HARP

Heating Appliances Retrofit Planning

Deliverable 2.2:
Building vs heating stock (space and water) matrix, EU and country level
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	23/11/2020	Update of Table 15 Average thermal capacity per unit (kW/unit), autonomous heating

ABBREVIATIONS AND DEFINITIONS

ABBREVIATION	DESCRIPTION
SFH	Single-Family House
MFH	Multi-Family House
MFH-A	Multi-Family House Autonomous
MFH-C	Multi-Family House Centralised
DHW	Domestic Hot Water
EIWH	Electric Instantaneous Water Heaters
ESWH	Electric Storage Water Heaters
GIWH	Gas Instantaneous Water Heaters
GSWH	Gas Storage Water Heaters
NC	Non-Condensing
Air/Water	A/W
Air/Air	A/A
Water/Water	W/W

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1 Introduction

This report is an analysis that characterises the building stock and the installed stock of heating appliances in France, Germany, Italy, Spain, Portugal and EU28 aggregated.

The building stock has been analysed for each country in terms of population, surface (total and heated), typology (SFH or MFH), age of construction.

The heating appliances have been distinguished into "domestic hot water (DHW) and space heating" and "water heating". The report presents for each country and for these two classifications, the units installed, the thermal capacity and the final energy consumption considering all the most common technologies.

At the end, as main objective of the report, the building stock and the heating appliances were combined to compose a matrix that matches the most common solutions/technologies to the building stock divided into Single-Family House (SFH) and Multi-Family House (MFH).

2 France

France has a population of 67M people, which are living in 33.9M dwellings: 56% (19M) are SFH, while the remaining 44% (14.9M) are dwellings in MFH (European Commission, 2019). (Table 21 in Annex)

The average square meter surface for a SFH in France is 112 m², while a dwelling in a MFH has an average of 66 m² (European Commission, 2019). (Table 24 in Annex)

The heated surface of France is 65% of the total floor space, which corresponds to 22M dwellings: 12.4M SFHs and 9.7M dwellings in MFHs (BSRIA, 2014). (Table 25 and Table 22 in Annex)

The average number of rooms per dwelling is 4 (SFH and MFH dwellings) (The Hague: Ministry of the Interior and Kingdom Relations, 2010). (Table 27 in Annex)

60.4% of the stock of dwellings has been constructed before 1980 and 26.7% are prior to 1945 (Table 1).

Table 1 Share of dwellings by age of construction (2014)

Country	<1945	1945-1969	1970-1979	1980-1989	1990-1999	2000-2010	>2010
France	26.7%	18.0%	15.7%	12.5%	9.8%	13.0%	4.3%
Germany	25.2%	34.1%	14.9%	11.0%	7.7%	5.2%	1.9%
Italy	19.8%	31.3%	17.6%	12.7%	7.7%	7.9%	3.0%
Portugal	16.4%	21.3%	14.1%	15.9%	15.6%	15.6%	1.0%

Country	<1945	1945-1969	1970-1979	1980-1989	1990-1999	2000-2010	>2010
Spain	12.8%	18.6%	17.4%	13.1%	14.3%	17.3%	6.5%
EU28	22.7%	26.2%	16.0%	12.5%	9.3%	9.6%	3.7%

2.1 Domestic hot water and space heating

2.1.1 Units installed

In France there are 23.4M heating appliances installed: 98% autonomous heating in SFH and Multi-Family House Autonomous (MFH-A) and 2% (400 thousand) in centralised systems.

Fossil fuel boilers are the most common solution, with 12.1M boilers installed (51.9%): 6.9M non-condensing gas boilers, 2.5M non-condensing oil boilers, 2.3M condensing gas boilers, 282 thousand condensing oil boilers and 90 thousand coal boilers (Figure 1).

Electric heating is also very common in French residential building stock: 9.3M units are installed in the country (39.5%).

Heat pumps stock is 1.2M: 53% Air/Water (A/W), 35% Air/Air (A/A) and 12% Water/Water (W/W).

Biomass stoves and boilers are 800 thousand units[1] and 28 thousand combi solar thermal systems are installed.

[1] Biomass boilers and stoves numbers are very difficult to be quantified. In this paragraph we only consider the numbers of units provided by the Bioenergy Europe Statistical Report 2018. The number of small items that are complementary heaters/room heaters are not taken into consideration, due to the lack of data available.

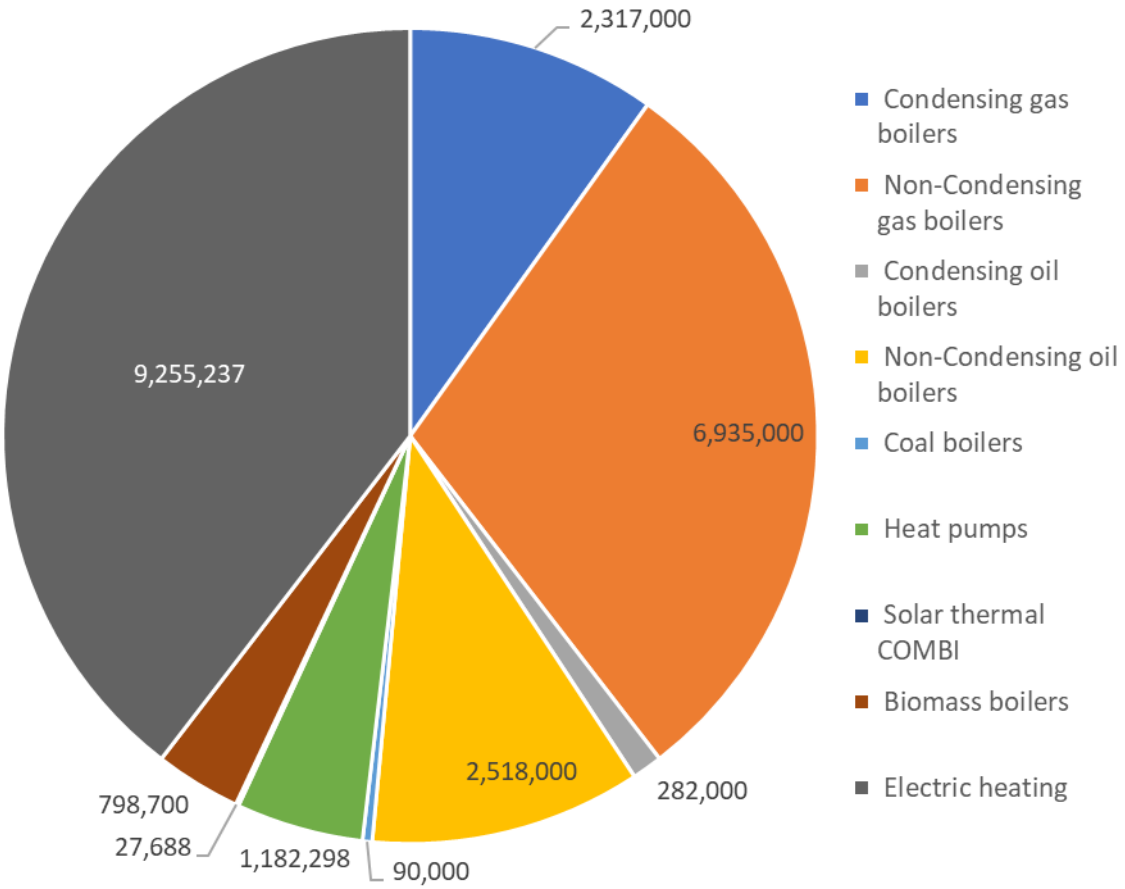

Figure 1 Space heating combi/space heating units installed in France in 2017

2.1.2 Overall thermal capacity installed and final energy consumption

The total thermal capacity installed in France is 435.5 GW, 76% in autonomous heating and the remaining 24% in centralised heating buildings.

Fossil fuels boilers represent 72% (317.7 GW) of the entire installed capacity: 167.4 GW Non-Condensing (NC) gas boilers, 78.5 GW NC oil boilers, 62.1 GW condensing gas boilers, 7.4 GW condensing oil boilers and 2.3 GW coal boilers (Figure 2).

81.4 GW are constituted by electric heaters, 17.6 GW by heat pumps and 12.1 GW by district heating.

6.4 GW installed capacity is provided by biomass and 0.2 GW by solar thermal systems.

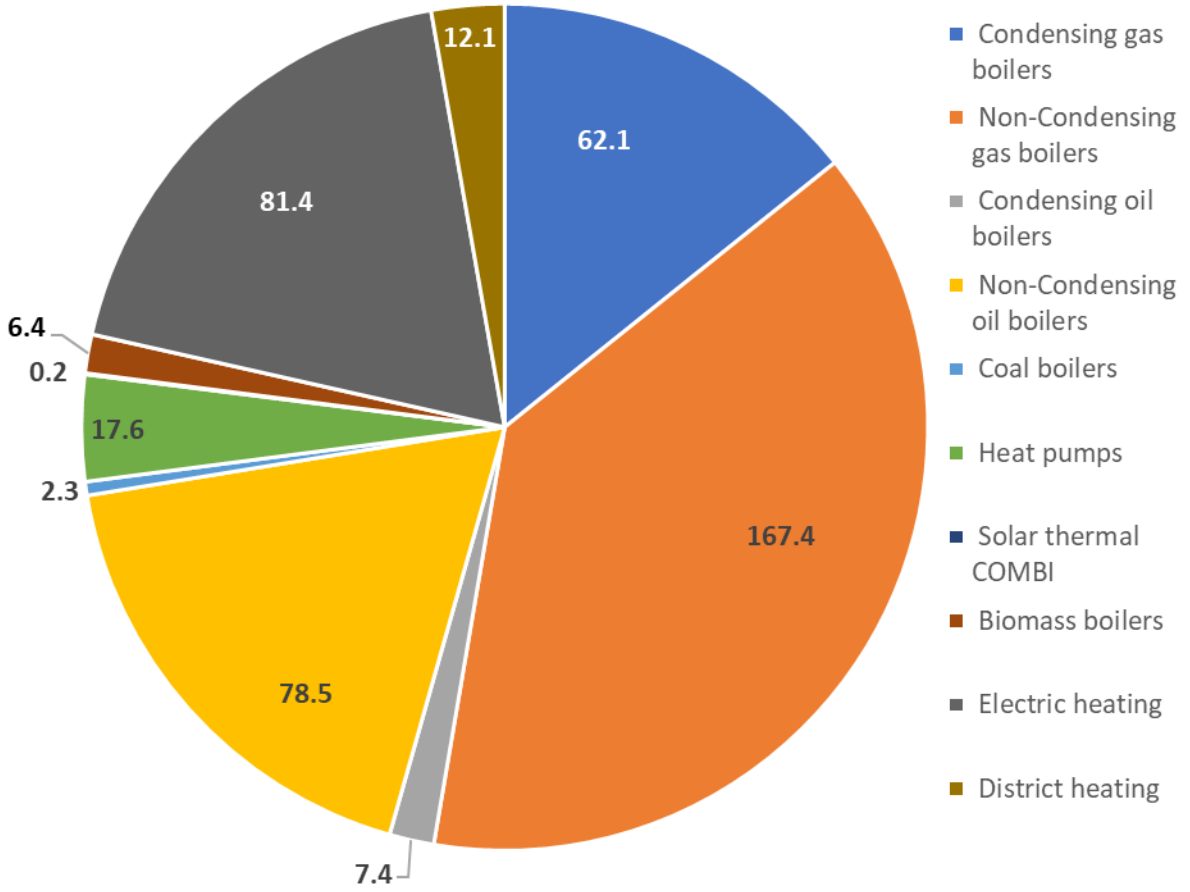

Figure 2 Space heating combi/space heating overall installed capacity in France in 2017 [GW]

The final energy consumption in France for space heating is 326.3 TWh (Eurostat, 2017).

In our analysis we took into consideration only the final energy consumption of the following renewable technologies: heat pumps, solar thermal and biomass, counting a total energy consumption of 3 TWh (Figure 3)[2].

Fossil fuels boilers represent 56% (174.1 TWh) of the total energy consumption: NC gas boilers are leading with 94 TWh, followed by NC oil boilers (47.7 TWh), condensing gas boilers (28.1 TWh) and coal boilers (0.6 TWh).

Biomass consumption is 77.5 TWh: 25% of the total[3].

[2] The final energy consumption is higher than the data of Eurostat because we also calculated the heat pump values, which are not taken into consideration by Eurostat.
[3] As explained in the previous paragraph, the actual number of biomass appliances installed is higher than the written in 2.1.1. In paragraph 2.1.4 we will try to quantify it.

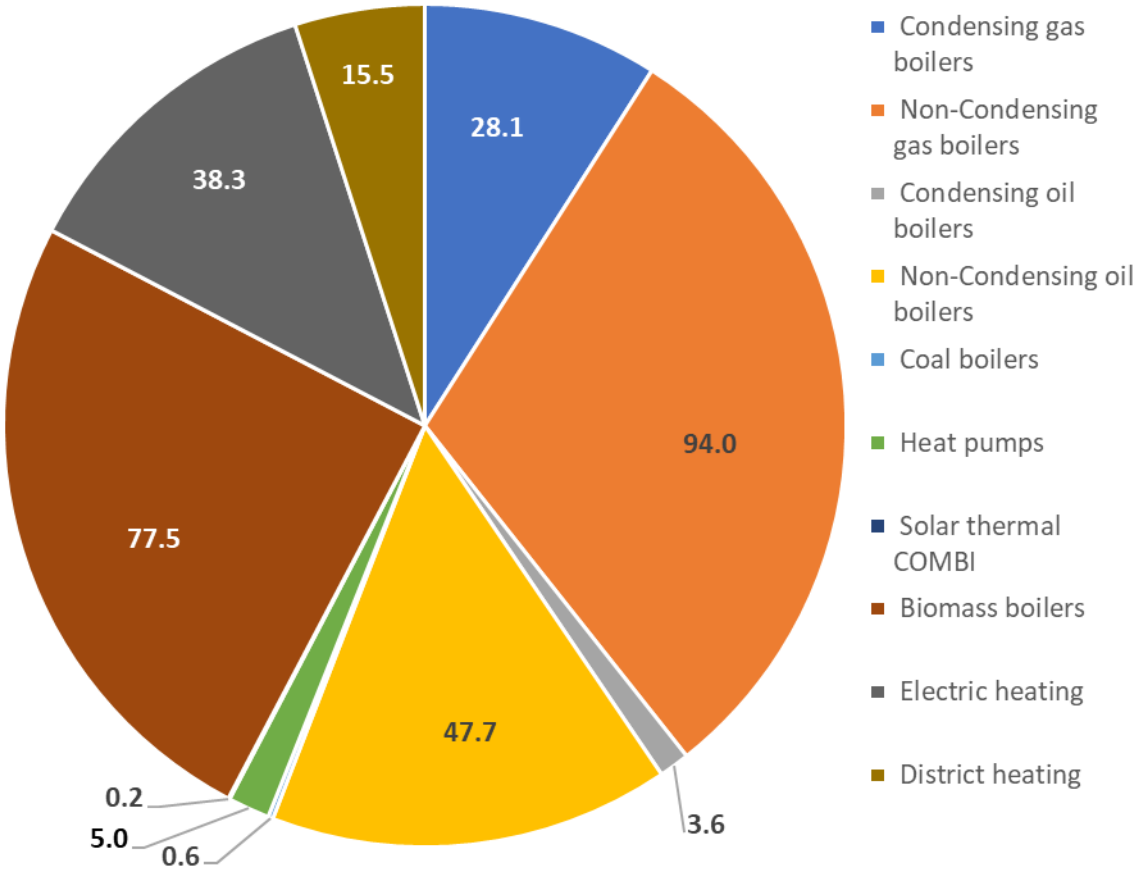

Figure 3 Space heating combi/space heating final energy consumption in France in 2017 [TWh]

Heat pumps, electric heating and district heating are also significant, respectively with .5 TWh, 38.3 TWh and 15.5 TWh.

Solar thermal systems complete the chart with 0.2 TWh.

2.1.3 Heated living area

The total heated living area of France is 3,115 Mm² (BSRIA, 2014): heated area is 65%, equivalent to 2,030 Mm².

We obtained a heated area of 1,905 Mm² (Figure 4), because heated surface is related to the final energy consumption and it is calculated by dividing the final energy consumption by the yearly consumption per square meter in the country, which is 161 kWh/m² (Table 25 in Annex).

The proportion are almost the same as for final energy consumption, with the dominance of fossil fuels boilers, followed by biomass, electric heating, heat pumps and district heating.

Fossil fuels boilers represent 57% of the heated surface with 1,084 Mm², followed by biomass (482 Mm²), electric heating (238 Mm²), district heating (76 Mm²) heat pumps (24 Mm²), and solar thermal systems (1 Mm²).

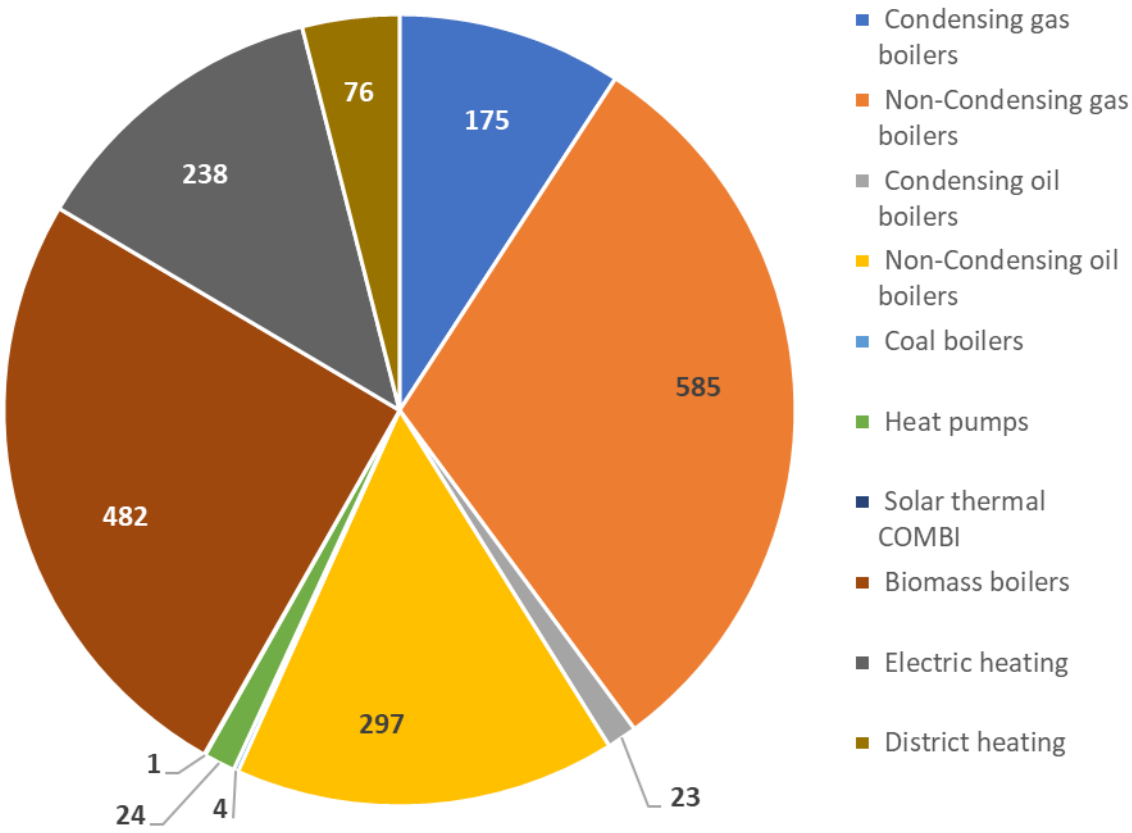

Figure 4 Space heating combi/space heating heated living area in France in 2017 [Mm²]

The number of biomass appliances installed is not compatible with the heated surface of this technology: as written in the previous paragraphs, the numbers that we are taking into consideration regarding biomass are the ones provided by Bioenergy Europe. They count only pellets boilers and stoves: the first unit it is considered as a primary heating device in the house, while stoves are single-room heaters or auxiliary heating devices.

Since the number of biomass-heated surface is so high, we can estimate that there is at least one stove for every autonomous heated dwelling. So, we divided the number of biomass heated surface and we divide it by the average size of an autonomous dwelling (89 m²)[4] (See Table 24 in Annex).

[4] SFH m² average is 112 m² and dwelling in MFH is 66 m². Since it is not possible to allocate the items into the two categories, we calculated the average of a dwelling in France, which is 89 m².

The total estimated number of biomass stoves and boilers is 5.4M units. This number includes boilers that are primary heating appliances and the auxiliary units (stoves).

2.1.4 Building stock and heating appliances

In order to create a matrix that matched the installed heating units and the building stock, we divided the installed units into two categories: autonomous heating and centralised heating (see 12.3).

Autonomous heating includes SFH and dwellings in MFH-A, while centralised only dwellings in Multi-Family House Centralised (MFH-C).

98% of the installed units in France are autonomous, corresponding to 76% of the installed capacity, 81% of final energy consumptiona and 86% of the heated living area (Figure 5).

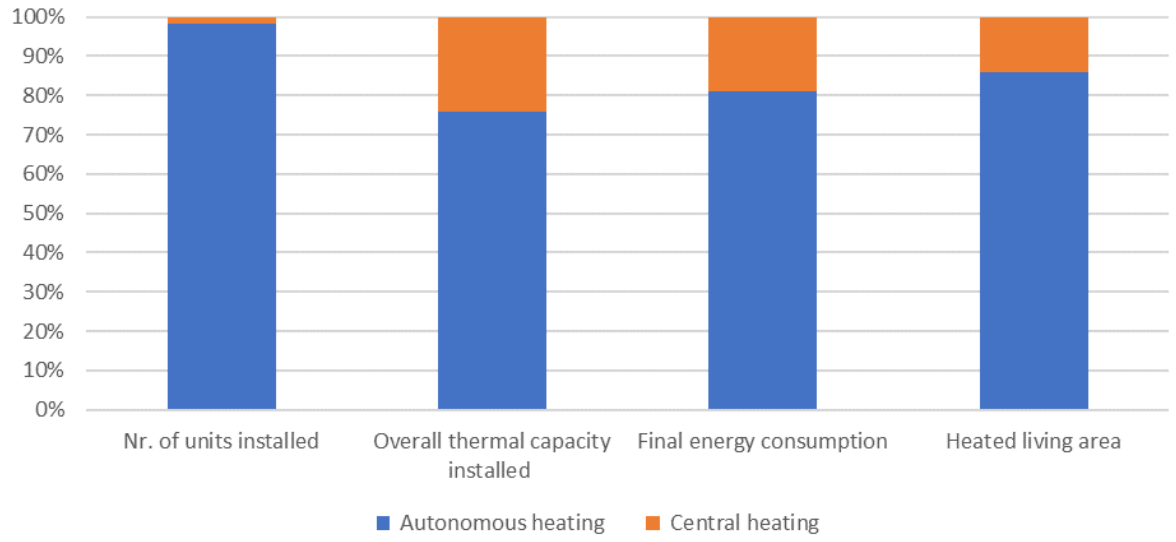

Figure 5 Share of autonomous/central heating units installed, overall thermal capacity installed, final energy consumption and heated living area in France in 2017

The total number of m² of residential floor in France is 3,115 Mm²: 2,129 Mm² SFH and 981 Mm² MFH (Table 22 in Annex) and there are 19M SFHs and 14.9 MFH dwellings (Table 21 in Annex).

In order to calculate the matrix of the heating appliances installed in France, we used the number of heated dwellings (Table 21 in Annex) and the assumption that we made in Paragraph 12.3 and Table 26 in

Methodology.

According to Table 2, there are 23.4 M heating appliances installed in France: almost 400 thousand are centralised.

For every SFH and MFH-A there is one heating appliance, while for MFH-C one unit provides heat to the whole building.

Table 2 Number of heating appliances installed in France (database)

FRANCE	Autonomous heating (SFH + MFH-A)	Central heating (MFH-C)	Total
Condensing gas boilers	2,237,000	80,000	2,317,000
Non-Condensing gas boilers	6,788,000	147,000	6,935,000
Condensing oil boilers	278,000	4,000	282,000
Non-Condensing oil boilers	2,484,000	34,000	2,518,000
Coal boilers	88,652	1,348	90,000
Heat pumps	1,052,245	130,053	1,182,298
Solar thermal COMBI	27,688		27,688
Biomass boilers	798,700		798,700
Electric heating	9,255,237		9,255,237
Total	**23,009,522**	**396,401**	**23,405,922**

In order to determine the share of SFH and MFH-A in autonomous heating we proceeded using the criteria explained in paragraph 12.3.

Since the number of heated SFH in France is 19M (Table 21 in Annex) and the sum of all the technologies except gas boilers for SFH is 5.2M[5], the remaining part (7.2M) should be heated with a gas boiler, with a share of condensing gas boilers of 25% over non condensing ones.

MFH dwellings are divided into MFH-A and MFH-C: to determine the share of autonomous and centralised, we summed the remaining part of the gas boilers not installed in SFH with the technologies installed in the calculations for MFH-A dwellings.

In France there are 9.7M heated dwellings in MFH: 3.6M in MFH-A and the remaining 6.1M in MFH-C, with an average number of 10 dwellings per MFH-C building.

[5] Only biomass boilers have been taken into consideration and not stoves. Dwellings heated by electric heaters have been calculated by dividing the number of electric heaters by the average rooms number per dwelling.

Table 3 is the matrix of the building stock matched with the installed heating appliances: all the technologies are counted in units, while district heating in number of dwellings heated.

For MFH-C there is one column representing the dwellings heated and one column with the number of centralised units installed.

This calculation (for France and all the other countries) has a lot of limitations and boundaries and should be considered as an attempt to describe the macro figure of buildings stock matched with the installed stock of heating appliances.

Table 3 Matrix of heating appliances and building stock in France (Number of units installed, estimation)

FRANCE	SFH	MFH-A	MFH-C (dwellings)	MFH-C (units)
Condensing gas boilers	1,791,575	445,425	765,065	80,000
Non-Condensing gas boilers	5,436,394	1,351,606	1,405,808	147,000
Condensing oil boilers	278,000		38,253	4,000
Non-Condensing oil boilers	2,484,000		325,153	34,000
Coal boilers	88,652		12,891	1,348
A/A Heat Pumps	181,575	181,575	429,237	44,884
A/W Heat Pumps	560,874		662,943	69,321
W/W Heat Pumps	128,221		151,556	15,848
Biomass	58,700			
Electric heating	1,156,905	1,156,905	2,340,746	244,763
District heating (dwellings)	243,187	411,512		
Total	**12,408,083**	**3,547,022**	**6,131,652**	**641,164**

2.2 Water Heating

2.2.1 Units installed

In France there are 17M water heating units installed (Figure 6): 86% (14.7M) are Electric Storage Water Heaters (ESWH).

The remaining share is completed by Gas Instantaneous Water Heaters (GIWH), Gas Storage Water Heaters (GSWI), solar thermal systems and air to water heat pumps, respectively with 1.1M, 546 thousand, 518 thousand and 201 thousand units installed.

