203	212	1690	416	12	3359	2258	15	815	396	3429	2542	3369	268	142	8725	8725	
COOKERS	TOTALS			93205	613	683	2789	109	19559	4256	34	2959	0	40048	8184	0	0	1468	6250	6250	
FIRES	TOTALS			8001	0	711	0	0	711	1426	0	4442	710	0	0	0	0	0	0	0	
OTHER	TOTALS			176	1	1	1	1	1	1	1	1	1	58	1	1	1	1	68	58	
CHP	TOTALS			60	6	0	0	0	3	30	21	0	0	0	0	0	0	0	0	0	
GHP	TOTALS			371	50	10	10	50	100	150	0	0	0	0	0	0	0	0	0	1	

DISCUSSION **BOILER/ WATER HEATERS**

Boiler// More segmentation in this sector?

Water heaters// More segmentation in this sector?

DISCUSSION Fires & Others

Fires// More segmentation in this sector?

Others// other appliances are Others? Improvement suggestions are welcome?

DISCUSSION COOKERS/CATERING

Partially premixed



Top gas burner

- I ring
- Multi ring

Covered burner : solid tops, grills (hotter environment for burners = more flashback)



Bar (ribbon?) burners
(grills, brat pans, ovens)



Wok burners (high power concentrated on the bottom of the pan)

Premixed



Premix ring burners
ovens and fryers
(rare ?)



Surface burners
(salamanders, rotisseries)

Seems more relevant because we can regroup different appliances with the same combustion process

DISCUSSION **CHP & GHP**

CHP// Differentiate between Stirling and Otto technologies? Stirling tests needed?

GHP// Hybrid HP and GHP; need to differentiate between both technologies? The boiler built in to HP included in the boiler segmentation. Is it a combination between boiler and GHP only? Do we need to think about the separation of both technologies (in CHP) in this case?

Who can deliver Hybrid HP for the tests, if necessary?

More segmentation in this sector?



Testing Hydrogen admixture for Gas Applications

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