HEATING AND COOLING
KNOWHOW AND SOLUTIONS

D3.3 - Topten HACKS Criteria Paper
Space and combination heaters
Electric, gas- and oil-fired boilers

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About HACKS

The objective of the Heating and Cooling Knowhow and Solutions (HACKS) project is to achieve market transformation for heating and cooling (HAC) appliances and improve comfort and health of European citizens.
Across the EU almost half of all buildings have individual boilers that were installed before 1992 with efficiency of 60% or less. The expected energy savings from a speedy replacement are immense.
To achieve this goal, 17 HACKS partners in 15 countries are working together, thanks to the financial support of the European Horizon 2020 programme.
After scanning market actors, current policies and most commonly used products in each country, starting from April 2020 the HACKS partners will implement involvement campaigns to raise awareness of the economic and environmental benefits brought by good HAC products and solutions:

- HACKS will motivate households equipped with old and inefficient devices – boilers, water heaters, air conditioners, certain types of boilers and stoves, etc. – to replace them with new super efficient equipment.
- In each country, partners will set-up dedicated on-line platforms to assist consumers in their purchasing process. The platforms will propose: tools to assess households' needs and provide customised information; best product lists with technical specifications; direct links to suppliers of most efficient products; and advice on how to use and maintain equipment.
- For those households who need to improve their situation because they feel too hot, too cold, or too humid but who cannot invest in new equipment or can avoid getting equipped, HACKS will propose simple and low costs solutions. It is possible to reduce energy consumption and energy bills while improving winter and summer comfort, air quality and health conditions through the installation of shading devices, thermostats, water saving taps and showerheads, etc.

Beyond households, HACKS will target all relevant stakeholders ("multipliers") that participate in the decision-making process of consumers by setting up strategic partnerships to facilitate the purchase of energy efficient appliances. HACKS places a strong emphasis on installers but also retailers and consumer organisations because of their proximity to consumers, their capacity to involve them and bring them guidance on energy efficient equipment.
More information on the HACKS project can be found at www.topten.eu.

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Executive summary

Energy consumption patterns worldwide reveal that buildings are the greatest energy consumer, consuming approximately 45 % of energy, followed by industry and transportation consuming 20 % (Anisimova 2011). Circa 54% of the building energy consumption is dedicated to heating.

The document provides an overview on space and combination heaters (oil-fired, gas-fired, electric and heat pumps), the regulations that govern these products and the market development in the European Union. It provides a recommendation for selection criteria for these products for the Topten product lists of most efficient products on the market. It also provides information on how to collect relevant product data for the creation of a corresponding best product list.

With the criteria papers, the intention is to be able to identify and select the most energy efficient models available on the market. The primary objective is to help HACKS project partners on their territory for their Topten and HACKS website, but the technical content may also support anyone willing to find good products from an environmental point of view.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

COP	Coefficient of Performance
EHPA	European Heat Pump Association
GCV	Gross Caloric Value
HVAC	Heating, ventilation and air conditioning

1 Topten selection criteria for space and combination heaters

Out of all the space heaters and combination heaters technologies presented in this criteria paper, Topten.eu only presents a product list for heat pump space heaters as they are most efficient space heating technology. Because of this, Topten.eu has chosen not to promote other space heating technology presented in this paper.

1.1 Topten.eu selection criteria for heat pumps

Within the HACKS project all Topten heat pumps meet the following criteria:

- Minimum energy efficiency class A++ for 35° C and 55° C.
- All models are in series production (no prototypes, no custom-made products).
- The data correspond to test results in accordance with standard EN 14511.

All products also need to have the value for the space heating energy efficiency (ηs) declared. The availability for this value (described more in detail in later chapters) was scarce in the beginning but has been increasingly supplied by manufacturers after it was made mandatory for listing the products on Topten.

1.2 National selection criteria

1.2.1 Topten Switzerland selection criteria for heat pumps

The selection criteria on Topten Switzerland are identical to the selection criteria on Topten.eu.

1.2.2 Topprodukte.at selection criteria for heat pumps

The selection is based on the information provided by the manufacturers according to the test reports of an accredited testing institute in accordance with EHPA-D-A-CH quality seal regulations.