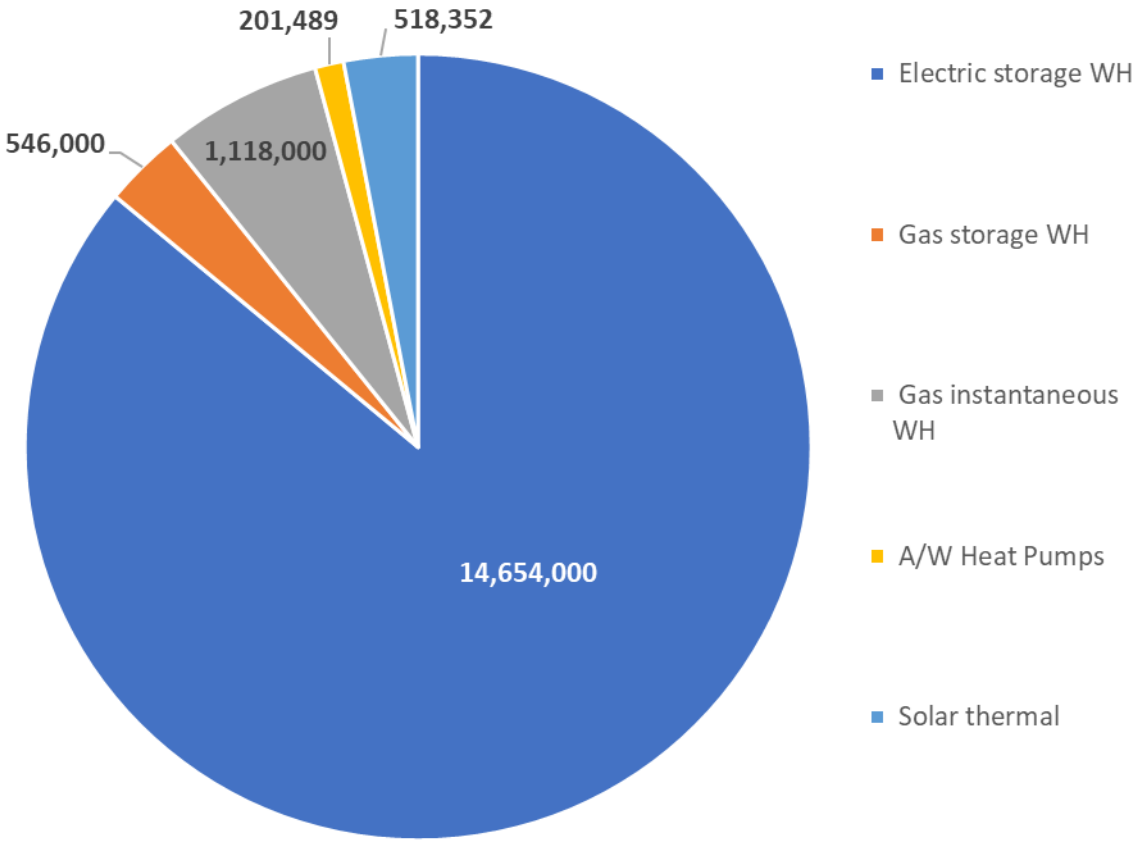

Figure 6 Water heating units installed in France in 2017

2.2.2 Overall thermal capacity installed and final energy consumption

The overall thermal capacity installed in France for water heating is 66.2 GW (Figure 7).

Electric water heating represents 55% of the overall installed capacity, followed by gas heating with 40%. The remaining 5% is shared by solar thermal and heat pumps water heating.

The installed capacity of gas water heating is higher compared to the number of units installed, because the average thermal capacity per unit is higher than the electric (see paragraph 8).

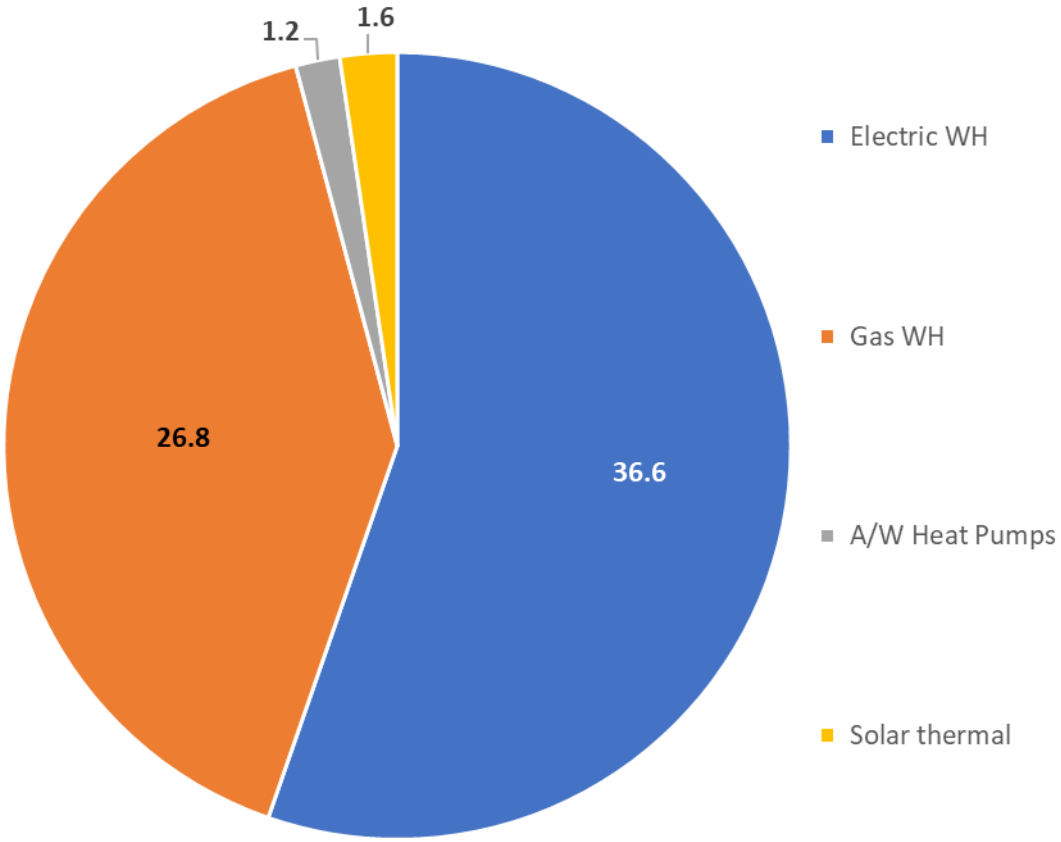

Figure 7 Water heating overall installed capacity in France in 2017 [GW]

Final energy consumption in 2017 in France for water heating was 54 TWh (Eurostat, 2017)[6].

We did not take into consideration biomass, solid fossil fuels and district heating water heating, because these are combi systems that provide both space and water heating.

[6] Eurostat do not provide heat pumps final energy consumption, which has been calculated.

Biomass boilers, district heating and coal boilers do not have water heating standalone systems: for this reason, their number of units/dwelling reached is already calculated in the *Domestic hot water and space heating* section of this chapter[7].

The total final energy consumption of electric, gas, solar thermal and heat pumps water heaters is 43.4 TWh[8] (Figure 8).

Final energy consumption is dominated in France by electric water heaters, which reach a consumption of 25.9 TWh (60% of total), followed by gas water heaters with 15.7 TWh (36%).

The remaining 6% is consumed by solar thermal with 1.7 TWh and heat pumps with 0.1 TWh.

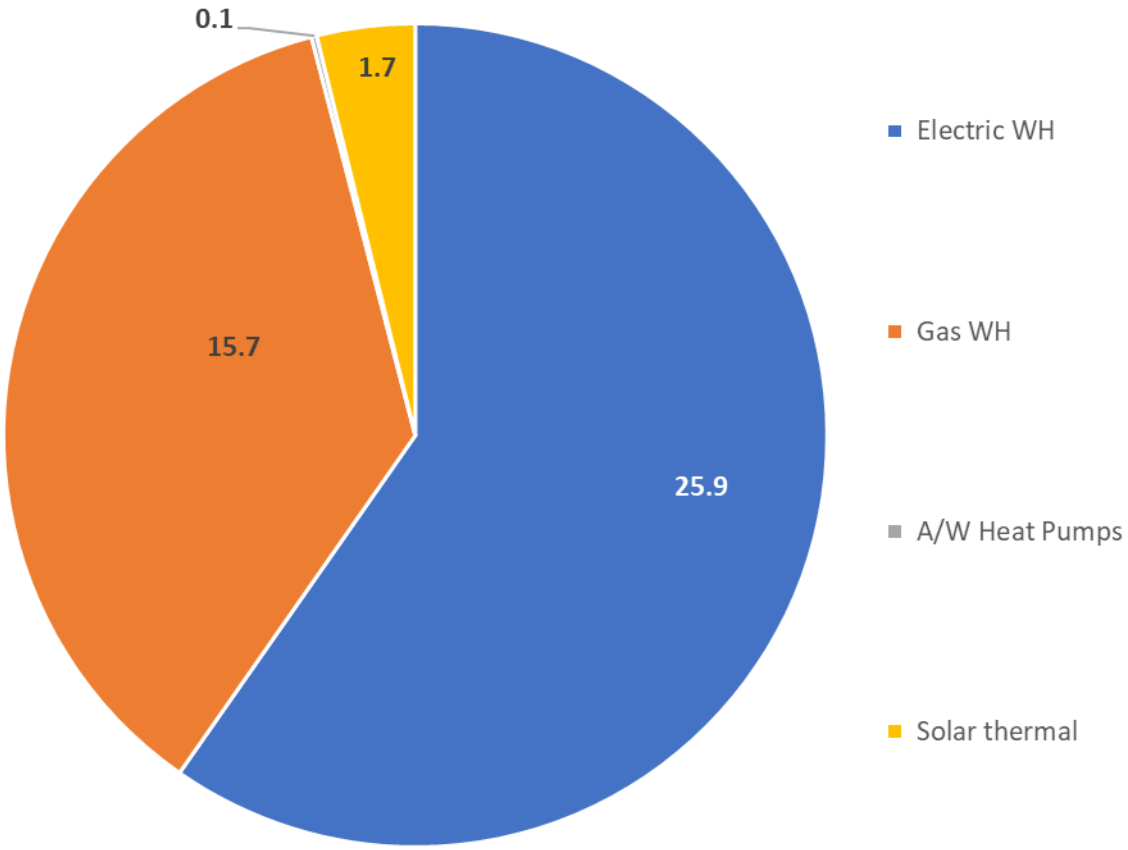

Figure 8 Water heating final energy consumption in France in 2017 [TWh]

2.2.3 Building stock and water heating appliances

For water heating units, the lack of information could not give us a perfect picture of the installed stock matched with the building stock in all the countries treated.

[7] The same criteria are applied to every chapter of this report.
[8] District heating is 3.3 TWh, biomass 0.35 TWh and solid fossil fuels 0.54 TWh.

We assumed that all the unheated dwellings in France are provided with a water heating unit: (Table 22 and Table 25 in Annex): that means 6.6M SFHs and 5.2M MFH dwellings.

Moreover, we also assumed that water heaters are installed only in autonomous heated dwellings (see

Methodology)[9].

These 11.8M dwellings cover 69% of the installed stock of water heaters. The remaining 5.2M units are installed in dwellings that have also a space heating device installed.

Unfortunately, we could not determine which typology of units (GIWH, ESWH, etc.) are installed where (SFH or MFH-A), due to the difficulties in finding reliable data regarding water heaters stock.

3 Germany

Germany is a country with 82.8 M habitants. The population of Germany lives in 41.2M dwellings, divided into 19.4M SFH and 21.8M MFH dwellings. (European Commission, 2019). (Table 21 in Annex)

The average size of a dwelling is almost the same of France: 112 m² for a SFH and 67 m² for a MFH dwelling. (European Commission, 2019). (Table 24 in Annex)

In Germany, 99% of the total floor is heated: namely 19.2M SFH and 21.5M dwellings in MFHs (BSRIA, 2014).(Table 25 and Table 21 in Annex).

The average number of rooms per dwelling is higher compared to France: 4.4 (The Hague: Ministry of the Interior and Kingdom Relations, 2010). (Table 27 in Annex)

74.3% of the stock of dwellings is has been constructed before 1980 and 25.2% is prior to 1945 (Table 1 in Paragraph 2). Only 14.8% of the building stock has been constructed after 1990.

3.1 Domestic hot water and space heating

3.1.1 Units installed

Germany has a total of 22.8M units installed: 63% autonomous heating, while the remaining 37% centralised systems.

82% of the installed stock units are fossil fuels boilers: 7M NC gas boilers, 6.3M condensing gas boilers, 4.8M NC oil boilers, 646 thousand condensing oil boilers and 20 thousand coal boilers (Figure 9).

Electric heating is represented by 1.5 million units of electric storage water heaters (Bayerische Rundfunk, 2018).

[9] The same criteria are applied to every chapter of this report.

There are 886 thousand heat pumps installed, almost equally divided into A/A HP (34%), A/W HP (30%) and W/W HP (36%).

The number of biomass boilers is 925 thousand units, while 709 thousand solar thermal combi systems are installed.

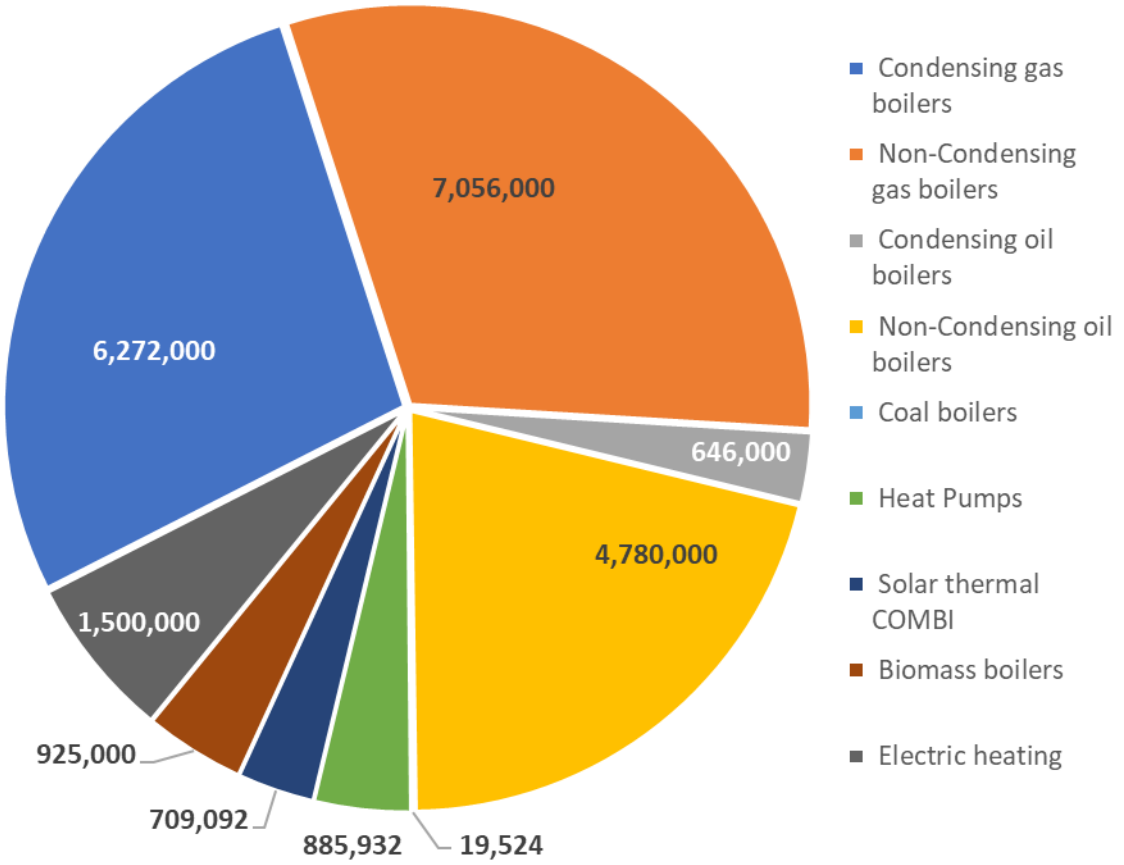

Figure 9 Space heating combi/space heating units installed in Germany in 2017

3.1.2 Overall thermal capacity installed and final energy consumption

The overall calculated thermal capacity installed in Germany in 2017 was 816 GW: 263 GW autonomous heating and 553 GW centralised heating systems (Figure 10).

90% of the entire capacity is covered by fossil fuels boilers: 295.4 GW by NC gas boilers, 262.6 GW by condensing gas boilers, 157.3 GW by NC oil boilers, 15.6 GW by condensing oil boilers and 0.8 GW by coal boilers.

District heating follows with 51.4 GW and there are 3 GW of installed capacity of electric heating.

Biomass boilers have 15.7 GW installed, while renewable energy technologies like heat pumps and solar thermal combi have respectively 8.9 GW and 5.7 GW installed.

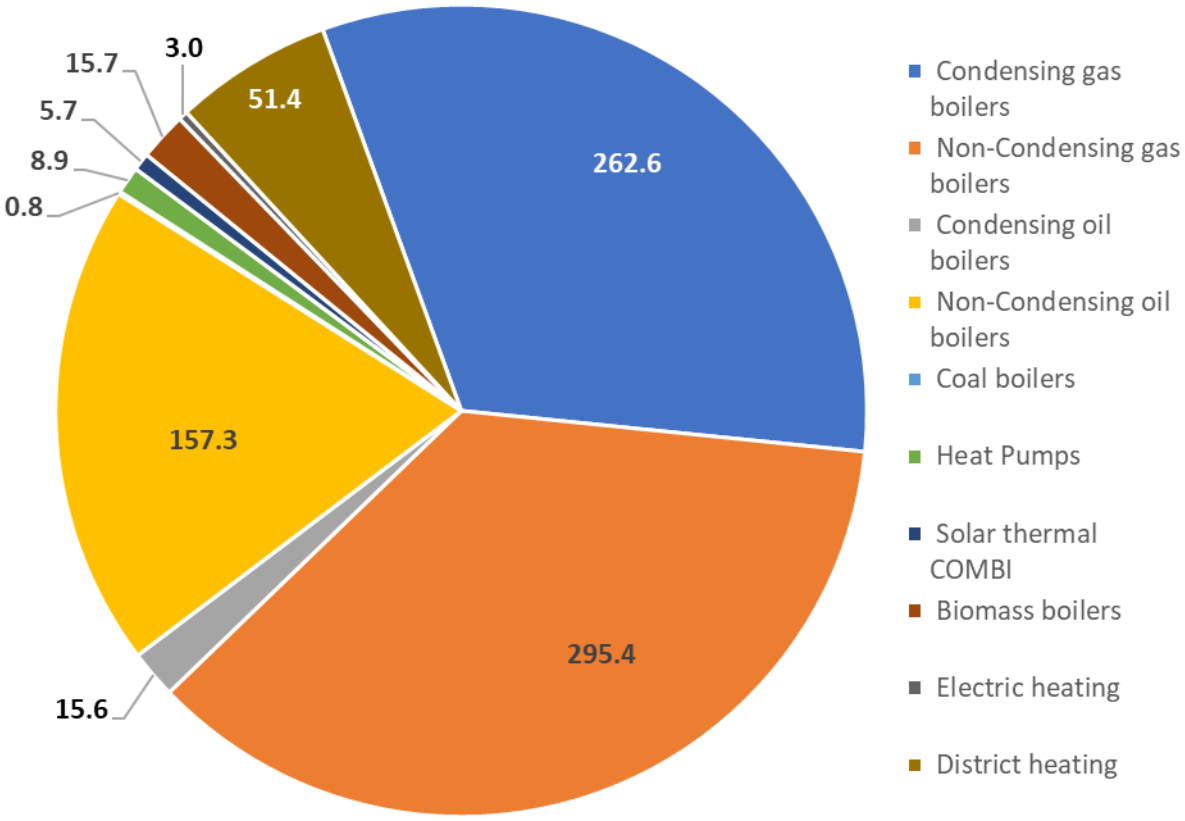

Figure 10 Space heating combi/space heating overall installed capacity in Germany in 2017 [GW]

The total final energy consumption in Germany was 465.6 TWh (Eurostat, 2017), while we calculated 467.3 TWh[10] (Figure 11).

75% of the final energy consumption is attributed to fossil fuels technologies: non-condensing gas boilers consume 130 TWh, condensing gas boilers 93 TWh, NC oil boilers 108 TWh, condensing oil boilers 9 TWh and coal boilers 12 TWh.

Biomass consumption is 55.5 TWh, followed by district heating with 47.1 TWh.

Electric heating and heat pumps and follow with 8.2 TWh and 5 TWh.

Solar thermal combi systems generation is 1 TWh.

[10] We calculated heat pumps that Eurostat does not, and we did not consider biogases consumption.

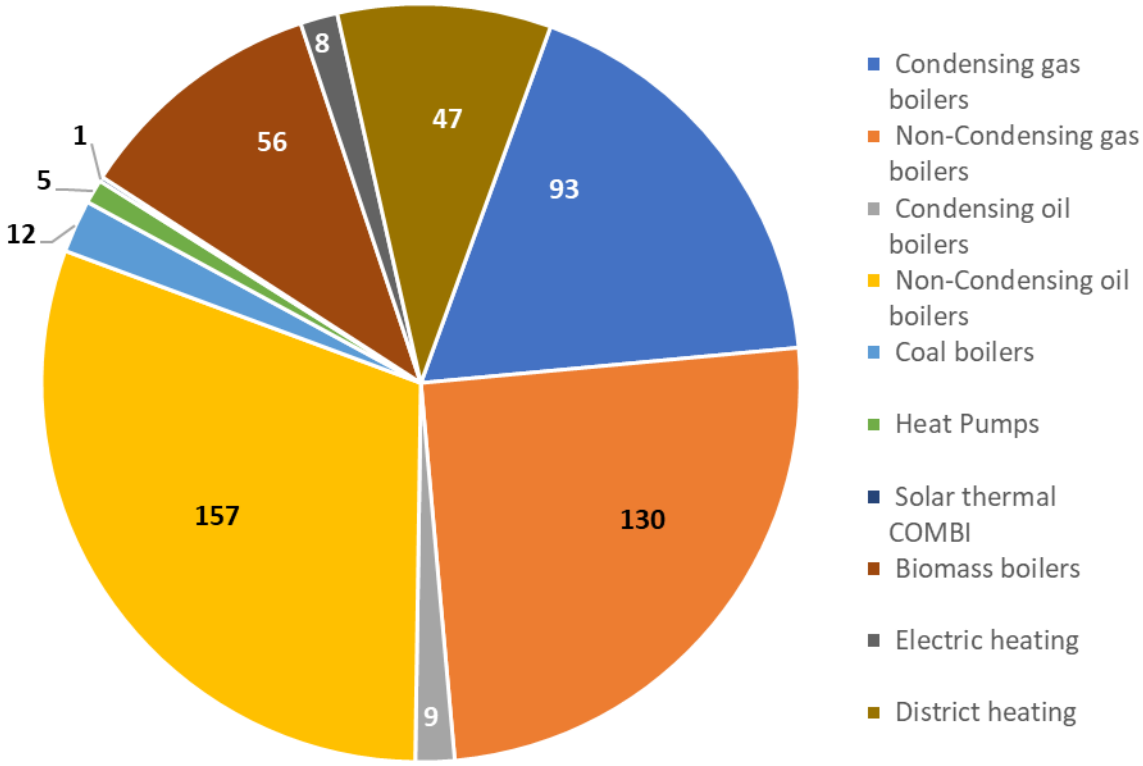

Figure 11 Space heating combi/space heating final energy consumption in Germany in 2017 [TWh]

3.1.3 Heated living area

The total heated living area calculated is 3,746M m², 99% of the total floor area[11].

2,820 Mm² (75%) are heated by fossil fuels boilers: gas boilers are the most common heating technology in the country, with 748 Mm² heated by condensing boilers and 1,043 Mm² by NC ones. Condensing gas boilers' share is 42%, NC is 58% (Figure 12).

Oil boiler technology heats 866 Mm² of floor surface: condensing technology is 7% of the total.

Coal boilers' heated surface is 94 Mm².

Biomass and district heating follow fossil fuel technology with respectively 447 Mm² and 379 Mm² heated.

27 Mm² are heated by heat pumps and 66 Mm² by electric heating systems.

Solar thermal combi systems provide heat to 8 Mm² of floor.

The number of biomass units in paragraph 2.1.1 does not reflect the actual number of units installed.

[11] Inspire project calculated 3,748M m².

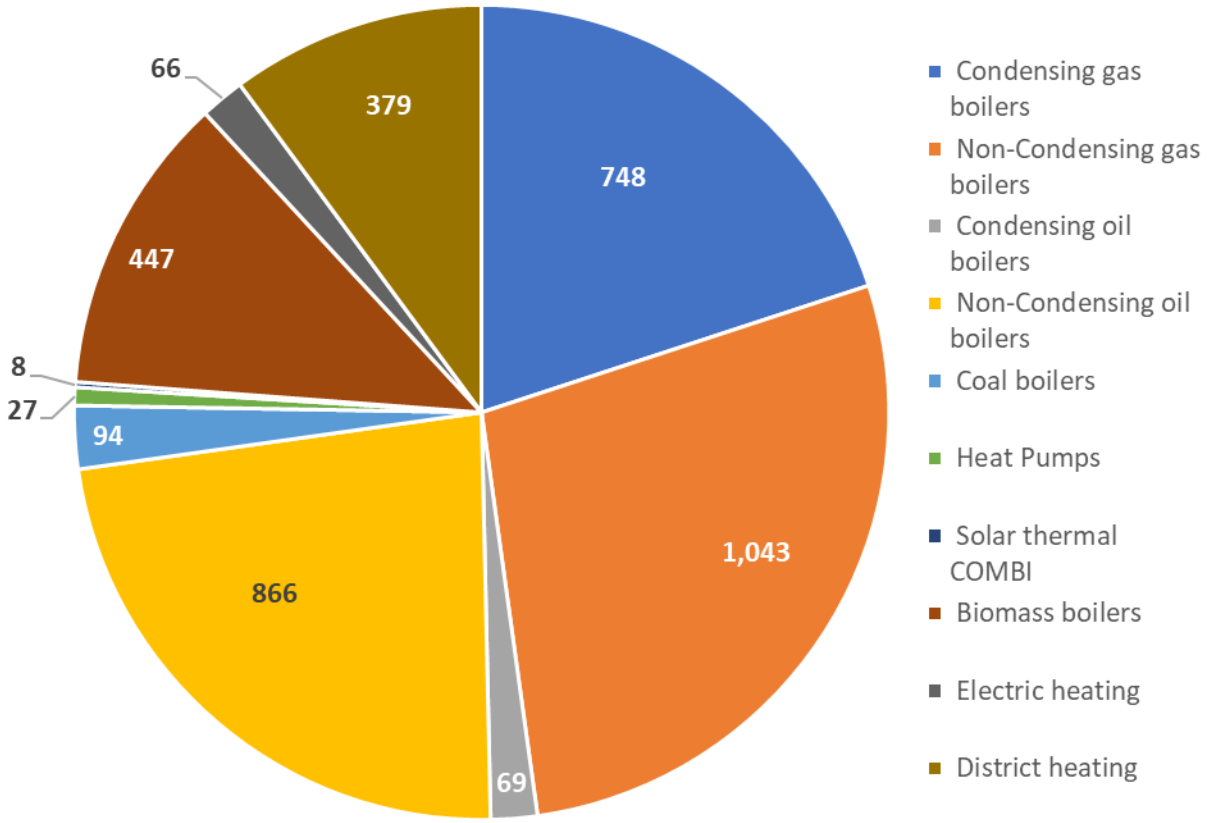

Figure 12 Space heating combi/space heating heated living area in Germany in 2017 [Mm²]

In Germany there are 11.2M biomass single-room stoves installed (Bundesverband des Schornsteinfegerhandwerk, 2018). Dividing this number by the average number of rooms per dwelling, we calculated that there are 2.5M SFH heated with biomass, on top of the 914 thousand of boilers counted in 3.1.1. See Table 27 in Annex.

Also, coal boilers number is not compatible with the heated surface calculated: heated surface calculation reveals that should be installed at least 220 thousand coal boilers in SFH[12].

3.1.4 Building stock and heating appliances

The first distinction of the heating and building stock is between autonomous and centralised heating (Figure 13).

Autonomous heating represents 63% of total units installed, 32% of the overall thermal capacity installed, 42% of final energy consumption and 43% of heated living area.

[12] We divided the heated surface for SFH (24M m²) by the average surface of a SFH in Germany (112 m²).

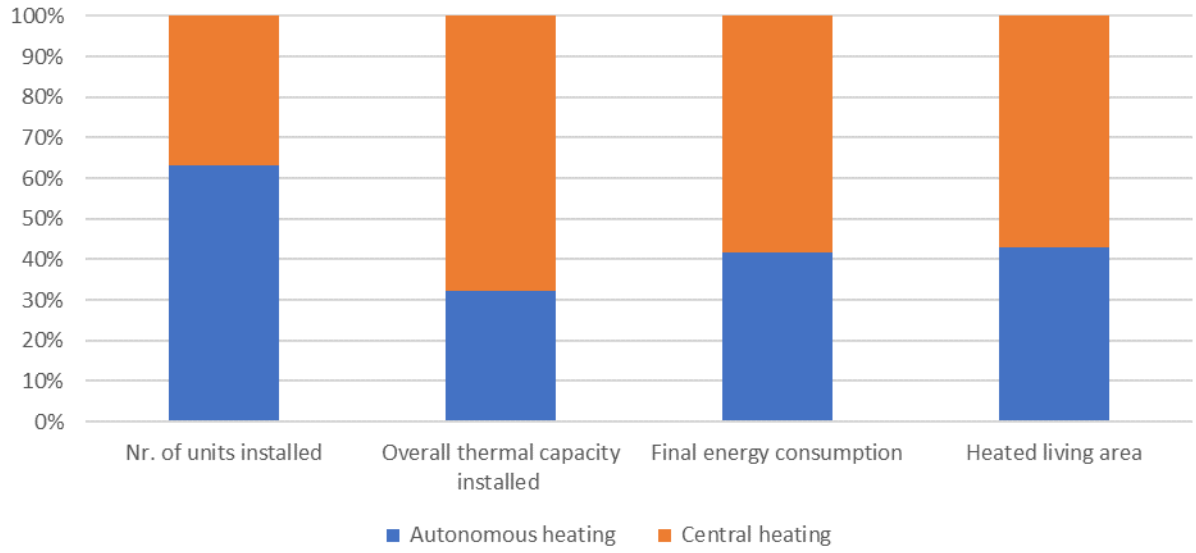

Figure 13 Share of autonomous/central heating units installed, overall thermal capacity installed, final energy consumption and heated living area in Germany in 2017

In Germany there are 22.8M heating appliances installed: 3.4M in SFH and MFH-A and 8.4M in MFH-C (Table 4).

The total number of dwellings is 41.2 M: 19.4 SFH and 21.8M MFH dwellings.

The average size of a SFH is 112 m², while a dwelling in MFH has an average of 67 m². the average number of rooms per dwelling in Germany is 4.4 (The Hague: Ministry of the Interior and Kingdom Relations, 2010)

Since 99% of the floor is heated, there are 19.2 SFH and 21.5 MFH dwellings heated (Table 21 and Table 22).

Table 4 Number of heating appliances installed in Germany (database)

GERMANY	Autonomous heating (SFH + MFH-A)	Central heating (MFH-C)	Total
Condensing gas boilers	3,436,757	2,835,243	6,272,000
Non-Condensing gas boilers	3,866,352	3,189,648	7,056,000
Condensing oil boilers	527,121	118,879	646,000
Non-Condensing oil boilers	2,619,212	2,160,788	4,780,000

GERMANY	Autonomous heating (SFH + MFH-A)	Central heating (MFH-C)	Total
Coal boilers	9,762	9,762	19,524
Heat pumps	841,635	44,297	885,932
Solar thermal COMBI	709,092		709,092
Biomass boilers	914,000	11,000	925,000
Electric heating	1,500,000		1,500,000
Total	**14,423,932**	**8,369,615**	**22,793,548**

As for the other countries, we considered the criteria of paragraph 12.3 and Table 26 in

Methodology and we followed the same procedure to determine the matrix heating appliances/building stock.

For Germany, we had to ponder two factors: the biomass and coal heating appliances.

In this country, single-room stoves are installed as main heating appliances. Every room has one unit installed, so we added 2.5M SFH heated with biomass to the matrix.

Moreover, coal boilers heated surface was not compatible with the number of items declared by the literature analysed (Fraunhofer ISI et al., 2016). According to our calculations, at least 218 thousand SFH are heated with coal boilers.

The number of heated SFH in Germany is 19.2M (Table 21 in Annex) and the technologies that are only attribute to SFH amount to 9M units. Therefore, the remaining 10.2M are heated with gas boilers. The share of condensing gas boilers is 48%, so there should be 4.8M condensing and 5.4M NC gas boilers in SFH in Germany (Table 5).

Unfortunately, the entire stock of autonomous gas boilers we calculated is 7.3M units, which cannot cover the entire building stock of heated SFH and MFH-A.

Even counting all the biomass and the corrected number of coal heated SFH, the number of gas boilers in MFH-A are negative.

One possible explication is that the number of SFH connected to district heating and MFH dwellings in centralised systems are higher, balancing the lack of boilers.

Moreover, we set the size of an autonomous system below 25kW: it is possible that a substantial share of SFH is equipped with boilers that are above 25kW. This hypothesis is confirmed by the low number of dwellings for MFH-C, that is 2 dwellings/MFH-C in our extrapolations.

The number of centralised units in Germany is 8.4M, corresponding to 22M of MFH-C dwellings.

Table 5 Matrix of heating appliances and building stock in Germany (estimation)

GERMANY	SFH	MFH-A	MFH-C (dwellings)	MFH-C (units)
Condensing gas boilers	4,808,582	-1,371,825	7,424,001	2,835,243
Non-Condensing gas boilers	5,409,655	-1,543,303	8,352,001	3,189,648
Condensing oil boilers	527,121		311,280	118,879
Non-Condensing oil boilers	2,619,212		5,657,960	2,160,788
Coal boilers	217,795		25,562	9,762
A/A Heat Pumps	144,940	144,940	39,950	15,257
A/W Heat Pumps	252,978		34,864	13,315
W/W Heat Pumps	298,777		41,176	15,725
Biomass	3,459,455		28,803	11,000
Electric heating	170,455	170,455		
District heating (dwellings)	1,333,481	2,220,618		
Total	**19,242,452**	**-379.116 (2.536.013)**	**21,915,595**	**8,369,615**

3.2 Water Heating

3.2.1 Units installed

In Germany there are 11.4M water heaters installed.

Electric water heaters represent 72% of the total: 6.3M are electric instantaneous and 1.9M are electric storage water heaters (Figure 14).

1.6 million units are the stock of gas water heaters, which are almost equally divided into GSWH (785 thousand) and GIWH (840 thousand).

Solar thermal systems are 1.4M, followed by heat pumps, with 97 thousand units.

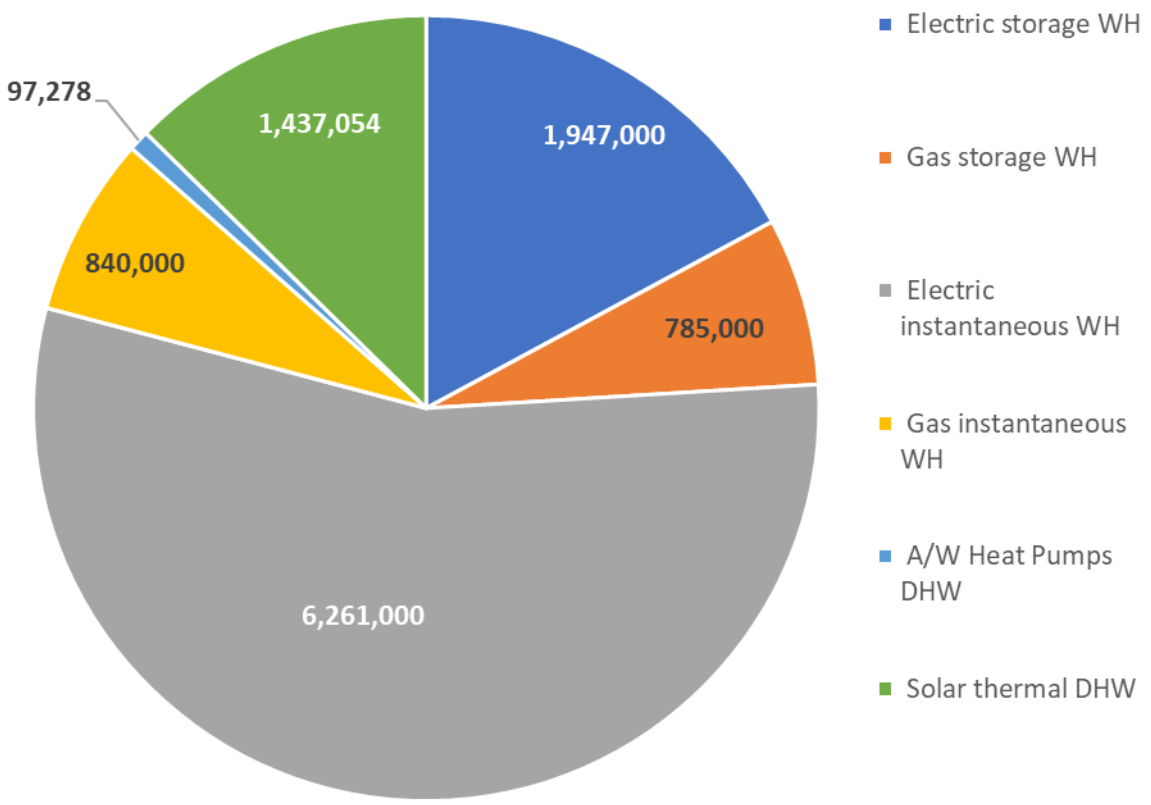

Figure 14 Water heating units installed in Germany in 2017

3.2.2 Overall thermal capacity installed and final energy consumption

Thermal capacity of water heating units in Germany 116 GW. First technology are electric water heaters, with 84 GW installed, followed by gas water heaters (24.2 GW) solar thermal systems (7.1 GW) and A/W DHW heat pumps (550 MW) (Figure 15).

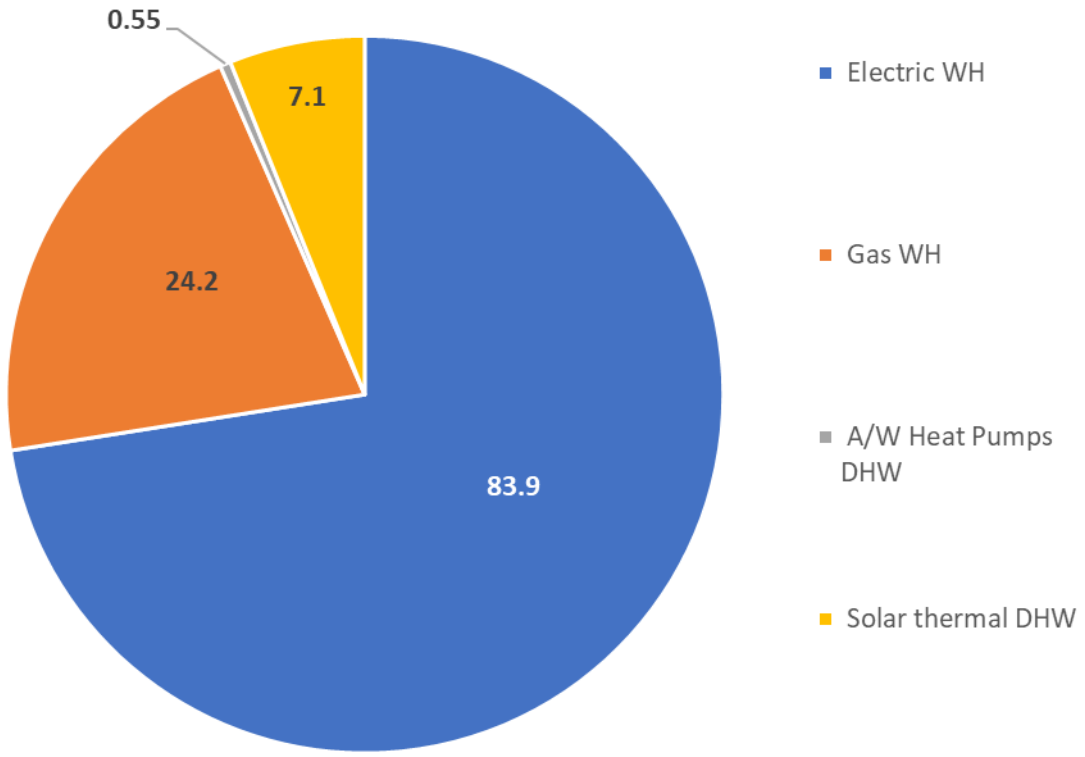

Figure 15 Water heating overall installed capacity in Germany in 2017 [GW]

The final energy consumption in Germany in 2017 for water heating was 110 TWh, while we calculated that gas, electricity, heat pumps and solar thermal consumed 77.6 TWh[13].

The main fuel of final energy consumption in water heating is gas: 55.5 TWh in 2017. Despite the high number of units, electric heaters consume 15.5 TWh per year (Figure 16).

6.5 TWh are produced by solar thermal systems, while heat pumps production was 300 MWh.

[13] We did not consider district heating and biomass/biogases.

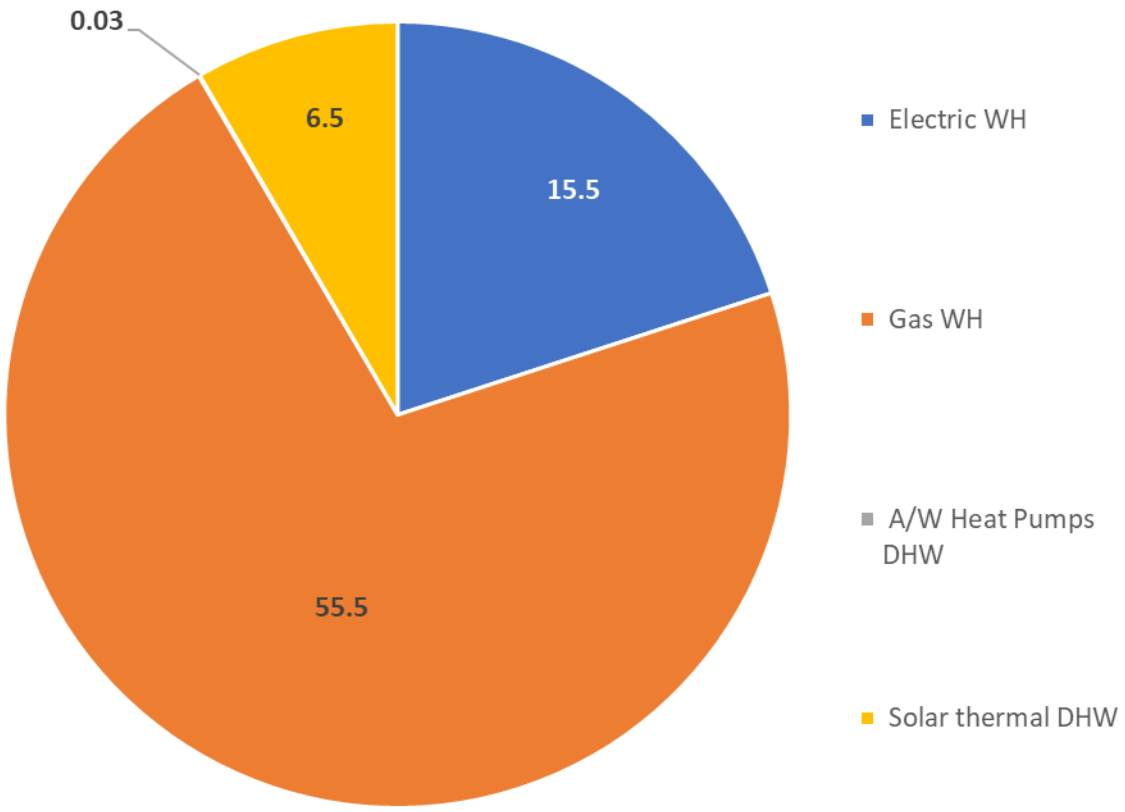

Figure 16 Water heating final energy consumption in Germany in 2017 [TWh]

3.2.3 Building stock and water heating appliances

Since in Germany 99% of the dwellings are heated, only 412 thousand dwellings are unheated and only have a water heating unit installed.

The rest of water heating stock (11M) is installed in a dwelling that has also installed a space heating unit.

4 Italy

The Italian population is 60.5M habitants: the number of SFH is 6.7M and MFH dwellings are 25.3M.

The majority of the population live in MFH buildings: Italy has the highest number MFH dwellings of all the country analysed in this study. (European Commission, 2019) (Table 21 in Annex).

The average size of a dwelling is smaller than France and Germany: 95 m² for a SFH and 67 m² for a MFH dwelling. (European Commission, 2019) (Table 24 in Annex).

In Italy, 80% of the total floor is heated (CRESME, 2019), corresponding to 5.3M SFH and 20.2M dwellings in MFHs (BSRIA, 2014).(Table 25 and Table 21 in Annex).

The average number of rooms per dwelling is in-between the two countries analysed in the previous chapters: 4.2 (The Hague: Ministry of the Interior and Kingdom Relations, 2010) (Table 27 in Annex).

The age of the building stock is similar to Germany, with 68.7% of the buildings constructed before 1980 and 18.6% after 1990 (Table 1 in Paragraph 2).

4.1 Domestic hot water and space heating

4.1.1 Units installed

Italy has 23.7M heating appliances installed: 77% in autonomous heating and 23% centralised.

Gas boilers are the most diffused technology with 17.6M units installed (29% condensing). See Figure 17.

Gas boilers represent 74% of the total units installed. If we consider all fossil fuels boilers, the share rises to 84% (adding 2.1M oil boilers and 90 thousand coal boilers).

Renewables are represented by biomass boilers with 2.7M units installed, followed by heat pumps with 762 thousand units and solar thermal combi boilers with 76 thousand systems installed.

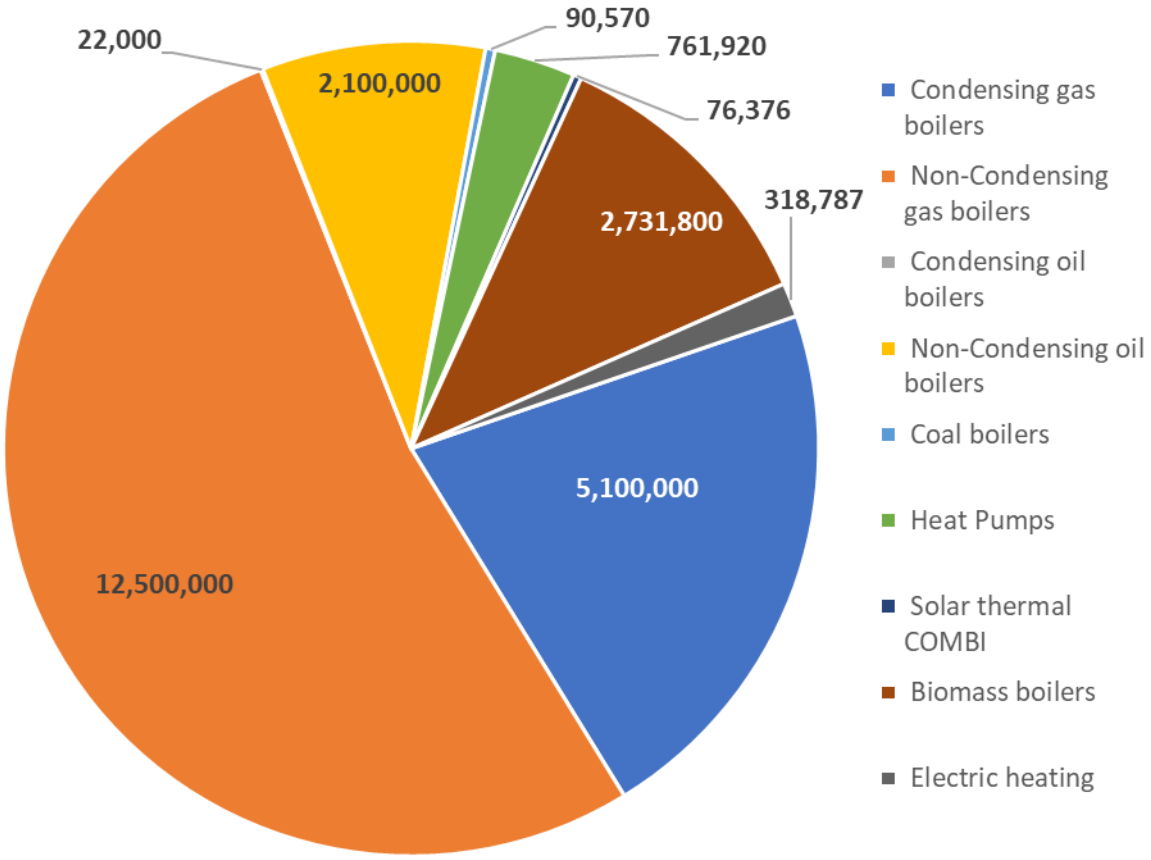

Figure 17 Space heating combi/space heating units installed in Italy in 2017

4.1.2 Overall thermal capacity installed and final energy consumption

Overall installed thermal capacity in Italy was 1,270 GW in 2017 (Figure 18).

81% of the installed capacity is hold by gas boilers (762 GW NC and 267 GW condensing); 182.3 GW by NC oil boilers, 1.6 GW by condensing oil boilers and 3.3 GW by coal boilers.

Fossil fuels boilers represent 96% of the whole installed capacity of Italy.

The remaining 4% is shared by all other technologies: 21.4 GW of biomass installed capacity, followed by 12.5 GW of heat pumps, 10.6 GW district heating, 8.6 GW electric heating and 0.6 GW solar thermal combi systems.

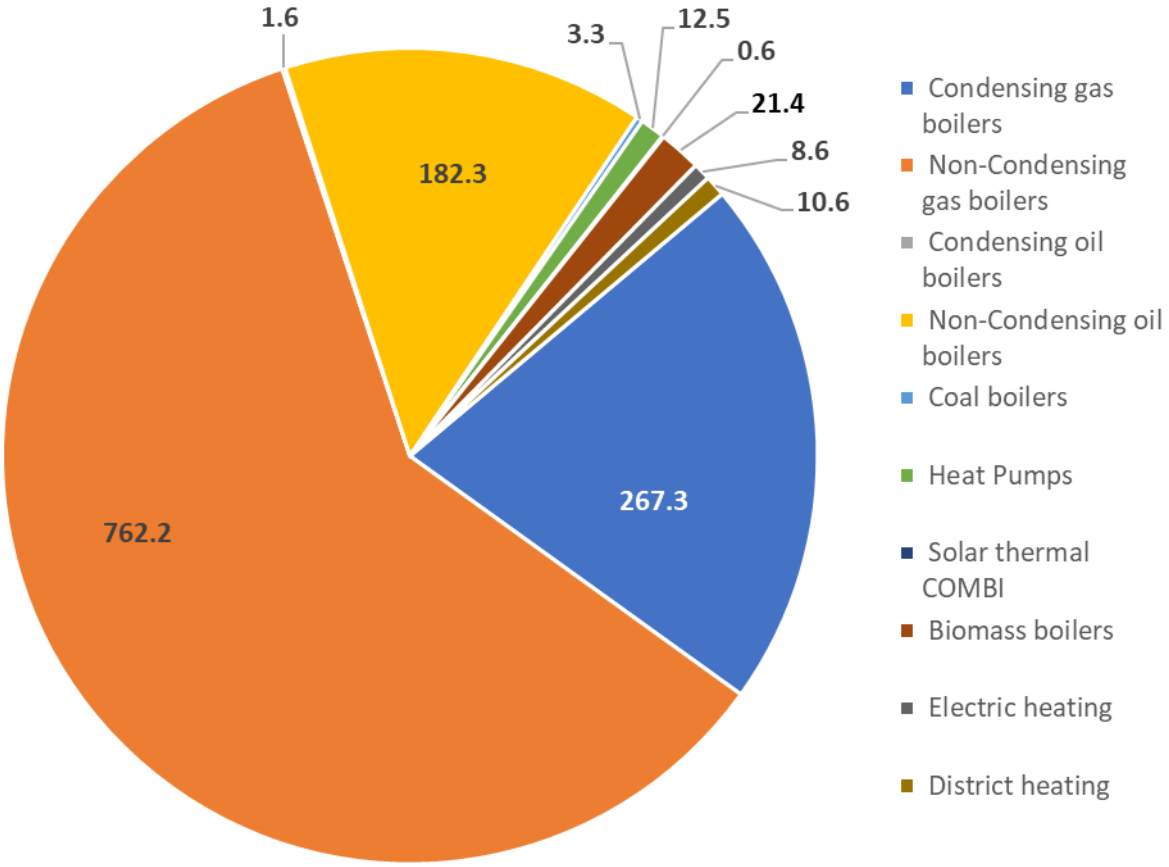

Figure 18 Space heating combi/space heating overall thermal capacity installed in Italy in 2017 [GW]

Final energy consumption calculated is 272 TWh, while the total final energy consumption in Italy in 2017 was 275 TWh[14] (Figure 19).

[14] We took into consideration also heat pumps.

171.2 TWh have been consumed by gas boilers (63% of the total). Biomass boilers consumed 74.7 TWh, followed by district heating, oil boilers and electric heating with 10.6 TWh, 9.8 TWh and 1.1 TWh.

Heat pumps consumed 3 TWh and Solar thermal combi boilers produced 0.1 TWh.