Table 1: Selection criteria for heat pumps for space heating on topprodukte.at – February 2022

Type of heat pump	Topprodukt GOLD Heating energy efficiency at 35°C (medium climate)	Sound power level (dB)	Topprodukt SILVER Heating energy efficiency at 35°C (medium climate)	Sound power level (dB)
Direct evaporator	≥ 215	-	≥ 210	-
Air-Water	≥ 200	≤ 52	≥ 195	≤ 56
Brine-Water	≥ 215	-	≥ 210	-
Water-Water	≥ 270	-	≥ 250	-

Source: topprodukte.at

1.3 Topten.eu: expected selection criteria for end of project

For space heaters and combination heaters, the space heating energy efficiency (η_s) is the key parameter. As heating demand is not constant over the year, it is good to reflect the part load operation in the performance criterion.
Since the heat pump heaters show the highest efficiency, Topten.eu only displays those products.
The selection criteria keeps as a basis that all models are serial products (no prototypes, no one-offs).
Additionally, based on the outcome of future product updates, Topten selection criteria may be adjusted to take into account the GWP of the refrigerants and to set minimum requirements accordingly in the future.

1.4 Best available product on Topten.eu

In February 2022, there were 219 models of 10 different brands on the Topten.eu product list for heat pumps from the following brand names: AerThermie, Bruderus, CTA AG, Hoval AG, Müba Energietechnik AG, Ochsner Wärmepumpen GmbH, Regli Energy Systems AG, Swisstherm AG, Vaillant GmbH, Zehnder Group.

2 Technical background

2.1 Scope

A boiler is defined as an appliance that is designed to provide hot water for space heating. A combination boiler "combi" has the capability to also provide domestic hot water.
This criteria paper covers dedicated space and combination heaters that are within the scope of the European regulation (EU) No 813/2013. The term "space and combination heaters" has been borrowed from the regulation above and applies to the products that fall into the scope of the regulation. These do not include:

- Local space heaters
- Solid fuel boilers

In this paper, the term boiler refers to oil-fired, gas-fired and electric and heat pump space heaters. These products are the heat generator of the heating system. It does not include products that are solely intended to prepare hot sanitary water (see criteria paper on water heaters).

2.2 Technical description

The boiler is one of the most important components of a central heating system. As opposed to local space heaters, boilers are intended to heat several rooms in a building. A central heating system is composed of a heat generator (the boiler), a heat distribution system and heat distribution medium.
Boilers can generate heat using different fuels to heat the heat distributions medium. The preferred medium is usually water (hydroponic heating system), but it can also be air[1]. The water circulates through the heat distribution systems, which consists of pipes, that feeds radiators or serpentine pipes that are laid across the surface under the floors.

[1] Space heating using air is the standard heating method in North America for example. It is less expensive than a hydroponic heating system.

Figure 1: Installation of an underfloor heating pipes

Source: www.johnguest.com

Once the heated water has entered the various heat-emitters, they subsequently transfer the heat into the rooms, either by convection, radiation or both. Flow controls determine the supply temperature and when, which emitters are heated, and to what extend they are heated. The real-life overall efficiency of a hydronic heating system is primarily determined by (in order of priority):

- System temperature heat-emitters
- Type of heat generator
- Type of heating schedule control
- Type of system temperature controls
- Type of flow controls

In urban areas, certain buildings do not need to have their own heat generator because they receive heat through district heating. The choice of boiler technology will also determine where is the best location for the boiler. While oil-fired boilers are usually placed in the basement because they need to be close to the oil tank, gas-fired boilers can be placed in the attic which avoids building a chimney (e.g. a flue) through the building.

2.2.1 Types of heat generators

There are many types of boilers available today on the market which makes choosing the right solution a difficult task for consumers. There are great differences between the individual types of heating systems in terms of acquisition costs, fuels, mode of operation, intended use and, as a result, energy efficiency.

Oil-fired boiler

The oil-fired boiler is historically one of the traditional boilers. Its acquisition costs range from just under EUR 6’000 to EUR 14’000[2], depending on whether only the oil heating

[2] The prices of heat generators throughout the paper are from the review study on space heaters. It is expected that these costs vary strongly from one country to the other.

system is replaced or if an oil tank must also be installed. In any case, there will be the need to store the heating oil. This solution requires a lot of space and must be easily accessible – by the supplier of oil when refilling the tank and it has to be easily connected to the distribution pipes of the heating system. Consumers are free to choose the oil supplier, but they are dependent on the crude oil prices. CO_2 emissions of an oil heating system are higher than a natural gas system. Nevertheless, like every other type of boilers, oil heating systems can also be combined with renewable energy sources, which reduces their overall impact. The amount of soot[3] is higher in oil-fired systems than in gas condensing boilers, and filter systems must be integrated to combat the sulphur content of the exhaust gases. This is also the reason why oil heating systems usually require more maintenance and cleaning.