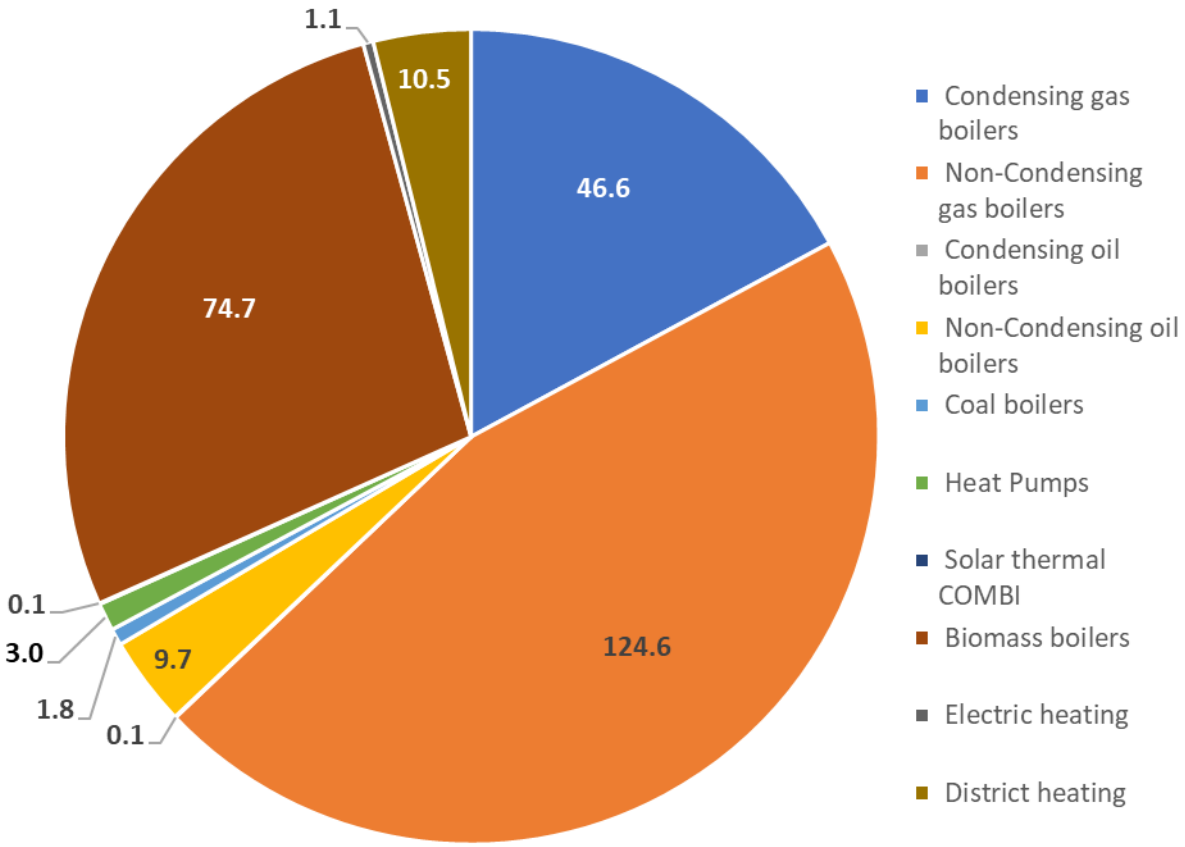

Figure 19 Space heating combi/space final energy consumption in Italy in 2017 [TWh]

4.1.3 Heated living area

We estimated that in Italy 1,870 Mm² are heated[15] (Figure 20).

63% of the heated floor is covered by gas boilers with 1,183 Mm².

The second largest share of heated floor is represented by biomass with 516 Mm², followed by oil boilers with 67 Mm³ and district heating with 63 Mm³.

The sum of gas, biomass, oil and district heating heated floor is 98% of the heated surface of residential sector in Italy.

The remaining 2% is covered by heat pumps (19 Mm²), coal boilers (12.5 Mm²), electric heating (7.5 Mm²) and solar thermal combi systems (0.8 Mm²).

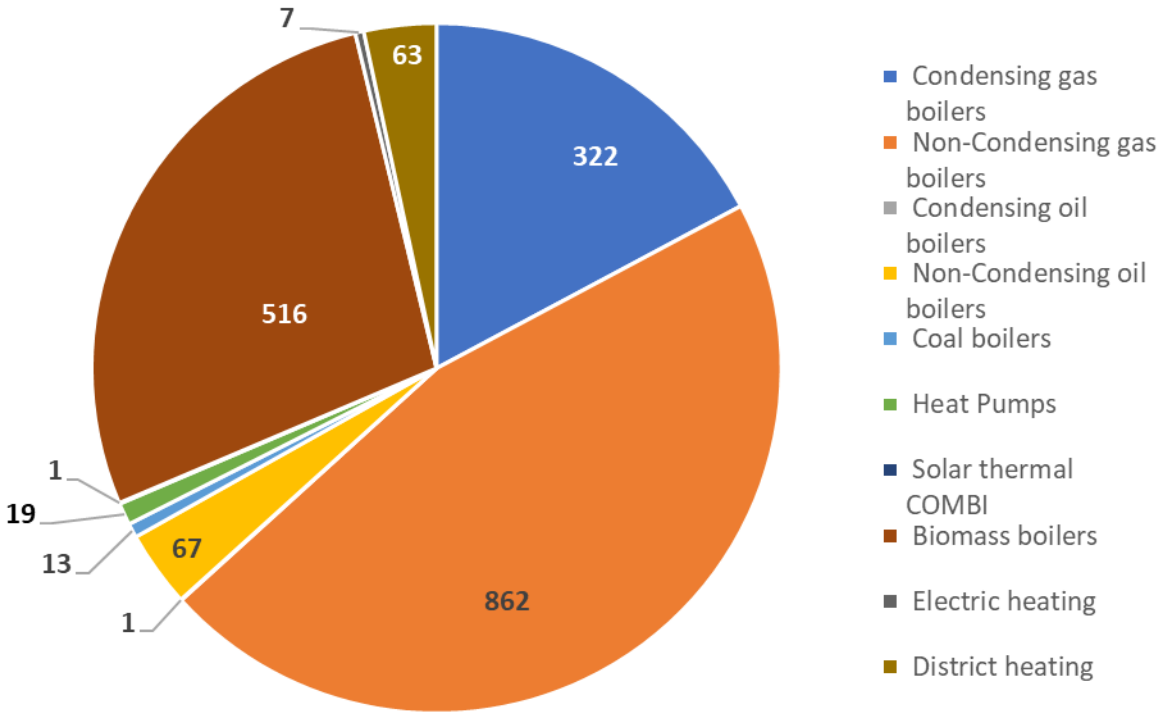

Figure 20 Space heating combi/space heating heated living area in Italy in 2017 [Mm²]

[15] 1,899M m² according to Inspire Project.

4.1.4 Building stock and heating appliances

Italy is a country with a higher number of MFH dwellings compared to the previous ones.

77% of the units installed is autonomous, corresponding to 31% of the overall installed capacity, 52% of final energy consumption and 52% of heated living area too (Figure 21).

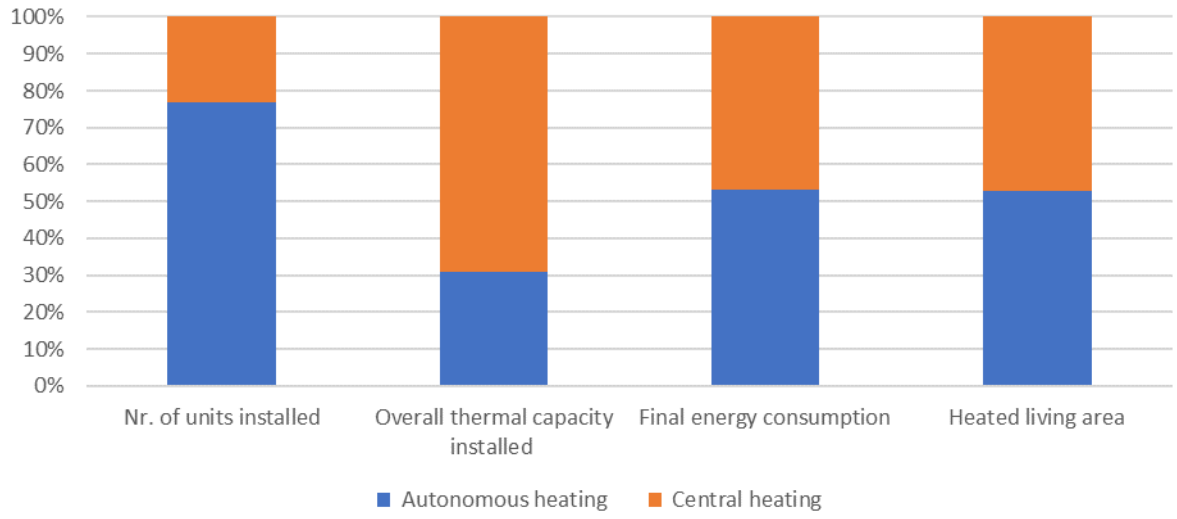

Figure 21 Share of autonomous/central heating units installed, overall thermal capacity installed, final energy consumption and heated living area in Italy in 2017

The total residential surface is 2,987 Mm²: 637 Mm² SFH and 1,685 Mm² MFH (Table 22 in Annex).

The number of SFH is 6.7M and 25.3M are the MFH dwellings (Table 21 in Annex).

As established for all the countries of this report, we used the number of heated dwellings (Table 21 in Annex) and the assumption that we made in Paragraph 12.3 and Table 26 in

Methodology to build the matrix.

According to Table 6, there are 23.7M heating appliances in Italy, with 5.5M centralised units.

Table 6 Number of heating appliances installed in Italy (database)

ITALY	Autonomous heating (SFH + MFH-A)	Central heating (MFH-C)	Total
Condensing gas boilers	3,929,040	1,170,960	5,100,000

ITALY	Autonomous heating (SFH + MFH-A)	Central heating (MFH-C)	Total
Non-Condensing gas boilers	9,630,000	2,870,000	12,500,000
Condensing oil boilers	10,085	11,915	22,000
Non-Condensing oil boilers	921,060	1,178,940	2,100,000
Coal boilers	90,394	176	90,570
Heat pumps	647,632	114,288	761,920
Solar thermal COMBI	76,376		76,376
Biomass boilers	2,725,000	6,800	2,731,800
Electric heating	186,449	132,339	318,787
Total	**18,216,036**	**5,485,417**	**23,701,453**

As usual, we proceeded using the criteria explained in Paragraph 12.3: heated SFH are 5.3M (Table 21 in Annex) and the sum of all the technologies except gas boilers for SFH is 1.8M[16], with a result of 3.5M SFH heated by gas boilers. The share of condensing gas boilers is 29%.

The remaining part of the autonomous gas boilers not installed in SFH is added to MFH-A dwellings.

The results of the matrix are in Table 7, where we tried to match the heating stock with the building stock: Table 3 there are 5.3M SFH, 10.7M MFH-A and 9.3 MFH-C heated dwelling in Italy.

The average number of dwelling per MFH-C is 2.

Table 7 Matrix of heating appliances and building stock in Italy (Number of units installed, estimation)

ITALY	SFH	MFH-A	MFH-C (dwellings)	MFH-C (units)
Condensing gas boilers	1,011,694	2,917,346	1,976,661	1,170,960
Non-Condensing gas boilers	2,479,643	7,150,357	4,844,757	2,870,000
Condensing oil boilers	10,085		20,114	11,915

[16] Only biomass boilers have been taken into consideration and not stoves. Dwellings heated by electric heaters have been calculated by dividing the number of electric heaters by the average rooms number per dwelling.

ITALY	SFH	MFH-A	MFH-C (dwellings)	MFH-C (units)
Non-Condensing oil boilers	921,060		1,990,131	1,178,940
Coal boilers	90,394		296	176
A/A Heat Pumps	267,833	267,833	159,572	94,529
A/W Heat Pumps	100,746		30,012	17,779
W/W Heat Pumps	11,220		3,342	1,980
Biomass	115,000		11,479	6,800
Electric heating	22,196	22,196	223,397	132,339
District heating (dwellings)	248,427	355,651		
Total	**5,278,298**	**10,713,383**	**9,259,760**	**5,485,417**

4.2 Water Heating

4.2.1 Units installed

In Italy there are 10.5M water heating units installed (Figure 22): 6.9M are ESWH, corresponding to 66% of the entire stock.

GIWH are the second most common product installed, with 2.1M units, followed by solar thermal with 870 thousand systems and GSWH with 674 thousand units.

DHW A/W installed heat pumps are 1,500.

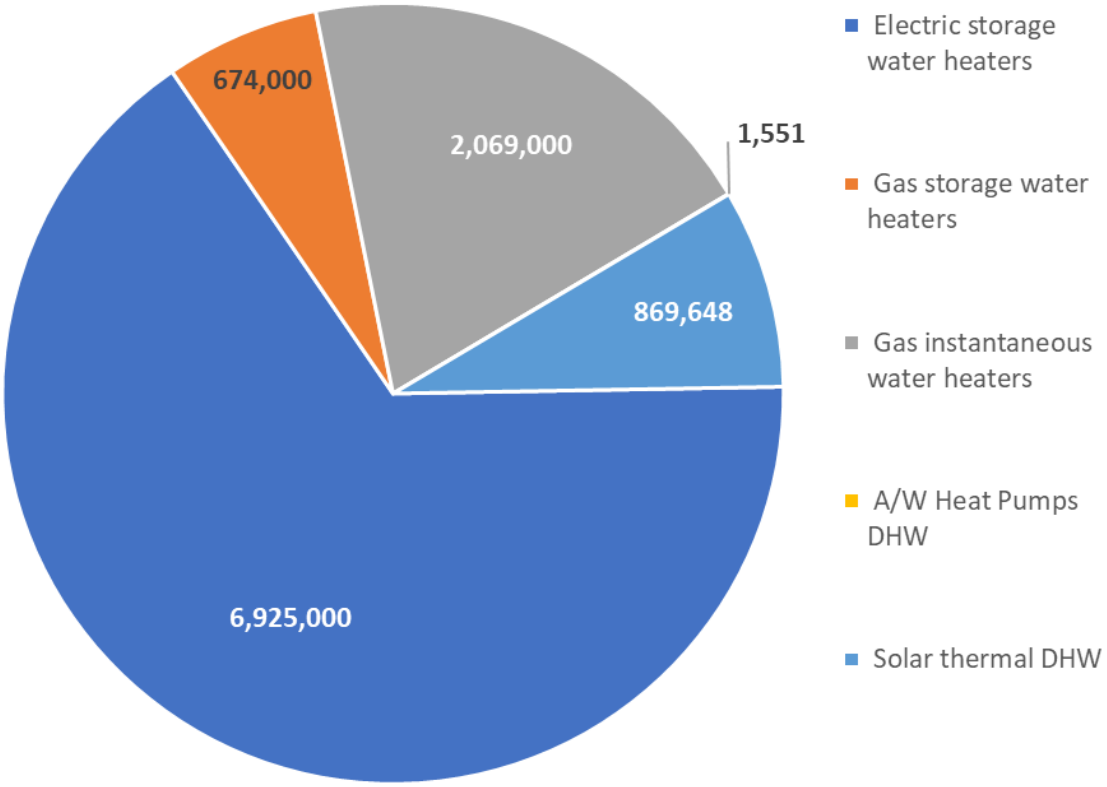

Figure 22 Water heating units installed in Germany in 2017

4.2.2 Overall thermal capacity installed and final energy consumption

Overall thermal capacity installed in Italy was 66 GW (Figure 23): gas water heating capacity is 46 GW and electric capacity is 17 GW. Gas and electricity installed capacity amounts to 96% of the total: the remanding share is represented by solar thermal systems (2.3 GW) and heat pumps (10 MW).

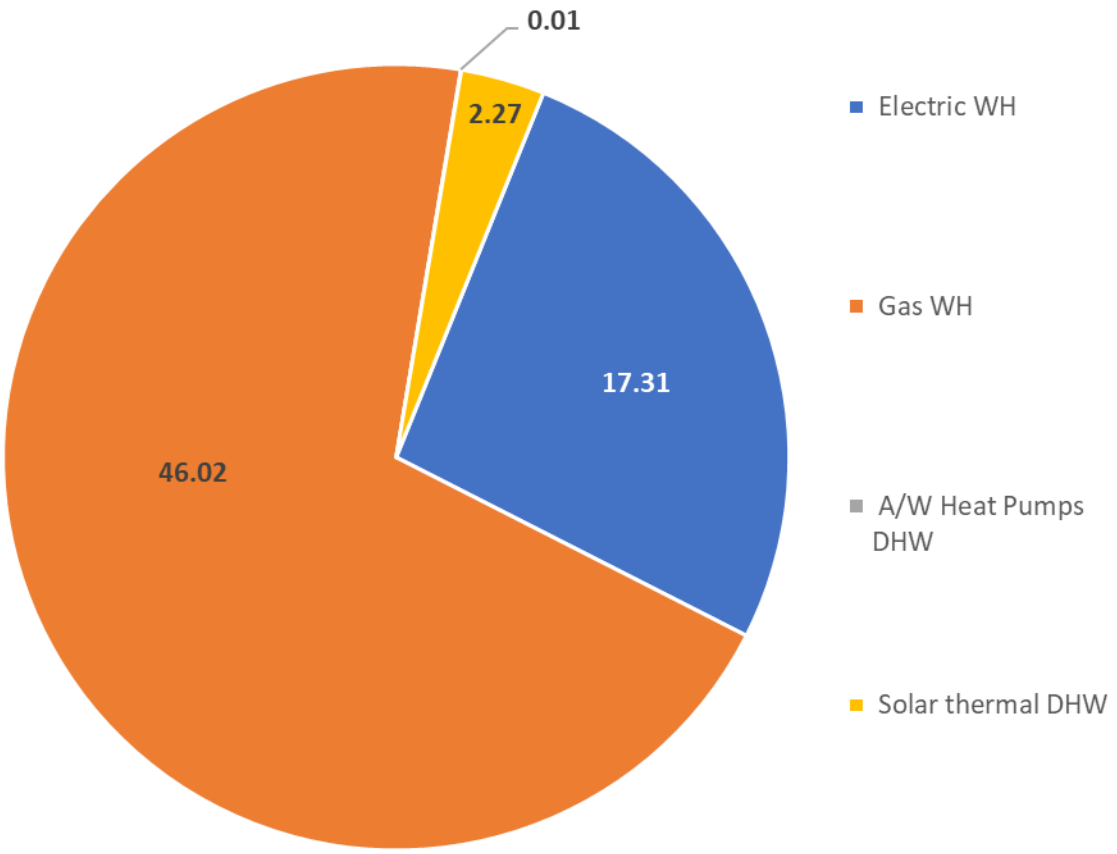

Figure 23 Water heating overall installed capacity in Italy in 2017 [GW].

Final energy consumption reflects the installed capacity: the technologies considered consume 41 TWh per year in water heating (total consumption 48.5 TWh[17]).

33 TWh are consumed by gas fuelled units, followed by electric heaters (6.4 TWh), solar thermal systems (1.7 TWh) and A/W DHW heat pumps (1 GWh).

[17] We did not consider biomass and district heating technologies.

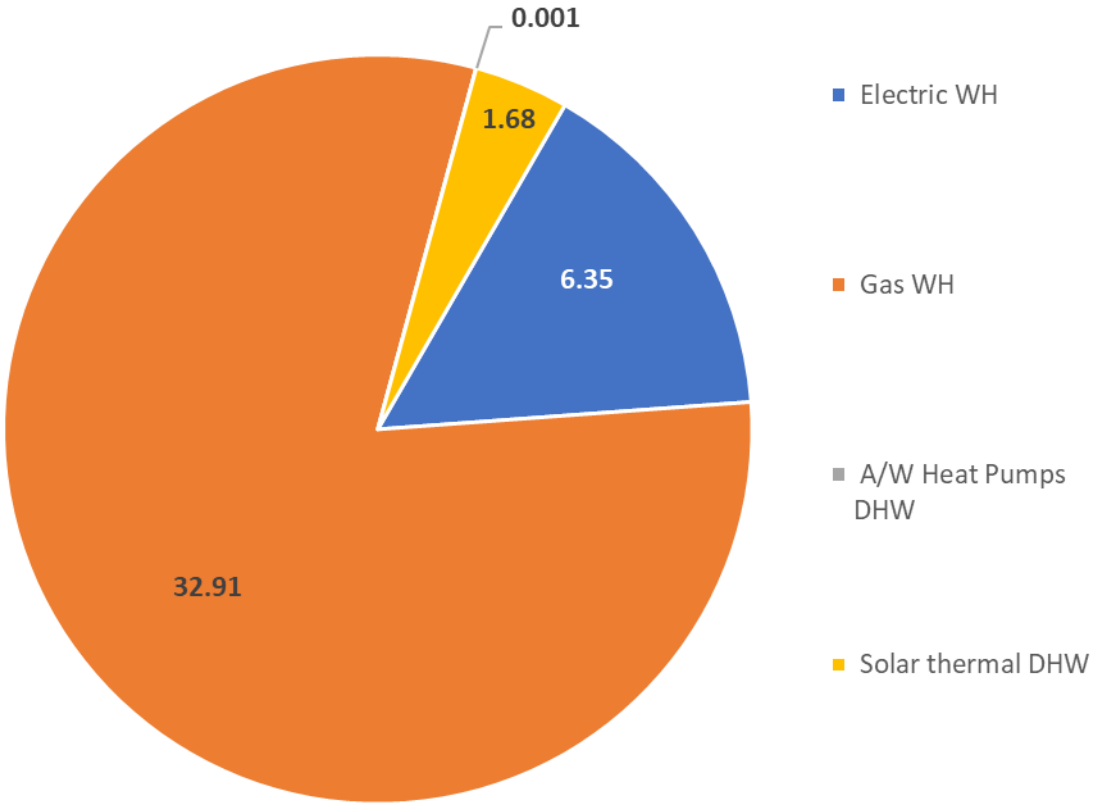

Figure 1 Water heating final energy consumption in Italy in 2017 [TWh]

4.2.3 Building stock and water heating appliances

The number of unheated dwellings in Italy is 6.7M units, which correspond to 64% of the entire stock of installed water heaters: 1.4M SFH and 5.3M MFH dwellings.

We can affirm that 3.8M dwellings in Italy possess both a heating unit and a water heating unit.

5 Portugal

Portugal is a country with a population of 10.3M inhabitants. The population of the country lives in 5.9M dwellings: the most common residential solution is SFH (3.5M units), corresponding to 59% the total stock. The remaining 41% are dwellings in MFH (2.4M). (European Commission, 2019) (Table 22 in Annex).

SHF have an average size of 81 m² and MFH dwellings 68 m², with an average of 75 m² for a dwelling in Portugal. (European Commission, 2019). (Table 24 in Annex)

The heated surface in Portugal is 58.6%:2M SFH and 1.4M MFH, with a total of 3.5M heated dwellings (BSRIA, 2014).(Table 25 and Table 22 in Annex).

The number of rooms per dwelling is 4.8. (The Hague: Ministry of the Interior and Kingdom Relations, 2010). (Table 27 in Annex)

The age of the building stock is almost equally divided between building constructed before 1980 (52%) and after 1980 (48%). Only 16% of the building stock has been constructed before 1945, while there has been an acceleration in construction after 1980 (Table 1 in Paragraph 2).

5.1 Domestic hot water and space heating

5.1.1 Units installed

In Portugal there are 2.6M units installed: 77% are electric heating devices (Figure 24.)

Gas boiler and heat pumps follow with 461 thousand and 100 thousand units installed.

There are 21 thousand oil, 8 thousand biomass and 5 thousand coal boilers installed.

Solar thermal combi systems are 2,600.

The installed stock of heating appliances is very different in Portugal compared to the other countries analysed: electric heaters and heat pumps are with gas boilers the dominant technologies.

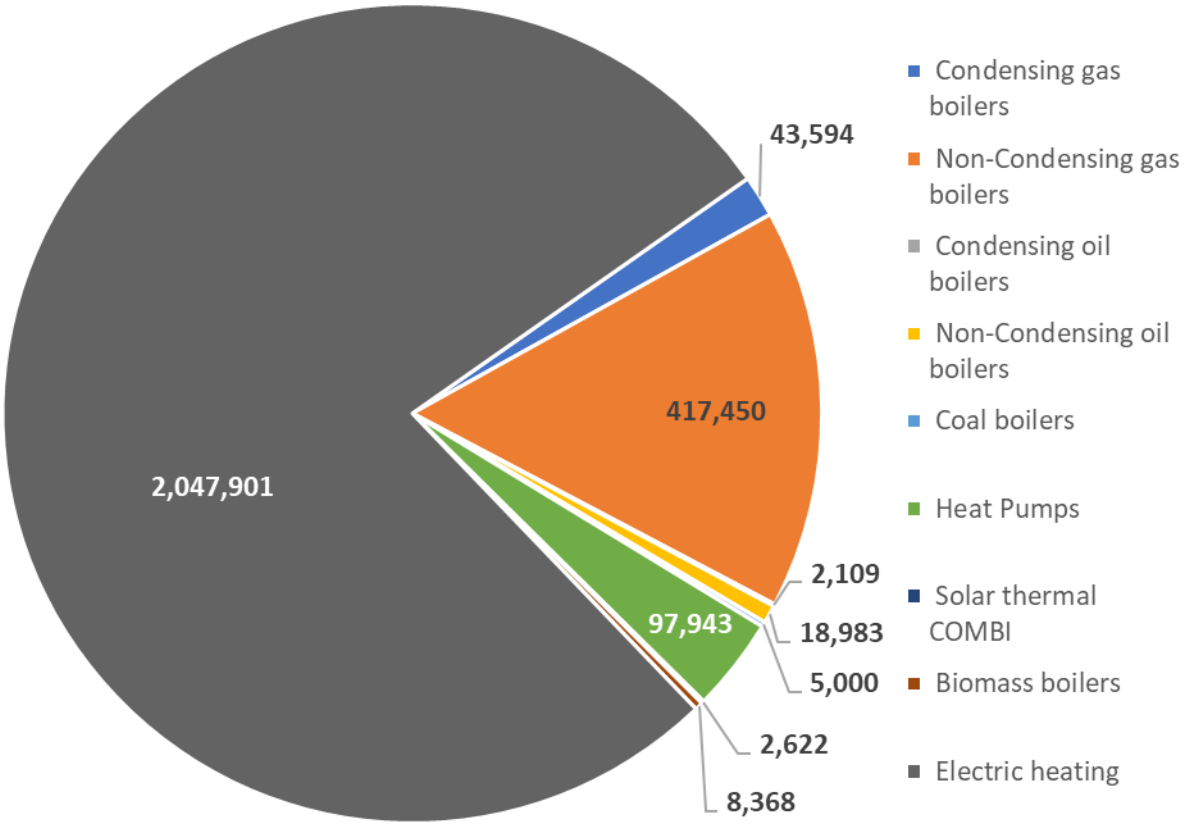

Figure 24 Space heating combi/space heating units installed in Portugal in 2017

5.1.2 Overall thermal capacity installed and final energy consumption

Overall thermal capacity installed in Portugal reaches 22.7 GW (Figure 25).

Gas boilers hold the highest share, with 15.4 GW installed (48%), followed by electric heaters with 4.1 GW and heat pumps (2 GW): these three technologies mentioned represent 95% of the entire installed capacity in the country.

The remaining 5% is shared among the following technologies: oil boilers (0.7 GW), biomass boilers (0.2 GW), coal boilers (0.1 GW) and solar thermal combi systems (20 MW).

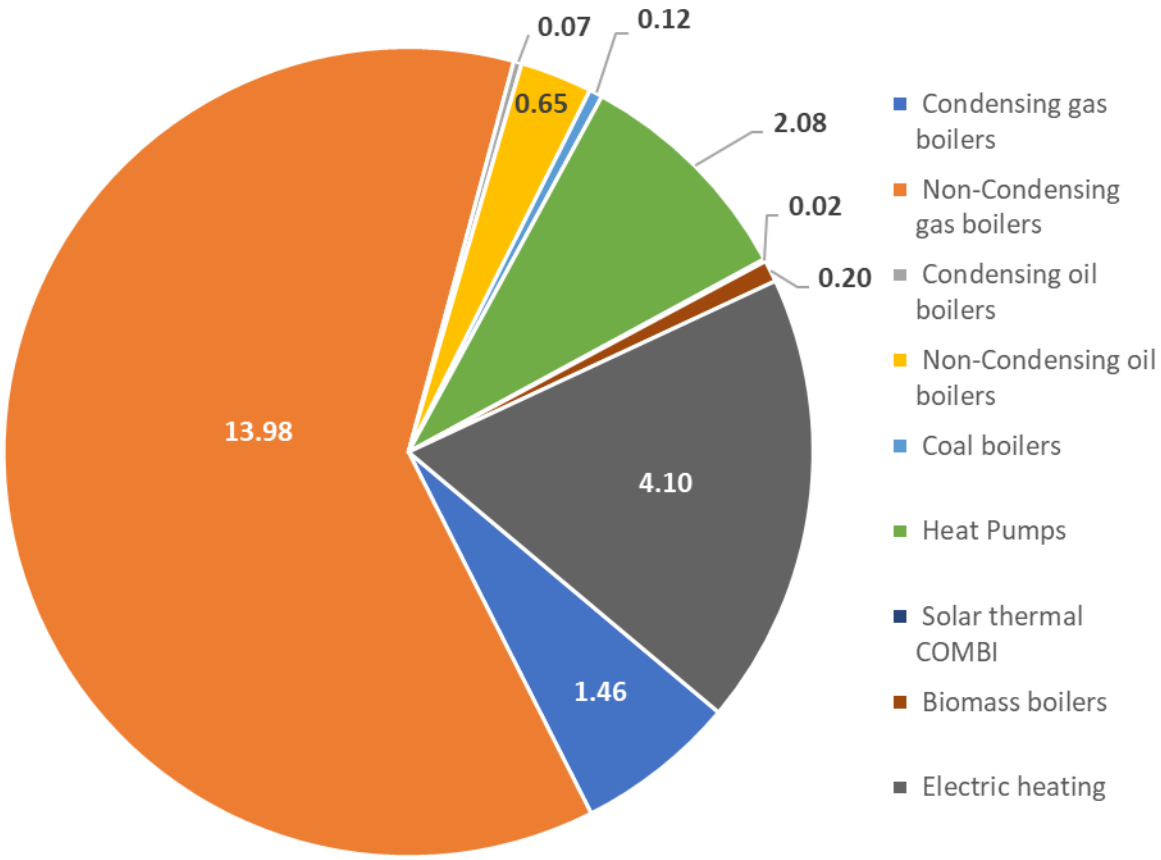

Figure 25 Space heating combi/space heating overall thermal capacity installed in Portugal in 2017 [GW]

Final energy consumption in Portugal in 2017 was 6.3 TWh (Eurostat, 2017), while in our calculations it is 6.8 TWh[18] (Figure 26).

[18] We considered heat pumps, that Eurostat does not include in its statistics.

In our extrapolations, the highest consumption is produced by biomass with 4.6 TWh and electric heaters with 1.1 TWh, followed by heat pumps, with 0.5 TWh[19] and NC oil boilers with 0.4 TWh (Figure 26).

Biomass, electric heating, heat pumps and NC oil boilers represent 97% of the whole final energy consumption in Portugal.

Gas boilers consume 0.1 TWh, while solar thermal systems 50 GWh and coal boilers 10 GWh.

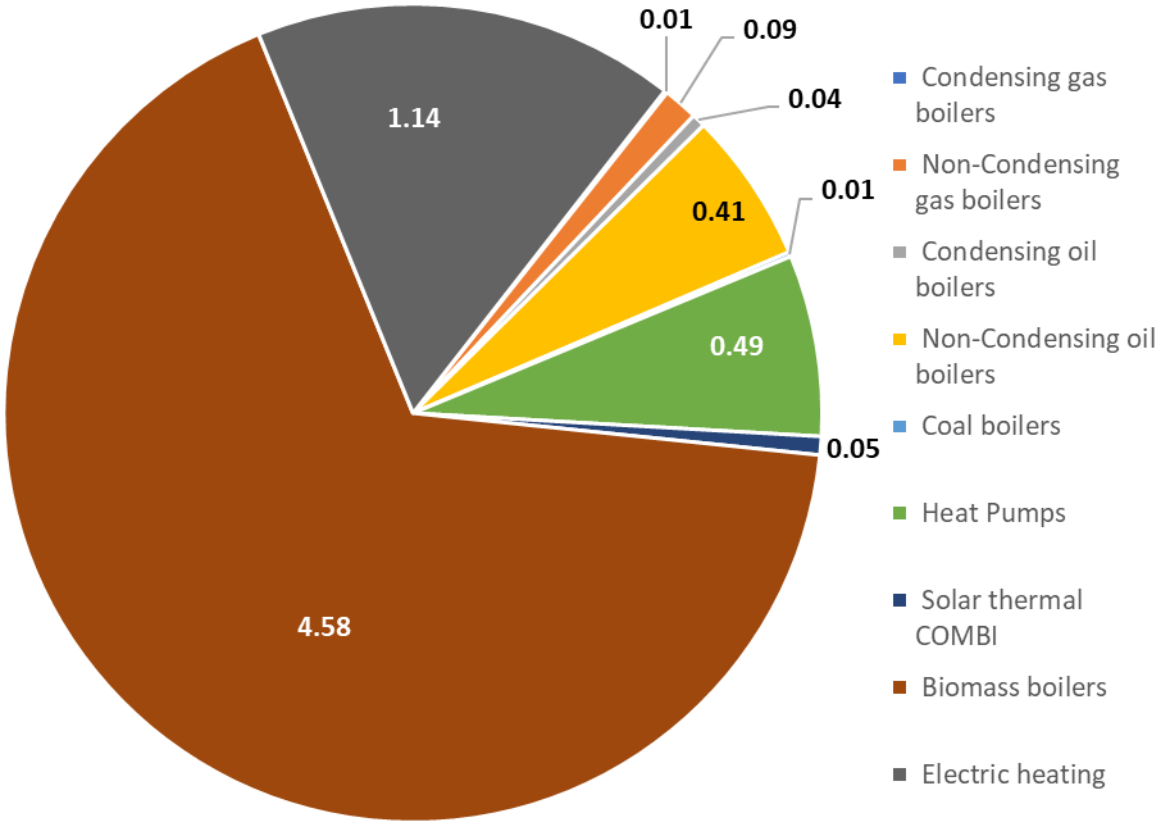

Figure 26 Space heating combi/space heating final energy consumption in Portugal in 2017 [TWh]

[19] In the case of heat pumps, the energy is not all consumed, but almost all produced (excluding electric consumption of the units). We decided to keep the word "consumed" to compare it with other traditional technologies, but we are aware that renewables are producing and not consuming energy.

5.1.3 Heated living area

Heated living area in Portugal is 417 Mm² (Figure 27).

281 Mm² are heated by biomass with 281 Mm² followed by electric heating with 70 Mm², heat pumps with 29 Mm²

Oil boilers heat 27 Mm², while gas boilers 6 Mm².

Solar thermal combi systems cover a surface of 3 Mm².

The number of heat pumps and biomass units installed of Paragraph 5.1.1 is not coherent with the final energy consumption and the heated floor.

If we divide the heated floor of biomass and heat pumps by the average size of a dwelling in Portugal, the results are different: the number of A/A heat pumps is 320 thousand and the biomass appliances 3.8M for autonomous dwellings[20].

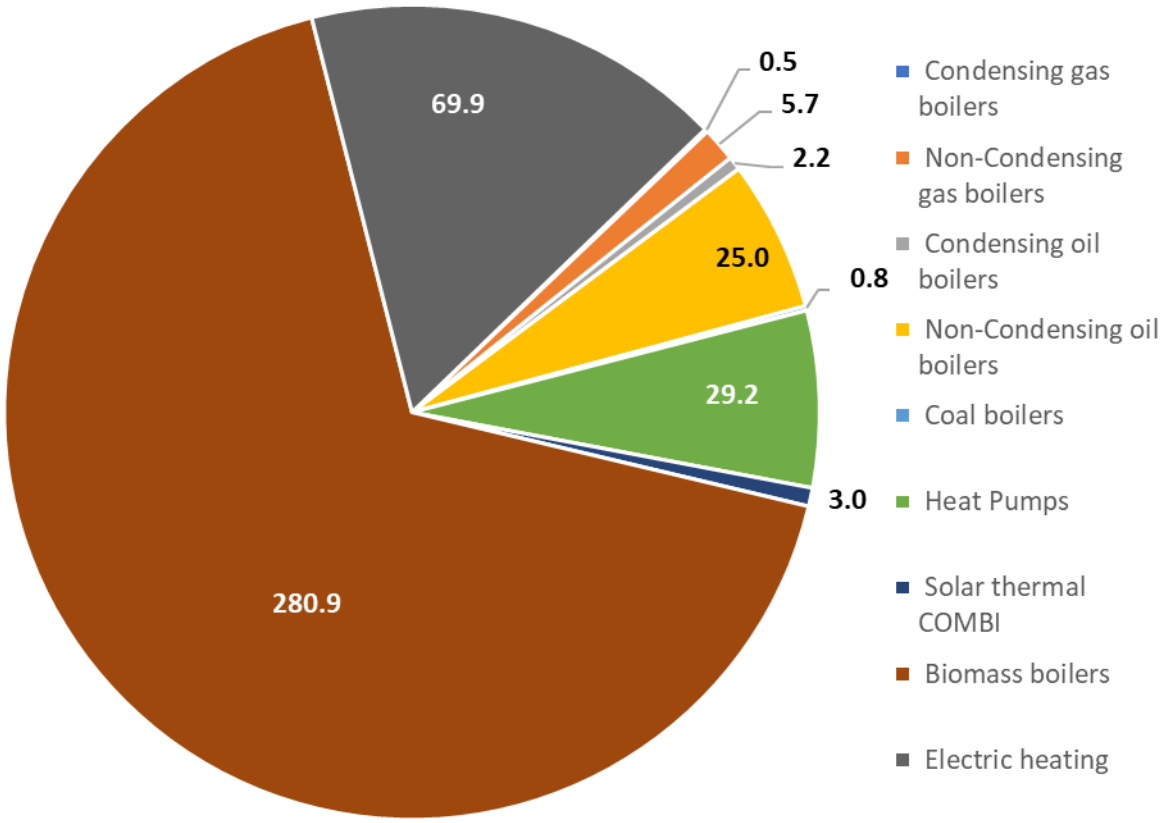

Figure 27 Space heating combi/space heating heated living area in Portugal in 2017 [Mm²]

[20] 241 Mm² heated by heat pumps and 281 Mm² heated by biomass divided by 75 m².

The sum of all the heating appliances is higher than the number of dwellings in Portugal. The explanation is simple: since biomass stoves are single-room heaters, they can either be installed in different rooms of the same dwelling or integrate other technologies.

In the case of heat pumps, in Portugal A/A heat pumps such as splits are used mainly for air conditioning and only to a lesser extent for heating purposes; the principle is the same as for biomass: there can be more than one split installed in a dwelling.

5.1.4 Building stock and heating appliances

Portugal is a country in which there are almost no centralised heating appliances. We calculated that autonomous heating represents 99.7% of all installed units, 98.5% of overall thermal capacity installed, 98.5% of final energy consumption and 98.9% of heated living area (Figure 28).

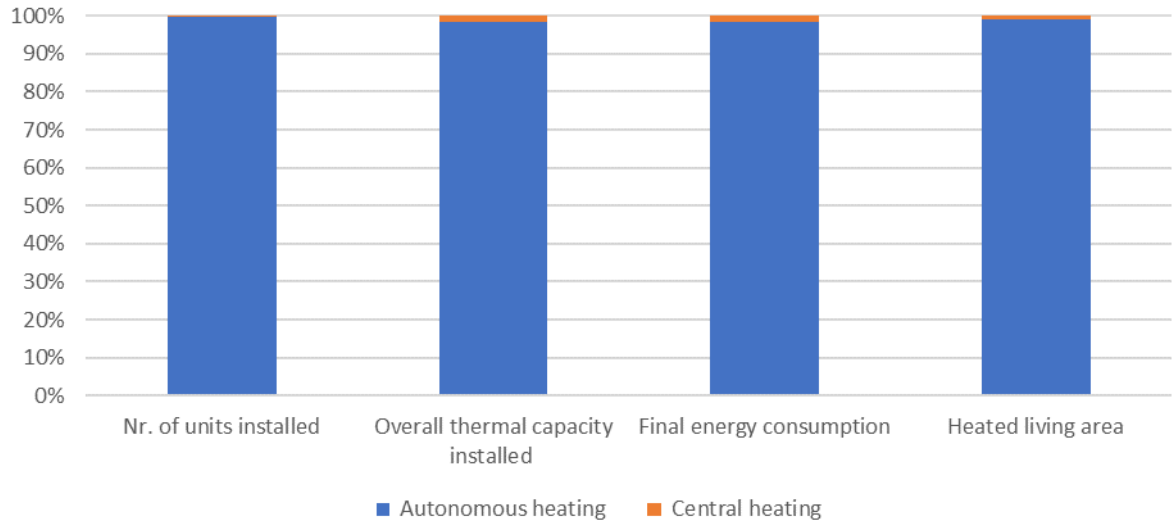

Figure 28 Share of autonomous/central heating units installed, overall thermal capacity installed, final energy consumption and heated living area in Portugal in 2017

The total residential floor in Portugal is 661 Mm²: 285 Mm² SFH and 165 Mm² MFH (Table 22 in Annex) and there are 19M SFHs and 14,9 MFH dwellings[21] (Table 21 in Annex).

In order to calculate the matrix of the heating appliances matched with the building stock, we used as usual the Table 21 in Annex and the assumptions made in Paragraph 12.3 and Table 26 in Methodology. According to Table 8, there are 2.6M heating appliances installed in Portugal: almost all autonomous.

[21] The number of SFH and MFH Mm² has been extrapolated by the EU Building Stock Observatory. For this reason, the sum of SFH and MFH Mm² do not coincide with the total, that is a data provided directly by the countries.

Table 8 Number of heating appliances installed in Portugal (database)

PORTUGAL	Autonomous heating (SFH + MFH-A)	Central heating (MFH-C)	Total
Condensing gas boilers	43,594		43,594
Non-Condensing gas boilers	417,450		417,450
Condensing oil boilers	2,109		2,109
Non-Condensing oil boilers	18,983		18,983
Coal boilers	5,000		5,000
Heat pumps	89,128	11,291	100,419
Solar thermal COMBI	2,622		2,622
Biomass boilers	8,368		8,368
Electric heating	2,047,901		2,047,901
Total	**2,635,156**	**11,291**	**2,646,447**

Using criteria in paragraph 12.3, we built the matrix for Portugal

The number of heated SFH in Portugal is 2.7M (Table 21 in Annex) and the sum of all the technologies except gas boilers for SFH is 300 thousand[22].The remaining part is 2.4M SFH that should be heated with a gas boiler, with a share of condensing gas boilers of 9% over non condensing ones (Table 9).

In Portugal, as for Germany, the entire stock of gas boilers cannot cover the entire stock of SFH and MFH-A: 2.5M estimated vs. 0.5 installed

As for Germany, two technologies distort the matrix results: biomass and heat pumps.

Biomass and heat pumps heated areas are not compatible with the number of units installed.

The explanation is the following: biomass heating appliances are complementary or single-room heaters, while A/A heat pumps are mainly used for cooling.

We correct the matrix in Table 10: we tried to calculate the number of SFH and MFH-A that are heated by these two technologies, adding to the matrix more than 1 million units[23].

[22] Only biomass boilers have been taken into consideration and not stoves. Dwellings heated by electric heaters have been calculated by dividing the number of electric heaters by the average rooms number per dwelling.
[23] We divided the Mm² heated by biomass and heat pumps by the average size of a dwelling in SFH and MFH-A: we obtained the number of dwellings heated by one biomass appliance and A/A heat pumps unit. In order to have

Even counting corrected biomass and heat pumps units, the number of gas boilers in MFH-A are negative.

As said before, the explanation is that heat pumps and biomass appliances are mainly used for cooling the first and as complementary units the second. Moreover, dwellings that have installed A/A splits and biomass have probably installed also another heating technologies, overlapping the Mm² heated.

Table 9 Matrix of heating appliances and building stock in Portugal (Number of units installed, estimation)

PORTUGAL	SFH	MFH-A	MFH-C (dwellings)	MFH-C (units)
Condensing gas boilers	230,493	-186,899		
Non-Condensing gas boilers	2,207,160	-1,789,710		
Condensing oil boilers	2,109			
Non-Condensing oil boilers	18,983			
Coal boilers	5,000			
A/A Heat Pumps	41,531	41,531	1,255,029	8,215
A/W Heat Pumps	3,319		50,146	328
W/W Heat Pumps	2,748		41,524	272
Biomass	8,368			
Electric heating	213,323	213,323		
Tot.	**2,733,034**	**(254,854)** **-1,721,755**	**1,346,699**	**8,815**

Table 10 Matrix of heating appliances and building stock in Portugal (Number of units installed, corrected estimation)

PORTUGAL	SFH	MFH-A	MFH-C (dwellings)	MFH-C (units)
Condensing gas boilers	129,032	-85,438		

a more realistic number of dwellings hated by these technologies, we divided the number of dwellings by the average number of rooms per dwelling. Even if not totally correct methodologically, we obtained a more reliable number of dwellings heated by heat pumps and biomass appliances.

PORTUGAL	SFH	MFH-A	MFH-C (dwellings)	MFH-C (units)
Non-Condensing gas boilers	145,159	-101,565		
Condensing oil boilers	1,390,013	-972,563		
Condensing oil boilers	2,109			
Non-Condensing oil boilers	18,983			
Coal boilers	5,000			
A/A Heat Pumps	159,222	159,222	1,421,222	8,215
A/W Heat Pumps	8,361		56,786	328
W/W Heat Pumps	5,489		47,023	272
Biomass	785,375			
Electric heating	213,323	213,323		
Tot.	**2,733,034**	**(372,545)** **701,583**	**1,525,031**	**8,815**

5.2 Water Heating

5.2.1 Units installed

In Portugal there are 5.4M water heaters installed: 4.2M gas instantaneous water heaters, 930 thousand electric storage water heaters, 200 thousand solar thermal DHW systems, 34 thousand gas storage water heaters, 2,400 heat pumps and 1,000 Electric Instantaneous Water Heaters (EIWH) (Figure 29).

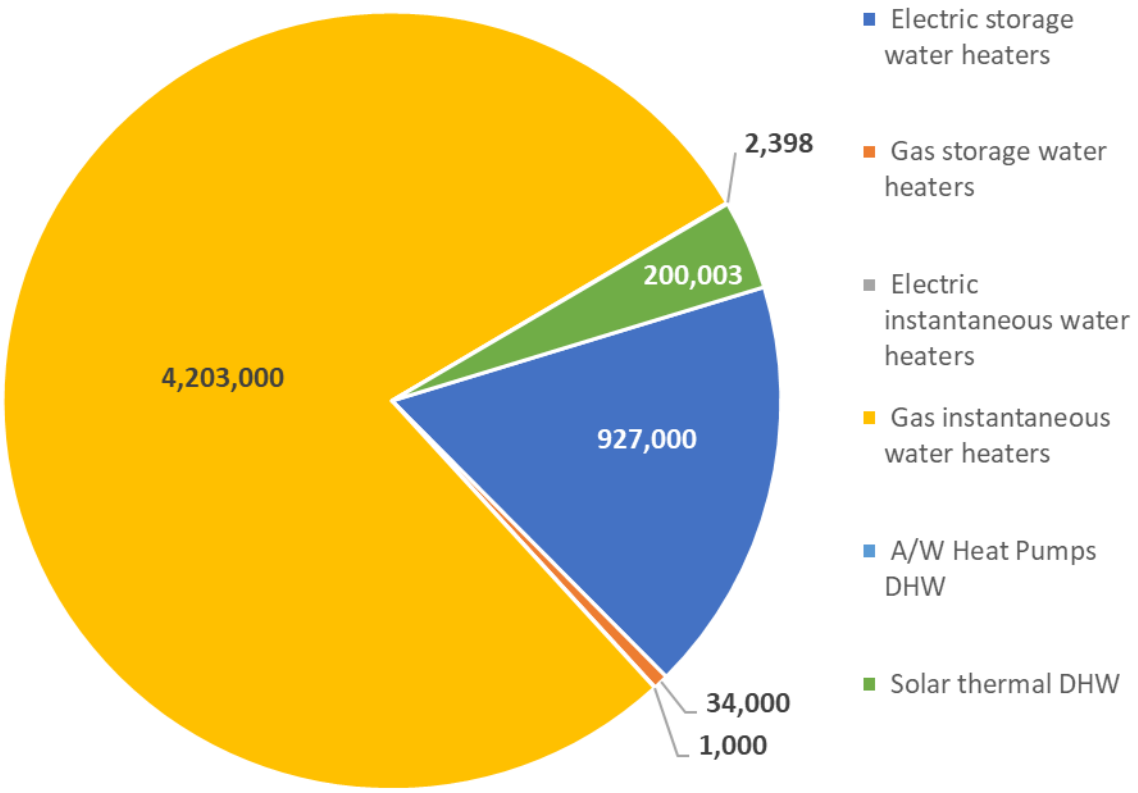

Figure 29 Water heating units installed in Portugal in 2017

5.2.2 Overall thermal capacity installed and final energy consumption

There are 82 GW of water heating thermal capacity installed in Portugal (Figure 30): 96% are gas water heaters (79 GW), followed by electric water heaters (2.3 GW), solar thermal systems (0.7 GW) and heat pumps (10 MW).

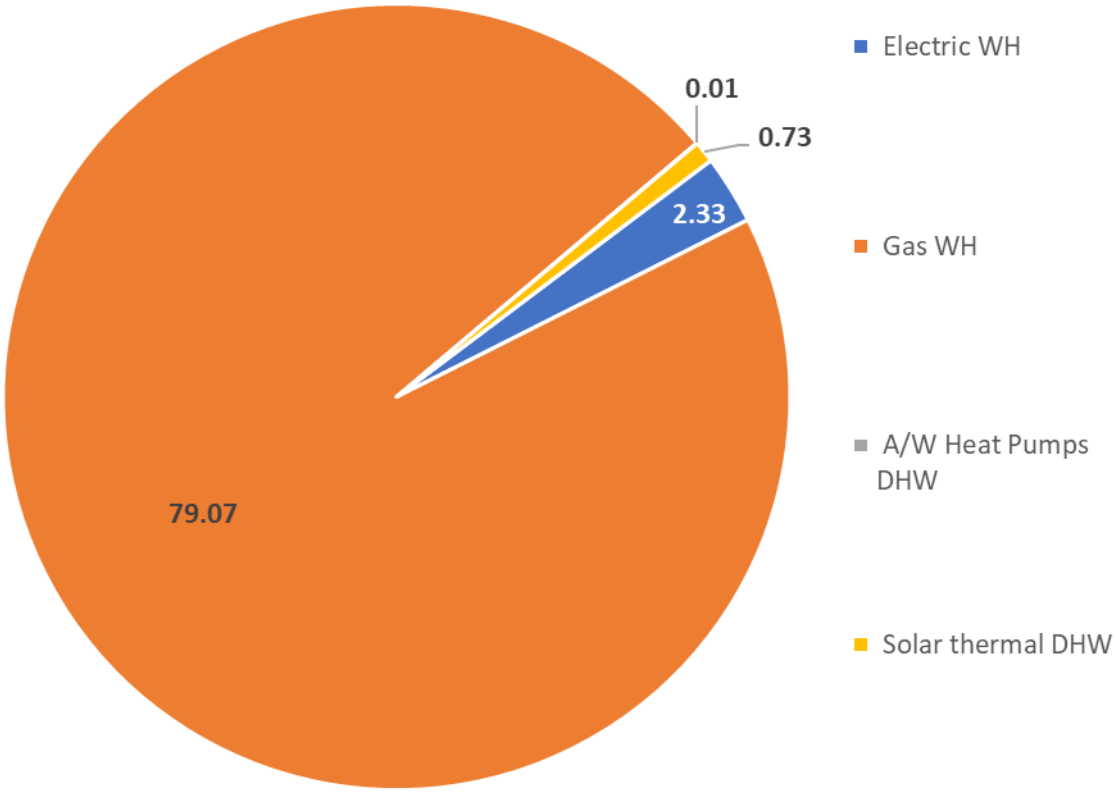

Figure 30 Water heating overall installed capacity in Portugal in 2017 [GW]

Final energy consumption amounts to 3 TWh: 2 TWh are consumed by gas water heating, 0.6 TWh are produced by solar thermal systems, 0.3 TWh are consumed by electric water heaters and 100 MWh are produced by heat pumps (Figure 31)

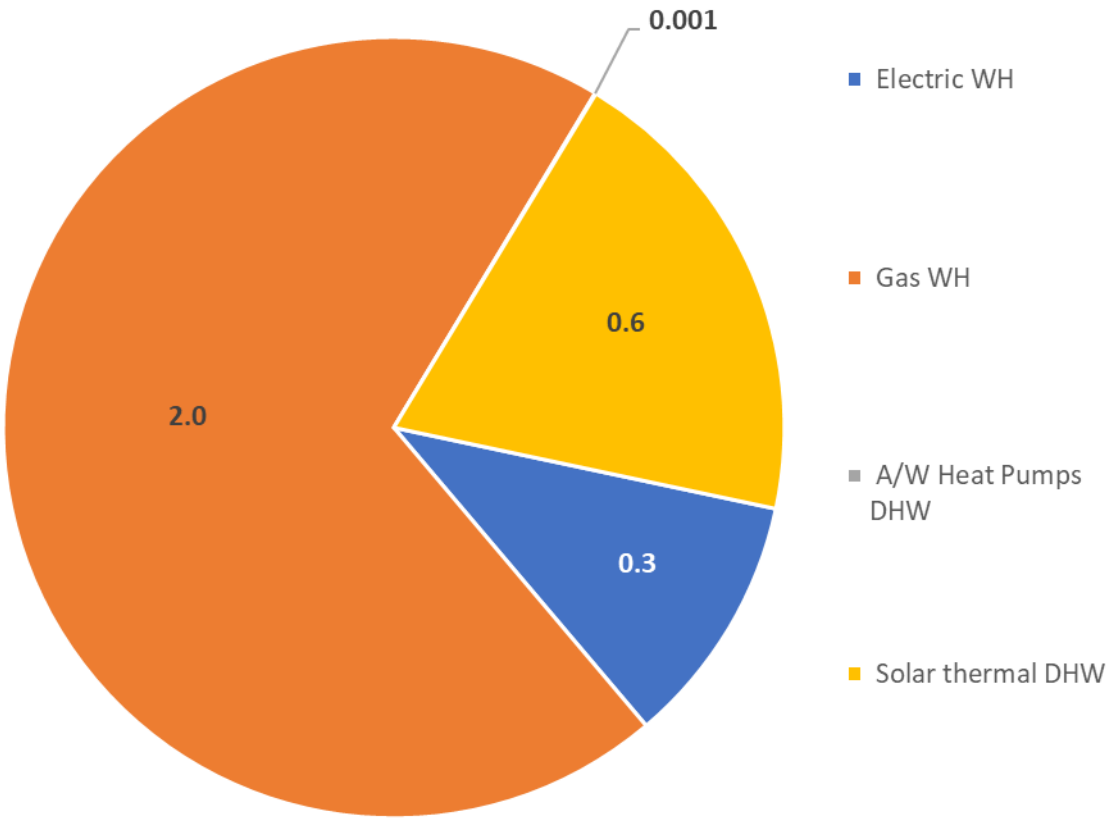

Figure 31 Water heating final energy consumption in Portugal in 2017 [TWh]

5.2.3 Building stock and water heating appliances

In Portugal, 78% of the dwellings are heated, while 771 thousand SFH and 535 MFH dwellings are not. These 1.3M dwellings are equipped with a water heating unit, covering 24% the whole installed stock of water heaters.

The remaining 4.1M have both a space heating and a water heating appliance installed.

6 Spain

The population of Spain is 46.7M people. There are 26.6M dwellings, 7.8M SFH and 18.8M dwellings in MFH (European Commission, 2019). (Table 21 in Annex)

The average surface of a dwelling in both SFH and MFH is 64 m², with and average number of 5.1 rooms per unit (Table 24 and Table 27 in Annex) (European Commission, 2019)) (The Hague: Ministry of the Interior and Kingdom Relations, 2010).

81% of the floor area is heated, corresponding to 21.4M dwellings: 6.3 SFH and 15.2M dwellings in MFHs (BSRIA, 2014).(Table 25 and Table 21 in Annex)

48.9% of the stock of dwellings has been constructed before 1980: most of the buildings in Spain have been constructed after 1980, with an acceleration in the decade 2000-2010 (Table 1).

6.1 Domestic hot water and space heating

6.1.1 Units installed

The number of space heating units installed in Spain are 18.6M: 14.6M are installed in autonomous heating systems, while 4M are in centralised systems (Figure 32).

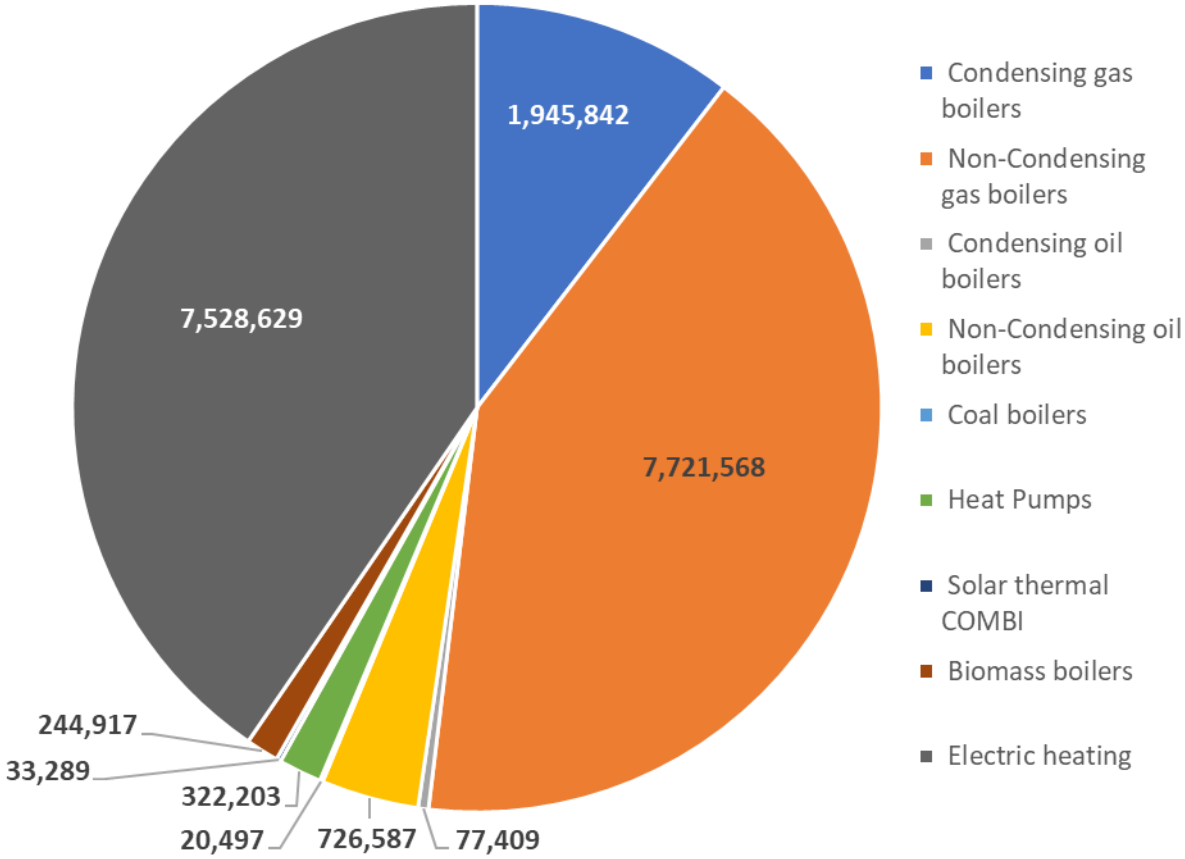

Figure 32 Space heating combi/space heating units installed in Spain in 2017

Gas boilers are the most common technology installed in the building stock of Spain: 9.7M. Almost 90% are installed in autonomous systems: 20% are condensing while 80% non-condensing.

Electric heating is also very common in Spain, with more than 7.5M units installed, 65% in SFH and MFH-A.

800 thousand oil boilers are installed, 90% of them are non-condensing.

The most popular renewable energy technologies are heat pumps and biomass boilers, 322 thousand and 245 thousand units installed, respectively.

Coal boilers and solar thermal combi systems complete the chart with 33 thousand and 21 thousand systems/units installed.

6.1.2 Overall thermal capacity installed and final energy consumption

The number of units installed influences the installed thermal capacity of the technologies analysed. The total installed capacity in Spain is 650 GW.

Non-condensing boilers have 342.4 GW installed, more than 50% of the total installed capacity, that summed with condensing gas boilers technology represents 65% of the total installed capacity in Spain.

Electric heating installed capacity is 185 GW: electric heating and gas/oil boilers represent 99% of the installed capacity in Spain.

The remaining 1% is shared by heat pumps (3.6 GW), biomass (2.9 GW), coal boilers (1 GW) and solar thermal systems (0.2 GW).

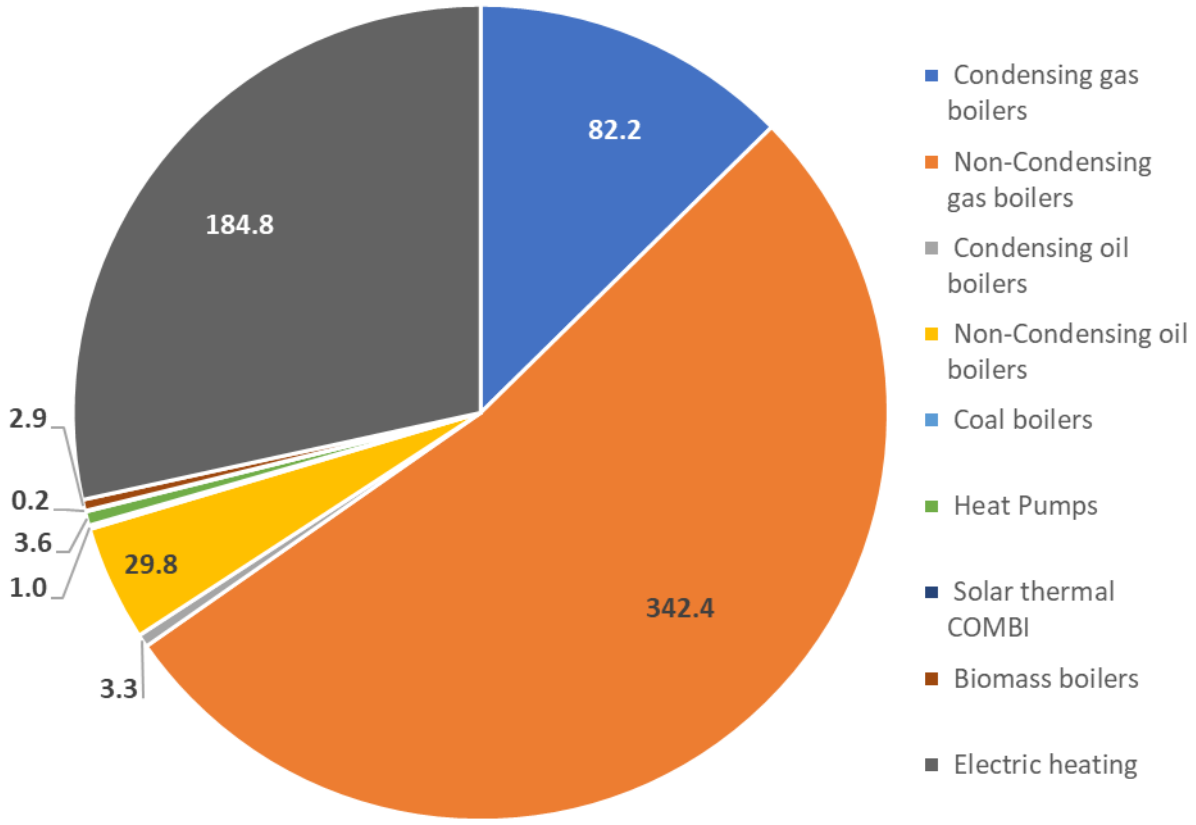

Figure 33 Space heating combi/space heating overall thermal capacity installed in Spain in 2017 [GW]

In 2017 in Spain the total final energy consumption was 79.4 GW (Eurostat, 2017): our calculations say 80 TWh[24].

Fossil fuels boilers final energy consumption is 45.7 TWh: 57% of the entire energy consumption in Spain. The main share is represented by NC oil boilers (20.3 TWh) and NC gas boilers (18.7 TWh), followed by condensing gas boilers (3.6 TWh), condensing oil boilers (1.8 TWh) and coal boilers (1.3 TWh). (Figure 34).

Biomass is the first technology in consumption, with 28.3 TWh (32% of total).

The remaining share is completed by electric heating (5.2 TWh), heat pumps (0.8 TWh) and solar thermal systems (0.2 TWh).

[24] We added heat pumps final energy consumption.

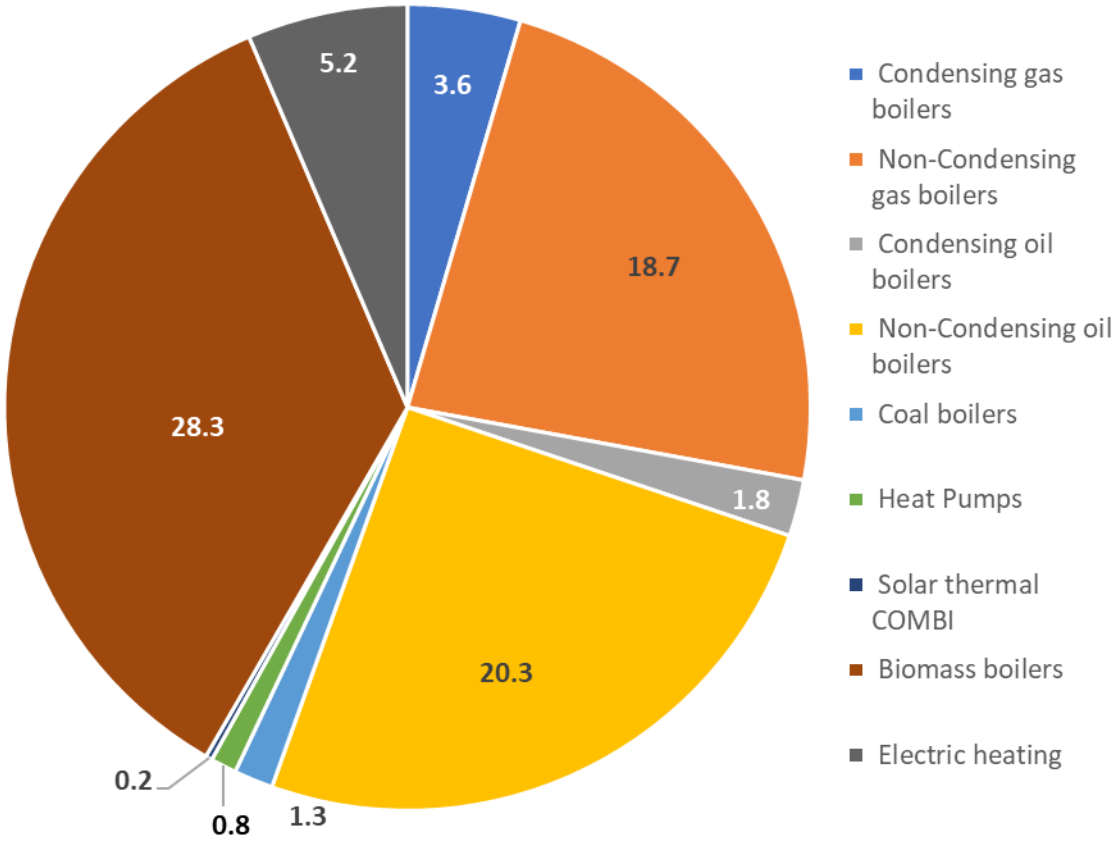

Figure 34 Space heating combi/space final energy consumption in Spain in 2017 [TWh]

6.1.3 Heated living area

The heated living area reflects the final energy consumption (see Figure 35)

In Spain the space heating energy consumption is 40 kWh/m²/yr and heated surface is 81% of the total floor space area, 1,961Mm² out of 2,434[25] Mm².

Our estimation is 1,979 Mm² heated: biomass covers 35% of the total heated floor in Spain. Since we counted only 250 thousand biomass boilers, we tried to estimate the number of biomass stoves (that are not primary heating devices) in the country using the average size of dwellings (See Table 24 in Annex).

We calculated that there are 6.7M biomass stoves in operation. As for the other chapters, these units are not counted in our extrapolation, because they are considered as complementary heating devices (they generally only heat a room) and not the main heating system.

[25] Inspire project calculations.

Because of their complementary heating purpose, it is possible that biomass stoves double count the heated surface: e.g. in a house that has a gas boiler and a biomass stove, the heated surface of biomass and of gas are overlapping.

Moreover, air-to-air heat pumps such as splits are mainly used for cooling, but during winter (the reversible models) are used for space heating. These units are not fully calculated in our database, because according to the European Heat Pumps Associations (EHPA) these units cannot be counted as heat pumps, but only as air conditioners.

Fossil fuels boilers' heated surface is 57% of the total: NC oil boilers and gas boilers heat respectively 501 and 462.7 Mm². They are followed by condensing gas boilers (89.6 Mm²), condensing oil boilers (44.9 Mm²) and coal boilers (31.1 Mm²).

Heat pumps occupy a surface of 19.8 Mm², while solar thermal combi systems 5.3 Mm².

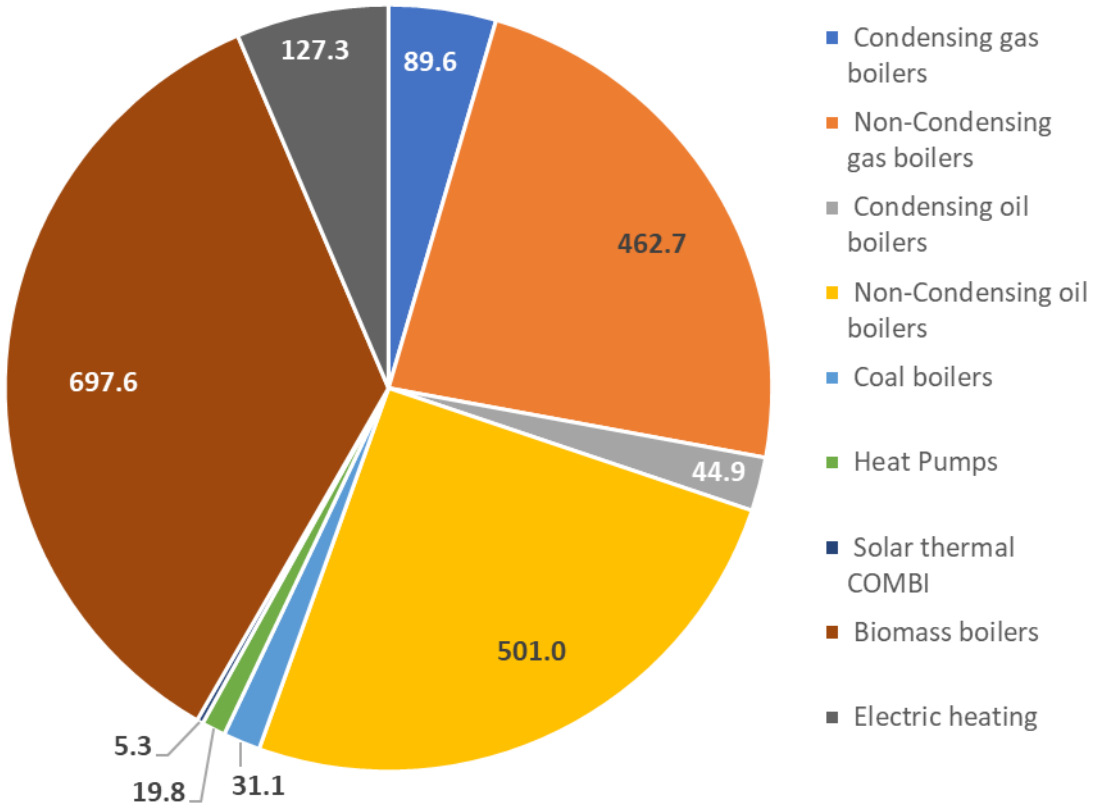

Figure 35 Space heating combi/space heating heated living area in Spain in 2017 [Mm²]

6.1.4 Building stock and heating appliances

In Spain, 79% of the units installed are autonomous heating, corresponding to 36% of the installed capacity, 48% of the final energy consumption and 48% of the heated living area (Figure 36).

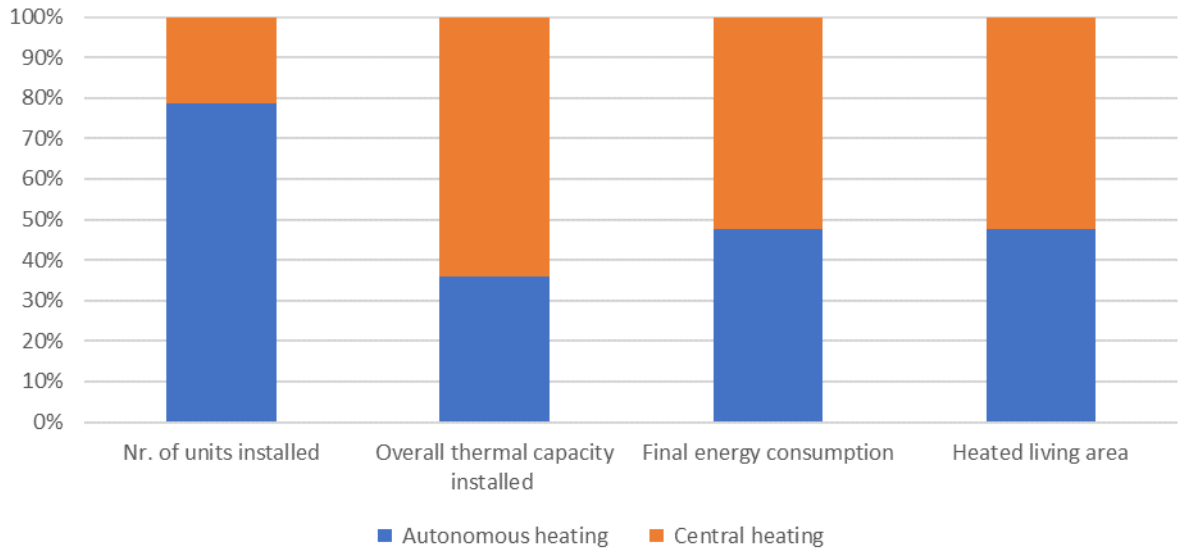

Figure 36 Share of autonomous/central heating units installed, overall thermal capacity installed, final energy consumption and heated living area in Spain in 2017

In Spain there are 7.6 million SFH and 18.8M are MFH dwellings, for a total of 26.6M : 81% of the total floor space is heated, corresponding to 6.3M SFH and 15.2M MFH dwellings (See Table 21 in Annex).

The average square meters per dwelling: in Spain the average is 64 m² for both SFHs and MFH (Table 24 in Annex).

According to Figure 32, there are 18.6 million heating appliances installed in Spain.

Almost 4M are central heating appliances in MFH-C, that installed mainly centralised electric heating and fossil fuels boilers. The remaining 14.6 million are autonomous heating appliances: SFH and MFH-A (Table 11).

Table 11 Number of heating appliances installed in Spain (database)

SPAIN	Autonomous heating (SFH + MFH-A)	Central heating (MFH-C)	Total
Condensing gas boilers	1,201,082	744,760	1,945,842
Non-Condensing gas boilers	7,480,276	241,292	7,721,568

SPAIN	Autonomous heating (SFH + MFH-A)	Central heating (MFH-C)	Total
Condensing oil boilers	47,504	29,905	77,409
Non-Condensing oil boilers	427,537	299,050	726,587
Coal boilers	11,605	8,892	20,497
Heat pumps	272,775	49,428	322,203
Solar thermal COMBI	33,289		33,289
Biomass boilers	233,551	11,366	244,917
Electric heating	4,918,662	2,609,967	7,528,629
Total	**14,626,282**	**3,994,660**	**18,620,942**

Considering the assumptions made in Paragraph 12.3 and Table 26 in

Methodology, we calculated that the sum of all the technologies exclusively installed in SFH is 1.3M units; therefore, the remaining part (5.1M) should be gas heated.

Considering the same share of condensing/non condensing units installed (14% condensing boilers) the total of condensing gas boilers installed in SFHs in Spain is 700 thousand, while 4.4M are non-condensing (Table 12).

In order to determine the share of MFH-A and MFH-C dwellings, we summed the part of the autonomous gas boilers not installed in SFH with the technologies calculated for MFH-A.

Since there are 15.1M MFH heated dwellings in Spain and the sum of the calculations for MFH-A was 4.2M units, the remaining share of MFH (10.9M) should be MFH-C dwelling.

The average of dwellings for MFH-C is 3 per building[26].

[26] The effective number of biomass heating appliances, electric heaters and A/A heat pumps that are mainly used for air conditioning are difficult to calculate. For this reason, the number of dwellings per MFH resulted lower as expected.

Table 12 Matrix of heating appliances and building stock in Spain (Number of units installed, estimation)

SPAIN	SFH	MFH-A	MFH-C (dwellings)	MFH-C (units)
Condensing gas boilers	708,966	492,117	2,046,050	744,760
Non-Condensing gas boilers	4,415,400	3,064,876	662,891	241,292
Condensing oil boilers	47,504		82,157	29,905
Non-Condensing oil boilers	427,537		821,568	299,050
Coal boilers	11,605		24,429	8,892
A/A Heat Pumps	127,605	127,605	123,729	45,037
A/W Heat Pumps	16,650		11,435	4,162
W/W Heat Pumps	915		629	229
Biomass	15,754	11,366	31,225	11,366
Electric heating	482,222	482,222	7,170,260	2,609,967
Total	**6,254,158**	**4,178,185**	**10,974,372**	**3,994,660**

6.2 Water Heating

6.2.1 Units installed

Spain has 14,6 million water heaters installed: 57% of the entire dwellings stock in Spain (25,6M) is provided with a water heating unit (Figure 37).

The stock is divided almost equally in electric storage water heaters (50% of the total WHs) and gas instantaneous water heaters (46%).

The remaining 4% is occupied by 450 thousand solar thermal DHW systems, 115 thousand gas storage water heaters and 2,200 DHW heat pumps.

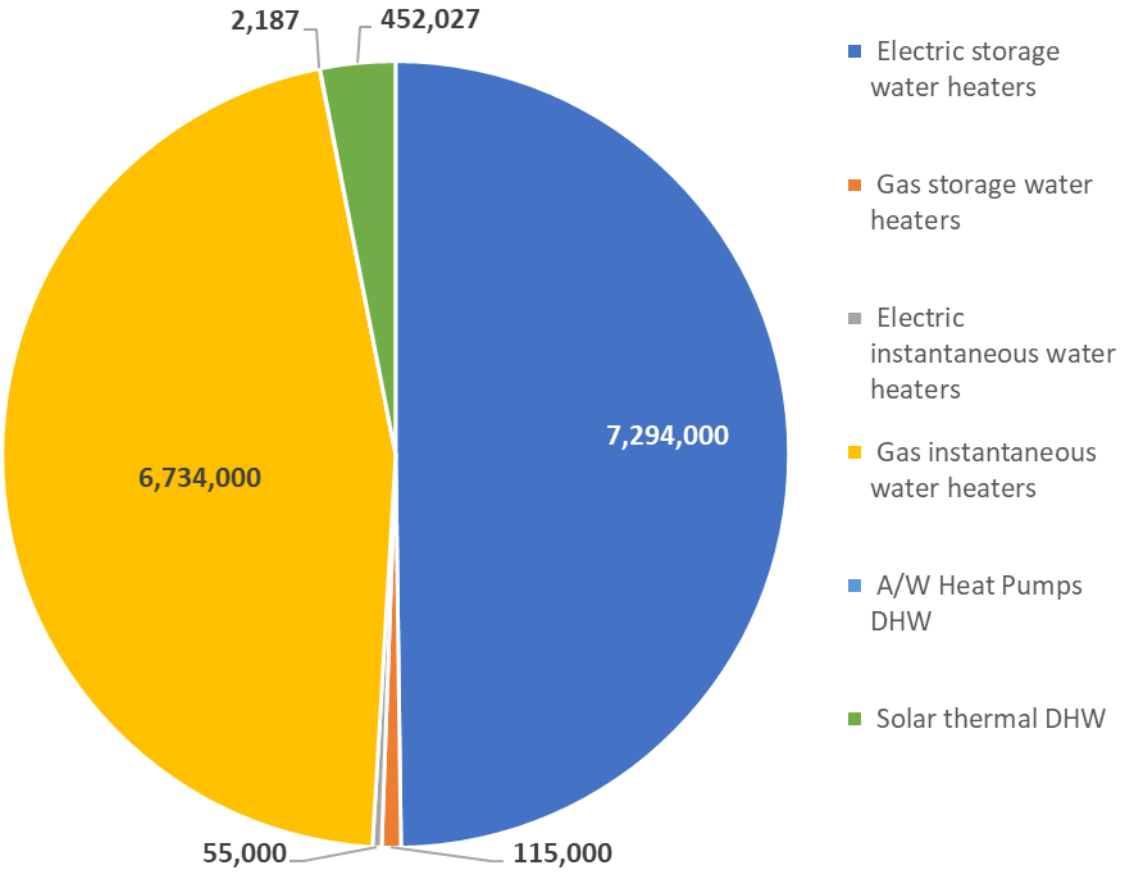

Figure 37 Water heating units installed in Spain in 2017

6.2.2 Overall thermal capacity installed and final energy consumption

According to our extrapolations, the installed capacity is Spain for water heating is 149 GW: 86% is represented by gas water heaters (127 GW), 13% by electric water heaters (19 GW) and the remaining 1.7% by solar thermal (2.5 GW) and heat pumps systems (30 MW) (Figure 38).

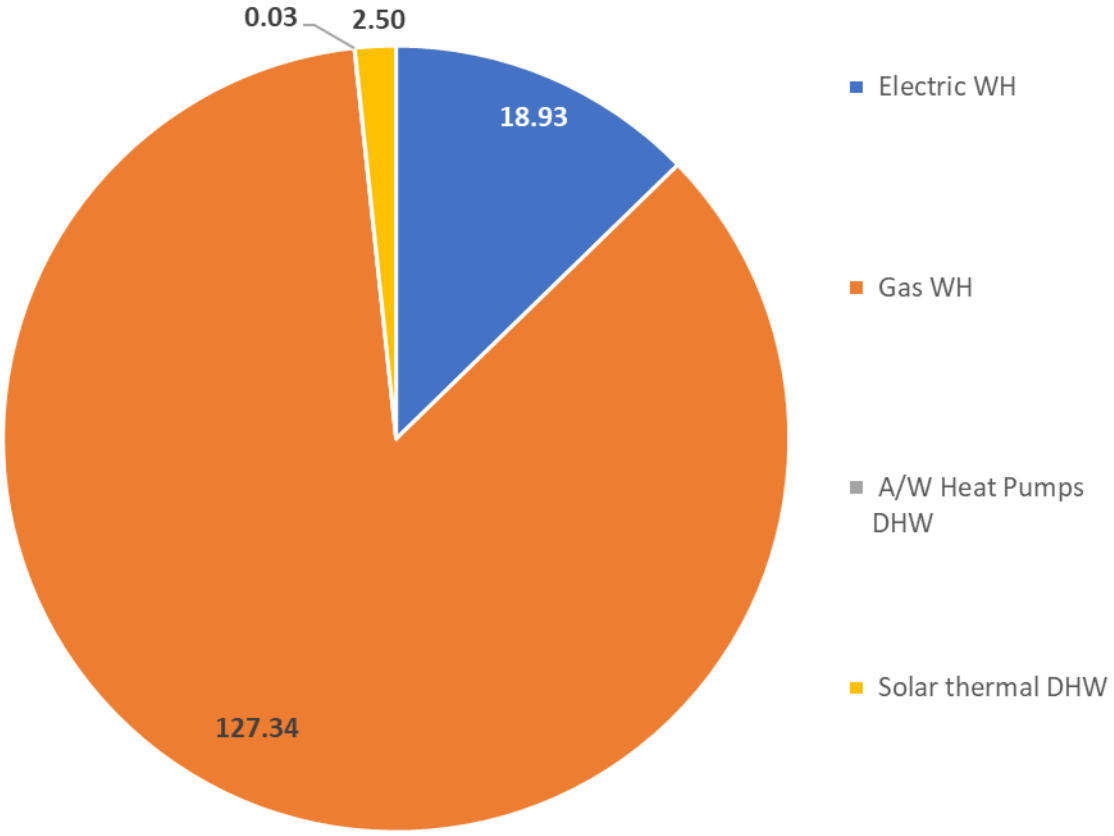

Figure 38 Water heating overall installed capacity in Spain in 2017 [GW]

Final energy consumption was provided by Eurostat (Eurostat, 2017): Spain consumed 35.8 TWh in 2017 for water heating. In our calculations we only considered the water heating consumptions related to gas, electricity, solar thermal and heat pumps, which we calculated as 28.6 TWh. Biomass and solid fossil fuels water heaters have not been taken into consideration.

The main part was provided by gas: 20.7 TWh, corresponding to 72% of the WH consumption, electric represents 18% (5.3 TWh), followed by solar thermal with 9% (2.7 TWh). The remaining share is represented by A/W heat pumps water heaters with 200 MWh (Figure 39).

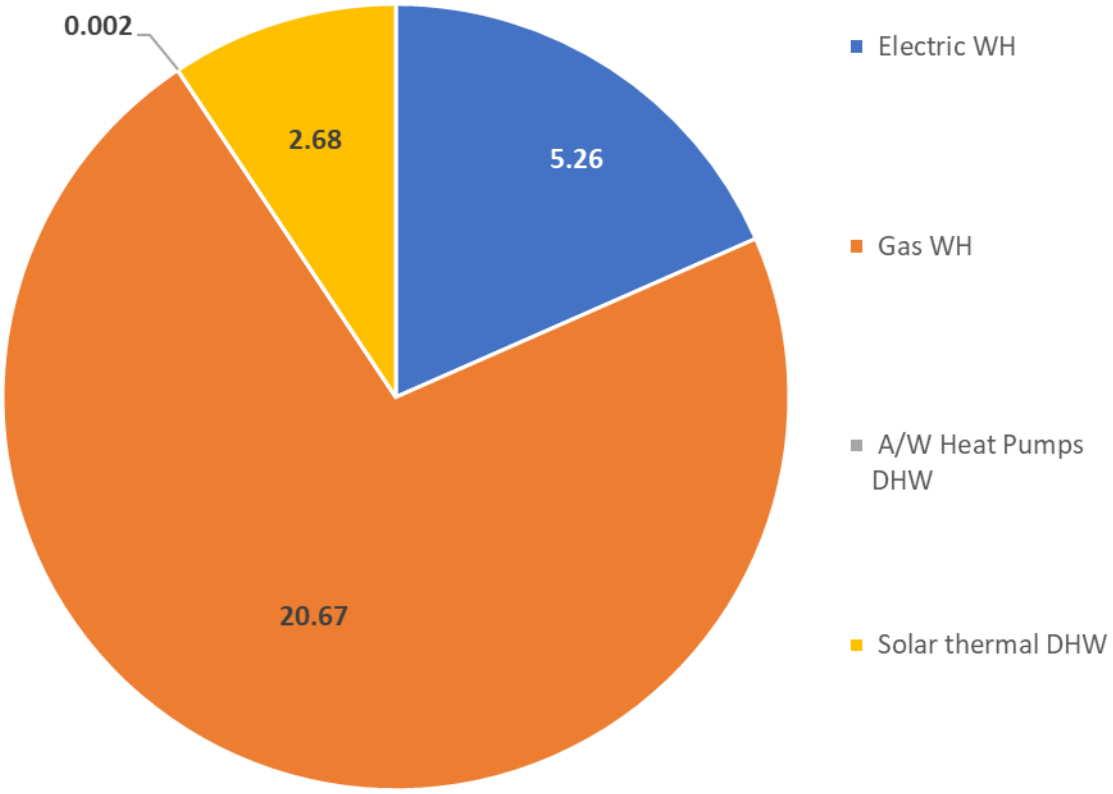

Figure 39 Water heating final energy consumption in Spain in 2017 [TWh]

6.2.3 Building stock and water heating appliances

The unheated dwelling stock in Spain is 19% of the total floor, corresponding to 5.16M dwellings.

1.5M SFHs and 3.7M unheated dwellings in MFHs absorb one part of the installed water heaters stock, while the remaining 9.5M units are installed in dwellings that already have a space heating system: 38,720 in centralised water heating systems and the rest in MFH dwellings.

7 European Union

The European Union has currently 28 member states, with 512.4 M citizens.

The total surface of residential floor is 22.7 billion m², 86% heated (19.5 billion m²).

The number of dwellings is 250M: almost equally divided into SFH (125M) and MFH dwellings (123M)[27] (European Commission, 2019). (Table 21 in Annex)

Heated SFH correspond to 107.5M and heated MFH dwellings are 105.8M (BSRIA, 2014).(Table 25 and Table 22 in Annex).

The average square meter surface for a SFH in is 91 m², while a dwelling in a MFH has an average of 66 m² (European Commission, 2019). (Table 24 in Annex)

The average number of rooms per dwelling is 4 (The Hague: Ministry of the Interior and Kingdom Relations, 2010). (Table 27 in Annex)

64,9% of the stock of dwellings is has been constructed before 1980 and 22,7% are prior to 1945. Only 3.7% of the stock has been constructed after 2010 (Table 1).

7.1 Domestic hot water and space heating

7.1.1 Units installed

The total number of heating appliances in the European Union is 160.5M units (Figure 40).

121M units are fossil fuels boilers, representing 76% of the entire stock.

Gas boilers are the most common installed technology with 92.4M units (58% of the total stock), oil boilers are 18.5M, while coal boilers are 10.4M.

The share of condensing gas boilers is 49% (51% NC) and condensing oil boilers are 8% (92% NC).

Electric heaters are 25M units, while renewables are represented by heat pumps with 8.3M units, biomass boilers (4.7M) and solar thermal systems (1.2M).

[27] The Building Stock Observatory does not provide data regarding Austria division between SFH and MFH. For this reason, the sum of SFH+MFH does not correspond to the total number of dwellings in EU28.

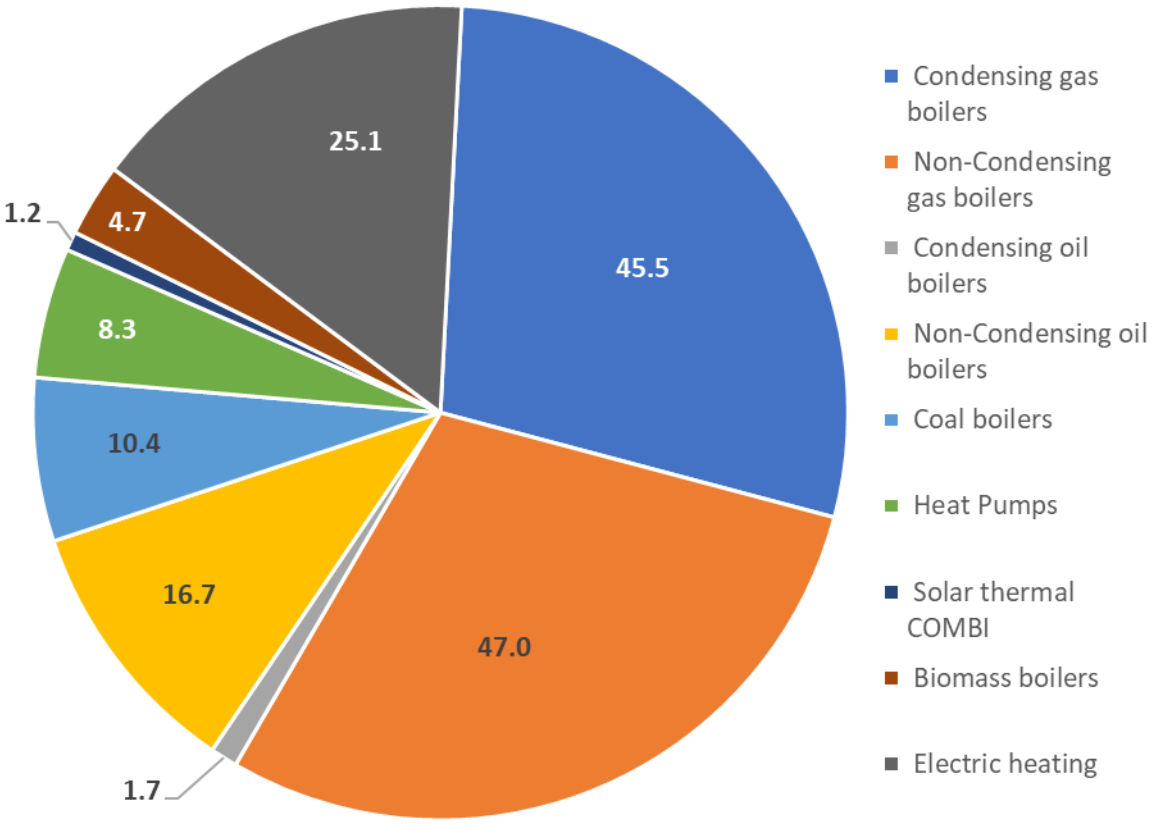

Figure 40 Space heating combi/space heating units installed in the EU in 2017

7.1.2 Overall thermal capacity installed and final energy consumption

The total installed energy capacity in the EU is 4.66 TW (Figure 41). (Eurostat, 2017)

Fossil fuels boilers cover 83% of the entire installed capacity: 3.1 TW gas boilers, 681 GW oil boilers and 114 GW coal boilers.

The remaining share is covered by electric heating with 333 GW, district heating with 318 GW, heat pumps with 100 GW, biomass boilers with 48 GW and solar thermal systems with 10 GW.

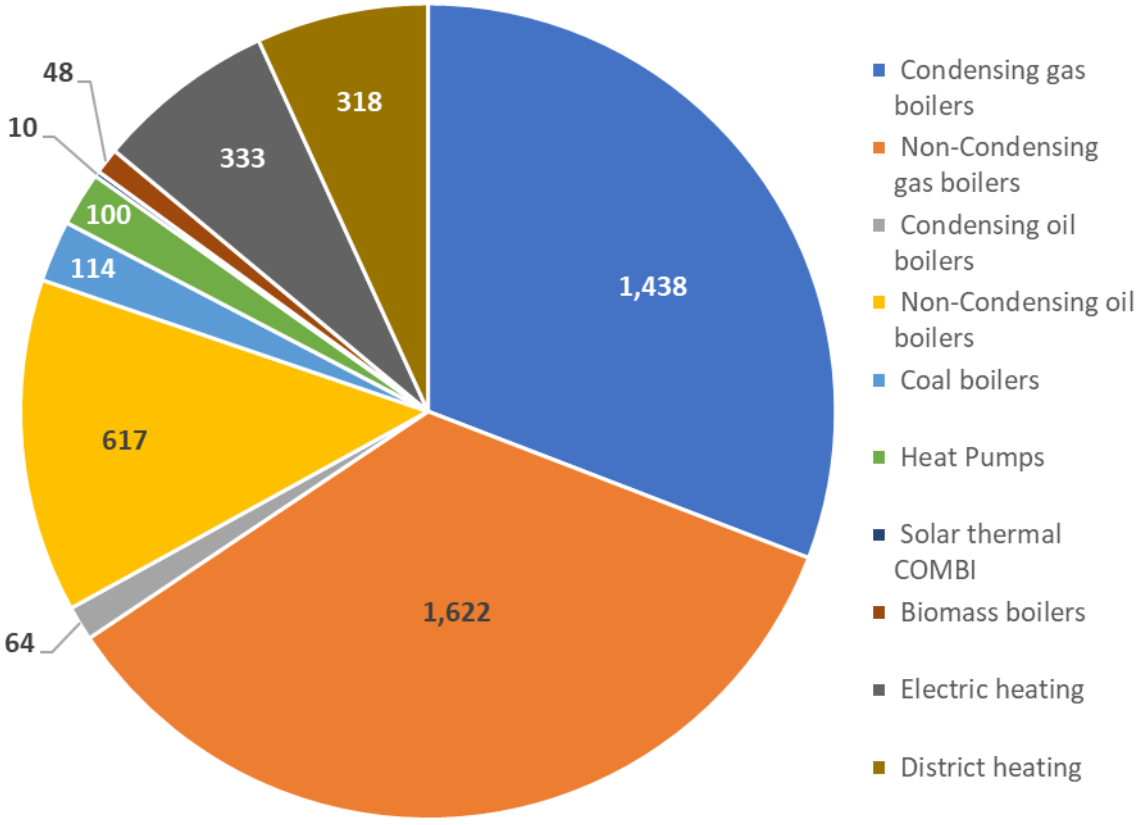

Figure 41 Space heating combi/space heating overall installed capacity in the EU in 2017 [GW]

Final energy consumption in EU in 2017 was 2,316 TWh: the consumption calculated by us is 2,346 TWh, because it takes into consideration also heat pumps.

64% of the total consumption comes from fossil fuels boilers: 1,012 TWh gas boilers, 304 TWh oil boilers and 188 TWh coal boilers.

Biomass final energy consumption is 440 TWh, followed by district heating (257 TWh), electric heating (114 TWh), heat pumps (28 TWh) and solar thermal systems with 3 TWh.

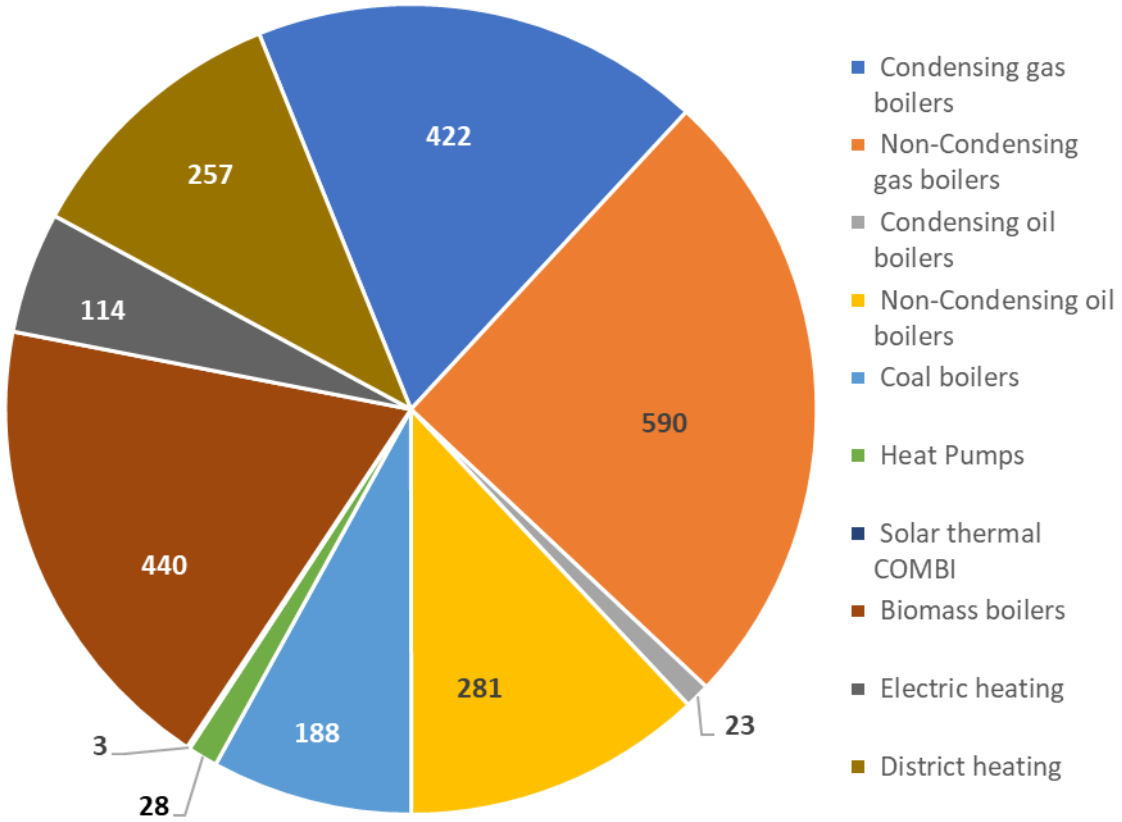

Figure 42 Space heating combi/space heating final energy consumption in the EU in 2017 [TWh]

7.1.3 Heated living area

The total calculated heated residential floor in the EU is 19 billion m² (Figure 43).

The division between technologies of the heated area reflects the final energy consumption: fossil fuels boilers are leading with 12.7 billion m² (8.5 Bm² gas boilers, 2.6 Bm² oil boilers and 1.5 Bm² coal boilers), followed by biomass (3.7 Bm²), district heating (1.7 Bm²), electric heating (956 Mm²) heat pumps (205 Mm²), and solar thermal systems (22 Mm²).

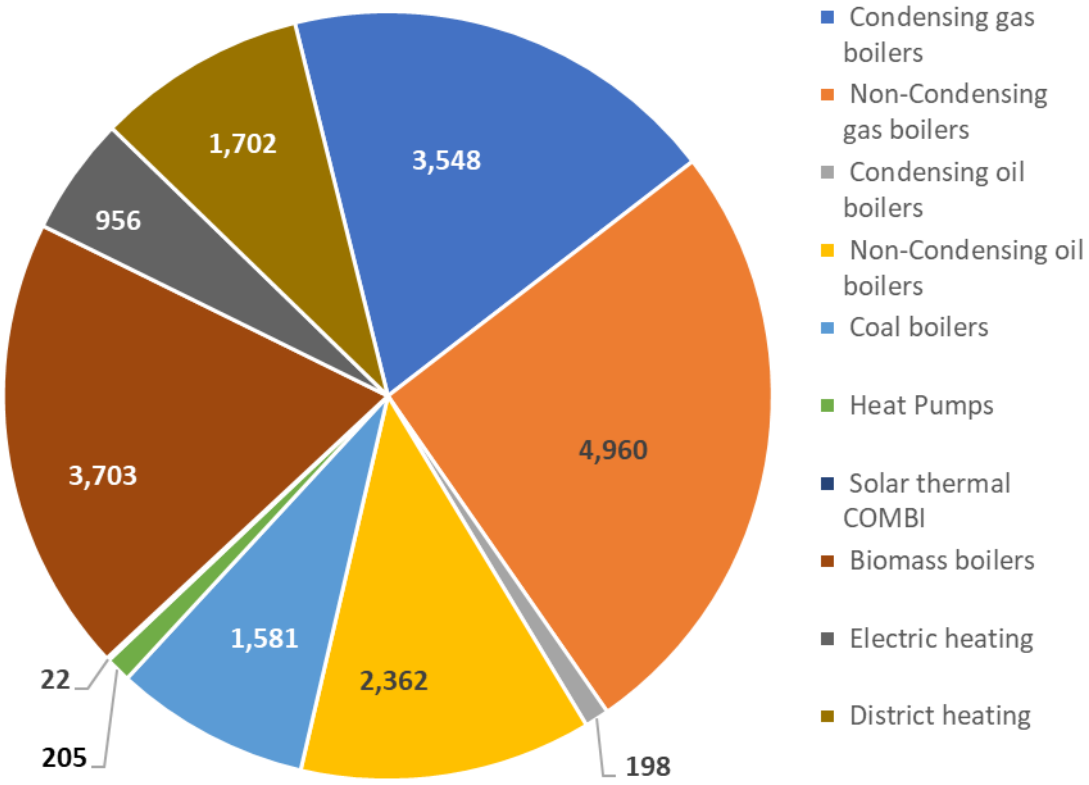

Figure 43 Space heating combi/space heating heated living area in the EU in 2017 [Mm²]

7.1.4 Building stock and heating appliances

According to Figure 44, in the EU 83% of the installed units are autonomous, corresponding to 60% of the installed capacity, 68% of final energy consumption and 67% of the heated living area.

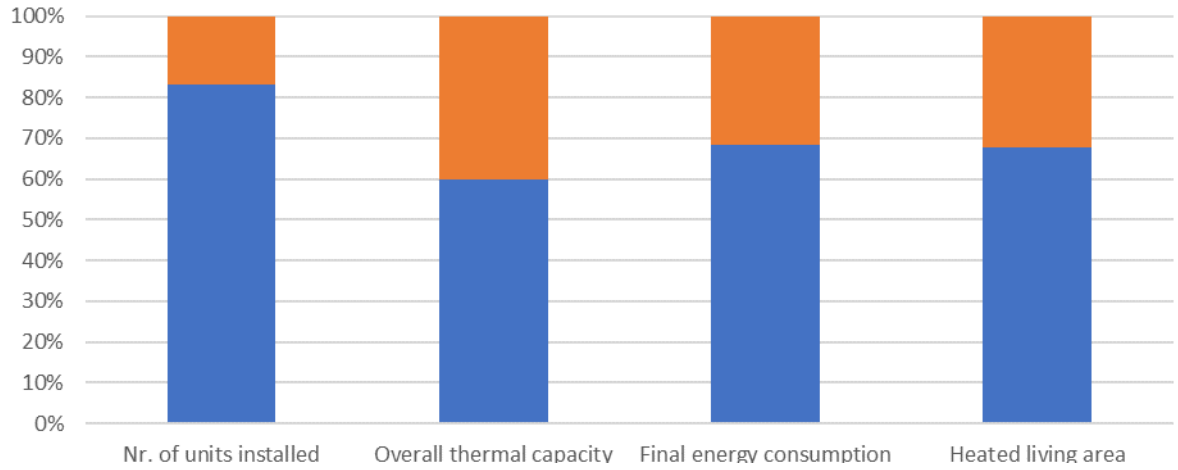

Figure 44 Share of autonomous/central heating units installed, overall thermal capacity installed, final energy consumption and heated living area in the EU in 2017

The residential floor in the EU is 19.6 Bm²: 11.4 Bm² SFH and 8.2 Bm² MFH (Table 22 in Annex) and there are 125M SFHs and 123M MFH dwellings (Table 21in Annex).

We calculated the matrix of the heating appliances installed in the EU with the number of heated dwellings (Table 21 in Annex) and the assumption that we made in Paragraph 12.3 and Table 26 in Methodology.

According to Table 13, there are 160.6M heating appliances installed: 26.7M are centralised.

Table 13 Number of heating appliances installed in EU28 (database)

EU28	Autonomous heating (SFH + MFH-A)	Central heating (MFH-C)	Total
Condensing gas boilers	39,641,803	5,808,505	45,450,308
Non-Condensing gas boilers	38,598,028	8,364,916	46,962,944
Condensing oil boilers	1,352,411	384,600	1,737,011
Non-Condensing oil boilers	13,038,995	3,708,037	16,747,033
Coal boilers	3,203,349	7,218,236	10,421,585
Heat pumps	7,551,554	746,857	8,298,411
Solar thermal COMBI	1,202,803		1,202,803
Biomass boilers	4,615,121	47,816	4,662,937
Electric heating	24,607,765	489,757	25,097,522
Total	**133,811,829**	**26,768,724**	**160,580,553**

Using the criteria explained in paragraph 12.3 of Methodology, we proceed in calculating the matrix of heating appliances and building stock of EU28.

The number of heated SFH is 106M (Table 21 in Annex) and the sum of all the technologies except gas boilers for SFH is 40M[28], the remaining part (68M) should be heated with a gas boiler, with a share of condensing gas boilers of 51% over non condensing ones.

[28] Only biomass boilers have been taken into consideration and not stoves. Dwellings heated by electric heaters have been calculated by dividing the number of electric heaters by the average rooms number per dwelling.

Heated dwellings in MFH are 106M: 29M in MFH-A and the remaining 77M in MFH-C, with an average number of 3 dwellings per MFH-C building.

The matrix of the building stock matched with the installed heating appliances can be seen in Table 14.

Table 14 Matrix of heating appliances and building stock in EU28 (estimation)

EU28	SFH	MFH-A	MFH-C (dwellings)	MFH-C (units)
Condensing gas boilers	34,332,394	5,309,408	16,692,058.36	5,808,505
Non-Condensing gas boilers	33,428,417	5,169,611	24,038,487	8,364,916
Condensing oil boilers	1,352,411		1,105,234	384,600
Non-Condensing oil boilers	13,038,995		10,655,888	3,708,037
Coal boilers	3,203,349		20,743,239	7,218,236
A/A Heat Pumps	2,441,418	2,441,418	1,387,774	482,918
A/W Heat Pumps	1,448,493		411,683	143,258
W/W Heat Pumps	1,220,224		346,806	120,682
Biomass	4,615,121		137,410	47,816
Electric heating	3,111,877	3,111,877	1,407,428	489,757
District heating (dwellings)	9,335,462	12,850,381		
Tot.	**107,528,162**	**28,882,696**	**76,926,008**	**26,768,724**

7.2 Water Heating

7.2.1 Units installed

Water heating appliances installed in the EU amount to 93M units: 56.8M ESWH, 17.2 GIWH, 8.3M EIWH, 6.4M solar thermal DWH systems, 3.6M GSWH and 400 thousand heat pumps (Figure 45).

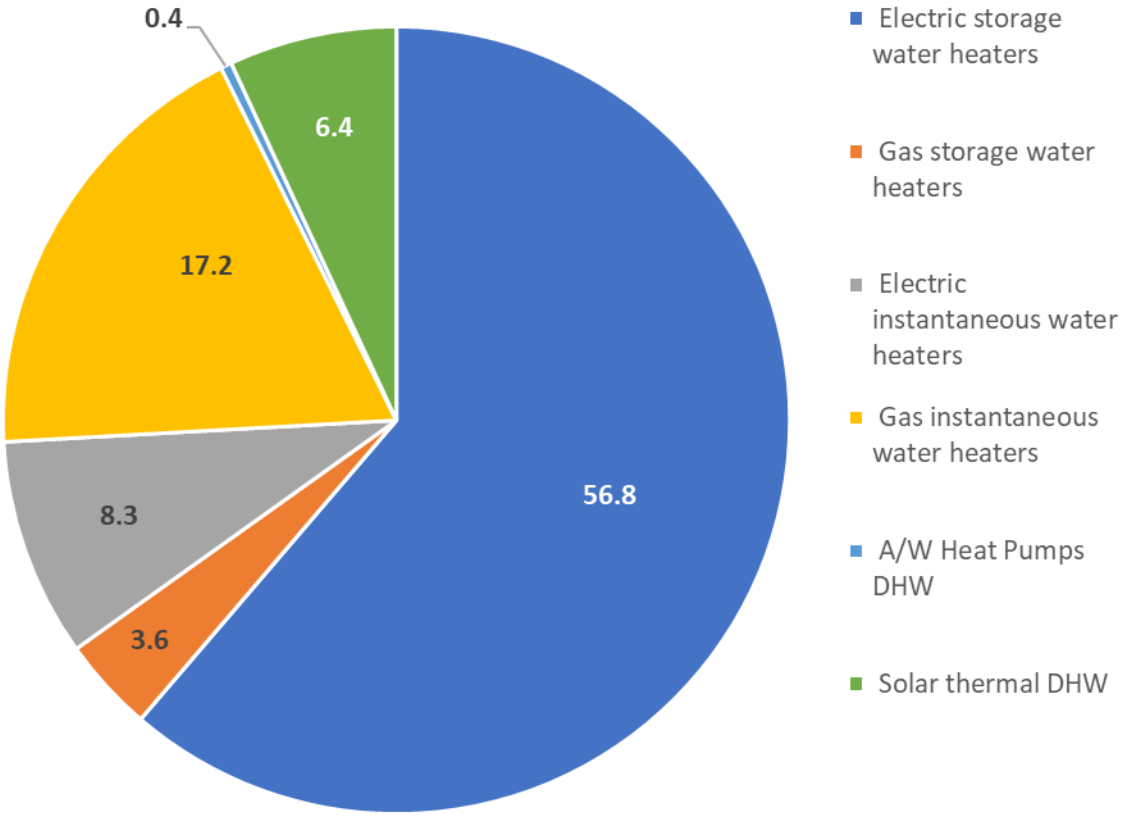

Figure 45 Water heating units installed in the EU in 2017

7.2.2 Overall thermal capacity installed and final energy consumption

The overall thermal capacity installed in EU for water heating is 635 GW (Figure 46).

Gas water heating represents 57% of the overall installed capacity with 360 GW, followed by electric devices with 247 GW (39%). The remaining share is mainly occupied by solar thermal systems with 24.8 GW and heat pumps (2.6 GW).

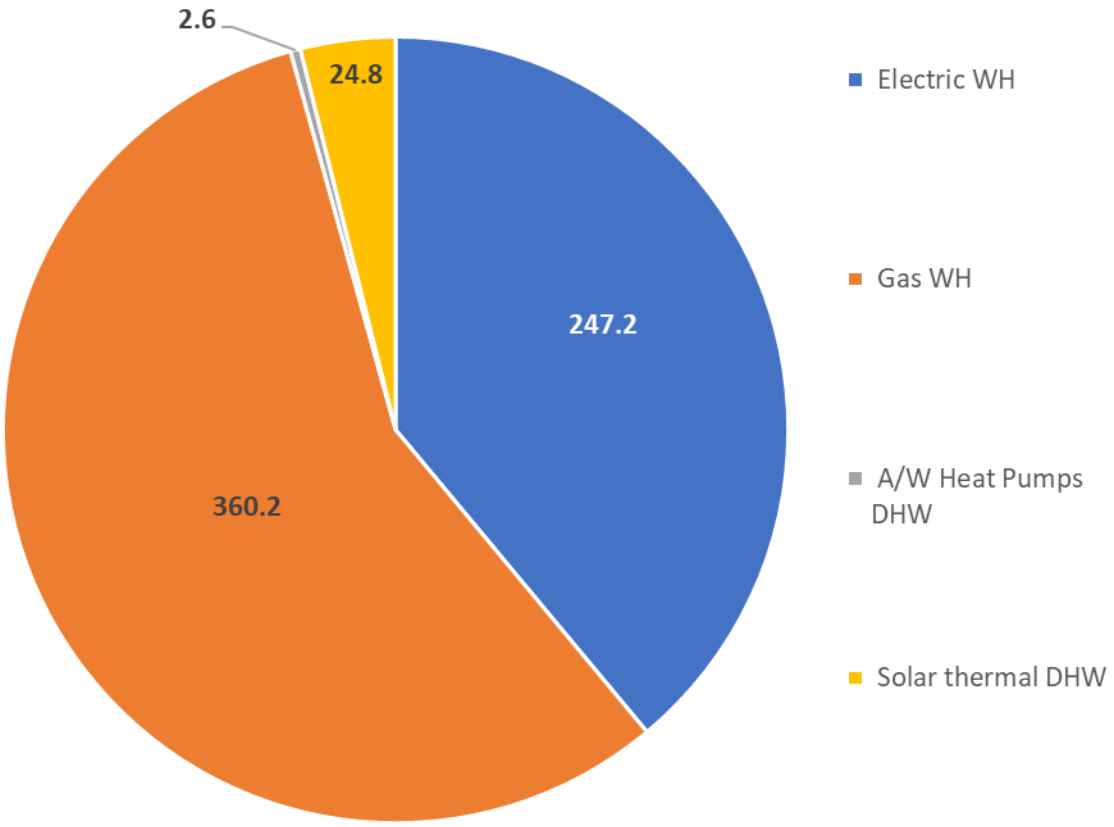

Figure 46 Water heating overall installed capacity in the EU in 2017 [GW]

The total final energy consumption of water heaters in the EU is 370 TWh[29] (Figure 47).

Final energy consumption is mainly gas driven, with 260 TWh consumed, followed by electric heaters (91 TWh), solar thermal systems (19TWh) and heat pumps (0.2 TWh).

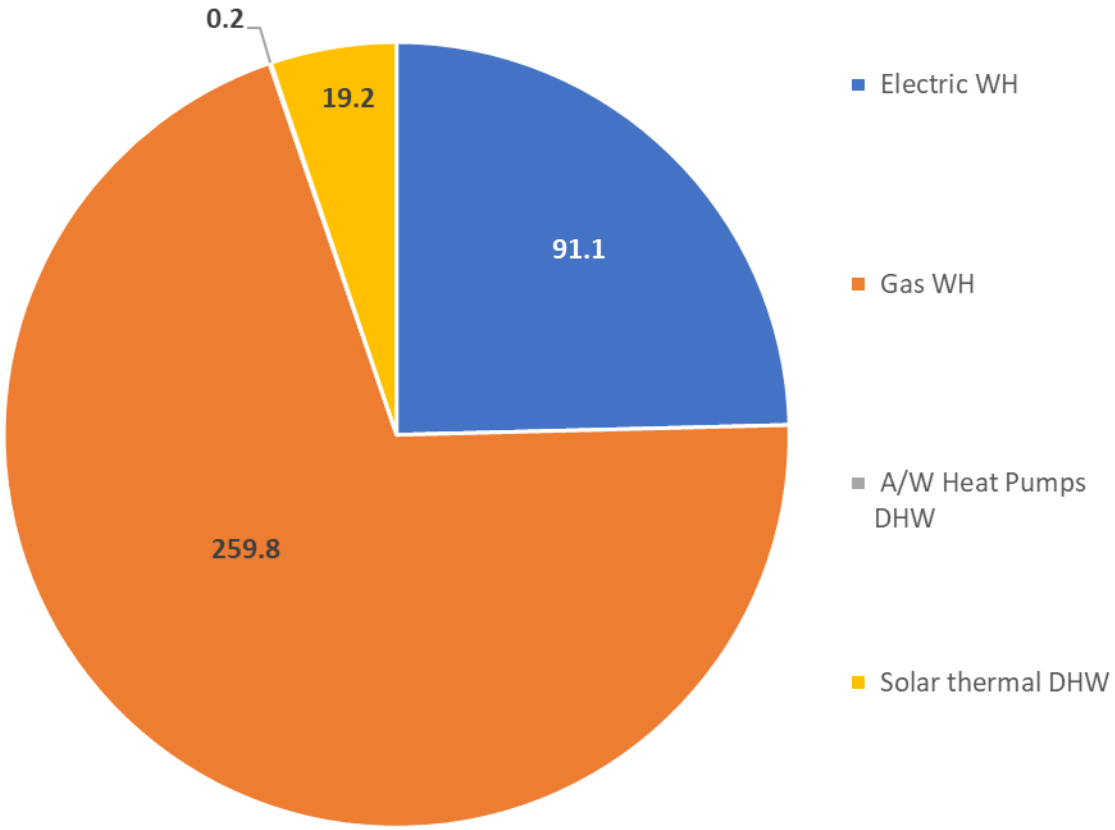

Figure 47 Water heating final energy consumption in the EU in 2017 [TWh]

7.2.3 Building stock and water heating appliances

All unheated dwellings in the EU we suppose that are provided with a water heating unit: (Table 21and Table 25 in Annex): 17.7 SFH and 17.4 dwellings in MFH, for a total of 35.1M units.

These 35.1M dwellings cover 38% of the installed stock of water heaters.

The remaining 57.6M units are installed in dwellings that have also a space heating device installed.

8 Average thermal capacity per unit

According to the existing literature, the association and experts consulted, we tried to build a table with the average thermal capacity per unit of every technology.

[29] District heating is 3.3 TWh, biomass 0.35 TWh and solid fossil fuels 0.54 TWh.

In Table 15 and Table 16 we summarised the data collected.

The bold-red values are directly provided by the associations, while the black values are an average provided by the literature available.

For autonomous heating devices, the range is between 17-37 kW per unit for gas boilers and 18-38 kW for oil boilers (Table 15).

Coal boiler average is 24 kW, while biomass range is 8-135 kW and for electric heating is 1-3 kW.

Heat pumps size for autonomous heating varies from 4 kW to 20 kW, depending the country in which it is installed and the typology of the unit.

Solar thermal combi systems have a range between 7-8 kW.

Water heating average is 2.5kW for EIWH, 10.8kW for GSWH, 12.6 for EIWH and 18.7kW for GIWH.

Solar thermal DHW systems sizes vary from 2 kW to 4 kW.

Table 15 Average thermal capacity per unit (kW/unit), autonomous heating

Autonomous heating	France	Germany	Italy	Portugal	Spain	EU28
Condensing gas boilers	25kW	17kW	24kW	20-24kW	24kW	24kW
Non-Condensing gas boilers	23kW	17kW	24kW	20-24kW	24kW	24kW
Condensing oil boilers	25kW	18kW	23kW	20-24kW	24kW	24kW
Non-Condensing oil boilers	**30kW**	**18kW**	**28kW**	**20-24kW**	24kW	24kW
Coal boilers	24kW	24kW	24kW	24kW	24kW	24kW
Electric storage water heaters	2.5kW	2.5kW	2.5kW	2.5kW	2.5kW	2.5kW
Gas storage water heaters	10.8kW	10.8kW	10.8kW	10.8kW	10.8kW	10.8kW
Electric instantaneous water heaters	12.6kW	12.6kW	12.6kW	12.6kW	12.6kW	12.6kW
Gas instantaneous water heaters	18.7kW	18.7kW	18.7kW	18.7kW	18.7kW	18.7kW
A/A Heat Pumps	**10kW**	**4kW**	**12kW**	**6kW**	**6kW**	**8kW**

Autonomous heating	France	Germany	Italy	Portugal	Spain	EU28
A/W Heat Pumps	11kW	12kW	15kW	12kW	12kW	12kW
A/W Heat Pumps DHW	3kW	3kW	3kW	3kW	8kW	4kW
W/W Heat Pumps	15kW	10kW	20kW	12kW	18kW	13kW
Solar thermal COMBI	8kW	8kW	8kW	8kW	7kW	8kW
Solar thermal DHW	2kW	4kW	2kW	3kW	3kW	3kW
Biomass boilers	8-135kW	8-135kW	8-135kW	24kW	8-135kW	8-135kW
Electric heating	1-3kW	1-3kW	1-3kW	1-3kW	1-3kW	1-3kW

For central heating the size of a centralised gas boiler varies from 63 kW to 185 kW, while for oil boiler the range is 51-176 kW (Table 16).

Coal boilers size average is 63-176kW, while biomass boilers have an average installed capacity of 90kW.

Heat pumps have a range that varies from 30kW to 100kW, while solar thermal DHW systems range is 14-35 kW.

Electric heating centralised systems have an installed capacity between 25kW and 250kW.

Table 16 Average thermal capacity per unit, centralised heating

Centralised heating	France	Germany	Italy	Portugal	Spain	EU28
Condensing gas boilers	63kW-176kW	72kW	149kW	63kW-176kW	63kW-176kW	63kW-176kW
Non-Condensing gas boilers	63kW-176kW	72kW	185kW	63kW-176kW	63kW-176kW	63kW-176kW
Condensing oil boilers	63kW-176kW	51kW	116kW	63kW-176kW	63kW-176kW	63kW-176kW
Non-Condensing oil boilers	63kW-176kW	51kW	133kW	63kW-176kW	63kW-176kW	63kW-176kW
Coal boilers	63kW-176kW	63kW-176kW	63kW-176kW	63kW-176kW	63kW-176kW	63kW-176kW

Centralised heating	France	Germany	Italy	Portugal	Spain	EU28
Electric storage water heaters	-	-	-	-	-	-
Gas storage water heaters	-	-	-	-	-	-
Electric instantaneous water heaters	-	-	-	-	-	-
Gas instantaneous water heaters	-	-	-	-	-	-
A/A Heat Pumps	38kW	38kW	38kW	38kW	38kW	38kW
A/W Heat Pumps	38kW	38kW	38kW	38kW	38kW	38kW
A/W Heat Pumps DHW	30kW	30kW	30kW	30kW	30kW	30kW
W/W Heat Pumps	100kW	38kW	38kW	38kW	38kW	38kW
Solar thermal COMBI	-	-	-	-	-	-
Solar thermal DHW	14kW	35kW	35kW	28kW	35kW	34kW
Biomass boilers	90kW	90kW	90kW	90kW	90kW	90kW
Electric heating	25-250kW	25-250kW	25-250kW	25-250kW	25-250kW	25-250kW

9 Average thermal efficiency

Average thermal efficiency per autonomous unit varies from 93%-96% for condensing gas/oil boilers, while for non-condensing units the range is 75%-90% (Table 17).

Coal boilers efficiency average in all countries is 75% and biomass autonomous average efficiency is 79%.

Heat pumps efficiency changes according to the climatic zones and typology; the range is 291-342%.

Electric heating has always 100% efficiency.

Water heating average efficiency is: 36% for ESWH, 49% for GSWH, 39% for EIWH and 53% for GIWH.

Table 17 Average thermal efficiency per unit, autonomous heating

Autonomous heating	France	Germany	Italy	Portugal	Spain	EU28
Condensing gas boilers	93%	93%	96%	93%	93%	93%
Non-Condensing gas boilers	75%	75%	90%	75%	75%	75%
Condensing oil boilers	93%	93%	96%	93%	93%	93%
Non-Condensing oil boilers	75%	75%	90%	75%	75%	75%
Coal boilers	75%	75%	75%	75%	75%	75%
Electric storage water heaters	36%	36%	36%	36%	36%	36%
Gas storage water heaters	49%	49%	49%	49%	49%	49%
Electric instantaneous water heaters	39%	39%	39%	39%	39%	39%
Gas instantaneous water heaters	53%	53%	53%	53%	53%	53%
A/A Heat Pumps	307%	291%	331%	319%	319%	291%
A/W Heat Pumps	307%	291%	331%	319%	319%	291%
A/W Heat Pumps DHW	329%	321%	342%	334%	334%	321%
W/W Heat Pumps	323%	328%	325%	317%	317%	328%

Autonomous heating	France	Germany	Italy	Portugal	Spain	EU28
Solar thermal COMBI	-	-	-	-	-	-
Solar thermal DHW	-	-	-	-	-	-
Biomass boilers	79%	79%	79%	79%	79%	79%
Electric heating	100%	100%	100%	100%	100%	100%

There are few differences in efficiency between autonomous and centralised units: gas and oil boilers have 1% more efficiency in centrliased heating systems in Italy (Table 18).

Coal boilers efficiency raises to 82% in centralised boilers from 75% of autonomous and also biomass boiler are 1% more efficient as centralised units.

Centralised heat pumps range is between 305% and 383%.

Table 18 Average thermal efficiency per unit, centralised heating

Centralised heating	France	Germany	Italy	Portugal	Spain	EU28
Condensing gas boilers	93%	93%	97%	93%	93%	93%
Non-Condensing gas boilers	75%	75%	91%	75%	75%	75%
Condensing oil boilers	93%	93%	97%	93%	93%	93%
Non-Condensing oil boilers	75%	75%	91%	75%	75%	75%
Coal boilers	82%	82%	82%	82%	82%	82%
Electric storage water heaters	36%	36%	36%	36%	36%	36%
Gas storage water heaters	49%	49%	49%	49%	49%	49%
Electric instantaneous water heaters	39%	39%	39%	39%	39%	39%
Gas instantaneous water heaters	53%	53%	53%	53%	53%	53%

Centralised heating	France	Germany	Italy	Portugal	Spain	EU28
A/A Heat Pumps	320%	305%	342%	329%	329%	305%
A/W Heat Pumps	320%	305%	342%	329%	329%	305%
A/W Heat Pumps DHW	372%	359%	383%	376%	376%	359%
W/W Heat Pumps	306%	305%	307%	309%	309%	305%
Solar thermal COMBI	-	-	-	-	-	-
Solar thermal DHW	-	-	-	-	-	-
Biomass boilers	80%	80%	80%	80%	80%	80%
Electric heating	100%	100%	100%	100%	100%	100%

10 Average installation age

Average European installation age for autonomous gas, oil and coal boilers is 28 years (Table 19). For the countries analysed in this report the range varies from 3 years for a condensing gas boiler in Italy to 22 for oil boilers in Portugal.

Heat pumps installation age is available only for Portugal and it is between 9-10 years for unit. Portugal also provides data for solar thermal DHW systems (8 years), biomass boilers (13 years) and electric heating (23 years).

Water heating average installation age is 15 years for all the countries analysed, while for Portugal is 27 years.

Table 19 Average installation age, autonomous heating

Autonomous heating	France	Germany	Italy	Portugal	Spain	EU28
Condensing gas boilers	6	19	3	18	28	28
Non-Condensing gas boilers	17	19	15	18	28	28
Condensing oil boilers	6	20	3	22	28	28
Non-Condensing oil boilers	20	20	20	22	28	28
Coal boilers	28	28	28	28	28	28
Electric storage water heaters	15	15	15	27	15	15
Gas storage water heaters	15	15	15	15	15	15
Electric instantaneous water heaters	15	15	15	15	15	15
Gas instantaneous water heaters	15	15	15	15	15	15
A/A Heat Pumps	-	-	-	-	-	-
A/W Heat Pumps	-	-	-	10	-	-
A/W Heat Pumps DHW	-	-	-	9	-	-

Autonomous heating	France	Germany	Italy	Portugal	Spain	EU28
W/W Heat Pumps	-	-	-	-	-	-
Solar thermal COMBI	-	-	-	-	-	-
Solar thermal DHW	-	-	-	8	-	-
Biomass boilers	-	-	-	13	-	-
Electric heating	-	-	-	23	-	-

Centralised systems have almost the same values as centralised ones (Table 20): the only differences are in the German stock, in which the average installation age of centralised gas and oil boilers is 3-4 years higher compared to autonomous units.

Table 20 Average installation age, centralised heating

Centralised heating	France	Germany	Italy	Portugal	Spain	EU28
Condensing gas boilers	6	22	3	18	28	28
Non-Condensing gas boilers	17	22	18	18	28	28
Condensing oil boilers	6	24	3	22	28	28
Non-Condensing oil boilers	20	24	20	22	28	28
Coal boilers	28	28	28	28	28	28
Electric storage water heaters	15	15	15	27	15	15
Gas storage water heaters	15	15	15	15	15	15
Electric instantaneous water heaters	15	15	15	15	15	15
Gas instantaneous water heaters	15	15	15	15	15	15
A/A Heat Pumps	-	-	-	-	-	-

Centralised heating	France	Germany	Italy	Portugal	Spain	EU28
A/W Heat Pumps	-	-	-	10	-	-
A/W Heat Pumps DHW	-	-	-	9	-	-
W/W Heat Pumps	-	-	-	-	-	-
Solar thermal COMBI	-	-	-	-	-	-
Solar thermal DHW	-	-	-	8	-	-
Biomass boilers	-	-	-	13	-	-
Electric heating	-	-	-	23	-	-

11 Annex

11.1 Building stock tables

Table 21 SFH and MFH dwellings. Total and heated numbers

Country	SFH Dwellings	SFH Dwellings heated	MFH Dwellings	MFH Dwellings heated	SFH+MFH Dwellings	SFH+MFH Dwellings heated
France	19,041,260	12,408,083	14,852,750	9,678,674	33,894,000	22,086,757
Germany	19,436,820	19,242,452	21,754,020	21,536,480	41,185,160	40,778,932
Italy	6,681,390	5,278,298	25,282,460	19,973,143	31,963,850	25,251,442
Portugal	3,503,890	2,733,034	2,432,790	1,897,576	5,936,690	4,630,610
Spain	7,761,800	6,254,158	18,805,270	15,152,558	26,567,070	21,406,715
EU28	125,230,370	107,528,162	123,227,840	105,808,704	249,652,260	213,336,866

Table 22 Mm² of surface floor of SFH and MFH

Country	Mm² SFH (extrapolated)	Mm² MFH (extrapolated)	Tot. m² SFH+MFH (extrapolated)	Tot. m² SFH+MFH (direct source)
France	2,129	981	3,110	3,115

Country	Mm² SFH (extrapolated)	Mm² MFH (extrapolated)	Tot. m² SFH+MFH (extrapolated)	Tot. m² SFH+MFH (direct source)
Germany	2,180	1,465	3,646	3,786
Italy	637	1,685	2,322	2,987
Portugal	285	165	450	661
Spain	499	1,209	1,708	2,434
EU28	11,417	8,161	19,578	22,684

Table 23 District heating Mm² and dwellings heated

Country	Mm² heated	Mm² SFH 50% heated	Mm² MFH 50% heated	m²/SFH	m²/MFH	SFH DH dwellings heated	MFH DH dwellings heated
France	54.4	27.2	27.2	112	66	243,187	411,512
Germany	299.2	149.6	149.6	112	67	1,333,481	2,220,618
Italy	47.4	23.7	23.7	95	67	248,427	355,651
Portugal				81	68		
Spain				64	64		
EU28	1702.2	851.1	851.1	91	66	9,335,462	12,850,381

Table 24 Average surface of SFH and MFH dwellings

Country	m²/SFH	m²/MFH	Average Dwelling
France	112	66	89
Germany	112	67	90
Italy	95	67	81
Portugal	81	68	75
Spain	64	64	64
EU28	91	66	79

Table 25 Total floor area, heated floor area, total heating consumption od space heating energy consumption

Country	Total floor area (Mm^2)	Heated floor area (Mm^2)	Share heated floor area/floor area	Total heating consumption residential sector (M TWh/yr)	Space heating energy consumption (kWh/m2/yr)
France	3,115.3	2,030.0	65.2%	326.3	160.7
Germany	3,785.9	3,748.0	99.0%	465.6	124.2
Italy	2,986.7	2,380.4	79.7%	274.7	144.7
Portugal	661.0	387.3	78.0%	6.3	16.3
Spain	2,433.8	1,961.1	80.6%	79.4	40.5
EU28	22,683.8	19,477.3	85.9%	2,316.3	118.9

12 Methodology

12.1 SFH, MFH-A and MFH-C

In our study, residential dwellings are divided in SFH and MFH.

SFH are Single-Family houses that only have one main heating appliance installed.

MFH are Multi-Family Houses and they are divided into two categories: MFH in which every dwelling has autonomous heating (MFH-A) and dwellings in which the heating is centralised and only one heating appliances heats all the dwellings of the building (MFH-C).

12.2 Energy consumed and energy produced

Energy of solar thermal and heat pumps technologies is not properly “consumed” but generated. Indeed, solar thermal technology does not consume energy and heat pumps consumes electrical energy to generate thermal energy.

In our study, when we use the words “energy consumption” for solar thermal and heat pumps technology, we are considering the energy they are providing to the residential units considered. We did it because in this way it is easier to compare the final energy consumption related to all the technologies analysed.

Heat pumps electric consumption is not considered in this report.

12.3 Autonomous and centralised heating

We tried to match the installed stock of units installed with the building stock of the countries analysed.

Some assumptions were made, based on the size of the units:

- Gas/oil/coal boilers: <25kW autonomous heating, >25kW centralised heating
- Heat pumps: <20kW autonomous heating, >20kW centralised heating
- Biomass boiler: <50kW autonomous heating, >50kW centralised heating
- Electric heating: <25kW autonomous heating, >25kW centralised heating

Moreover, to distinguish between autonomous heating in SFH and in dwelling in MFH we used the criteria of Table 26:

- Gas boilers are 50% installed in SFHs and 50% in MFH dwellings
- Oil and coal boilers are 100% installed in SFHs
- A/W and W/W heat pumps are 100% installed in SFH
- Solar thermal COMBI systems are 100% installed in SFH but not counted because auxiliary to other technologies (e.g. condensing gas boilers)
- Biomass boilers are 100% installed in SFH
- Electric heaters are 50% installed in SFHs and 50% in MFH dwellings
- In order to extrapolate the number of dwellings heated with electric heaters, we divided the number of installed units by the average numbers of rooms per dwelling in every country (see Table 27)
- District heating dwellings are divided into 50% SFH and 50% MFH-A.

Table 26 Share of technologies attributed to different categories of dwellings

Country	SFH	MFH-A	Tot	MFH-C
Condensing gas boilers	50%	50%	100%	100%
Non-Condensing gas boilers	50%	50%	100%	100%
Condensing oil boilers	100%	0%	100%	100%
Non-Condensing oil boilers	100%	0%	100%	100%
Coal boilers	100%	0%	100%	100%

Country	SFH	MFH-A	Tot	MFH-C
A/A Heat Pumps	50%	50%	100%	100%
A/W Heat Pumps	100%	0%	100%	100%
W/W Heat Pumps	100%	0%	100%	100%
Solar thermal COMBI	100%	0%	100%	100%
Biomass boilers	100%	0%	100%	100%
Electric heating	50%	50%	100%	100%
District heating	50%	50%	100%	0%

Table 27 Average number of rooms per dwelling

Country	Average number of rooms per dwelling
France	4.0
Germany	4.4
Italy	4.2
Portugal	4.8
Spain	5.1
EU28	4.0

12.4 Water heaters

In our extrapolations we assumed that 100% of water heaters devices that are installed in autonomous heating dwellings. For central heating we have only data for A/W DHC heat pumps and Solar Thermal domestic hot water systems.

We did not take into consideration collective indirect water heaters, since they are included in the combi centralised systems analysis.

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