Figure 2: Example of an oil-fired boiler

Source: ECOS (2019)

Gas-fired boiler

The acquisition costs of a classic gas heating system are between EUR 5’000 and EUR 10’000. The natural gas for the gas heating system can be delivered via a central gas pipeline, and consumption can be measured easily using appropriate meters. With this system, there is no need to have a storage chamber for the fuel.
With the use of an efficient gas condensing boiler, this type of heating causes less CO_2 emissions.

[3] A deep black powdery or flaky substance consisting largely of amorphous carbon, produced by the incomplete burning of organic matter.

Figure 3: Example of gas-fired boiler

Source : ECOS (2019)

Electric boilers

Electric boilers use the Joule resistance effect to generate heat. They are very uncommon in Europe and represent less than 2 percent of the market share for boilers.

Figure 4: Example of an electric boiler

Source : ECOS (2019)

Solar heating system

A solar heating system is often combined with another type of heating system and supports it with additional heat. It is not possible to store heat inter-seasonally so that the heat stored during warmer months can be used during the winter. A solar thermal system costs between EUR 5’000 and EUR 14’000. To optimize the system, the panels on the roof need to be aligned and tilted towards the sun.

Heat pumps

Like electric boilers, heat pumps are fuelled by electricity. However, heat pumps extract heat from their surroundings (external air, the ground or groundwater) and release it to a warmer space using a thermodynamic process. It moves thermal energy in the opposite direction of spontaneous heat transfer (from warm to cold) through a thermodynamic cycle. The working

fluid for this process is the refrigerant. Refrigerants, if released, have a global warming potential (GWP) which means that they are greenhouse gases that are more than 2000 times more powerful than CO_2.

Figure 5: Heat pump boiler

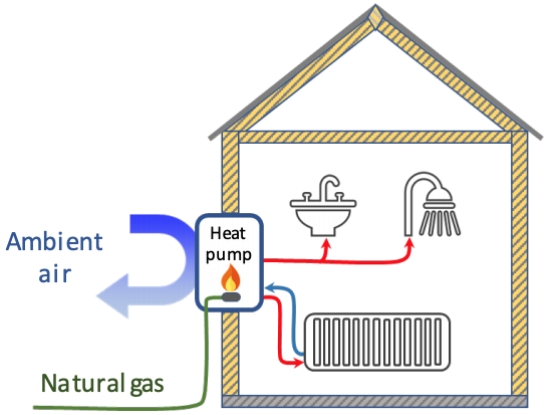
Source: ECOS (2019)

The installation of a heat pump heating system is estimated to cost about EUR 8'000 to EUR 10'000. Compared to other technologies, heat pumps are the most efficient. The sink from which the heat pump extracts the heat, determines the type of heat pump. There are 3 main types of heat pumps:

- Air-to-Water: An external unit is placed outside and the refrigerant circulating in the cycle absorbs the heat in the ambient air. The heat is then released via the refrigerant to the water in the pipes of the distribution system. The outside units can also use the heat of exhaust air. The dedicated "exhaust air-to-water heat pump" is a special type of air-to-water heat pump. This heat pump is placed indoors and receives all its air from the exhaust ventilation system. It should not be confused with the mixed exhaust and outdoor air solution.
- Water-to-water: The heat pump uses two ground water boreholes: one to extract the heat from the ground water and one to drain the cooled groundwater.
- Brine-to-water: The primary heat exchange takes place 30 to 100 meters in the ground. Beyond a drilling of 100-meters, the heat pump can be a called a geothermal heat pump. Because an additional geothermal heat collector is required for a brine-water heat pump, an additional EUR 10'000 to EUR 15'000 should be planned for a single-family house, depending on the type of collector and its size.

In some cases, the heat pump might need supplementary heating to provide the desired temperature. It may be equipped with a resistance heater using the Joule effect or a combustion element for fossil and/or biomass fuels. In these cases, the heat pump is a **fuel-driven heat pump**.

Figure 6: Principle of a gas heat pump



Source: Critoph (2019)

Cogeneration space heaters

Cogeneration space heaters generate heat and electricity at the same time. Cogeneration is a more efficient use of fuel because otherwise-wasted heat from electricity generation is put to some productive use. Combined heat and power (CHP) boilers recover otherwise wasted thermal energy for heating. The supply of high-temperature heat first drives a gas or steam turbine-powered generator. The resulting low-temperature waste heat is then used for water or space heating. At smaller scales (typically below 1 MW) a gas is used as a fuel.

2.2.2 Low temperature heating systems

A low-temperature heating system is a heating system that operates at comparatively low system temperatures. All individual components of these systems are specifically designed for this low temperature application. In contrast to a conventional heating system, where the flow temperature is 60°C or more, a low-temperature heating system often does not exceed 35 °C even on cold winter days.

A low-temperature boiler is a boiler that can operate in a low-temperature heating system. In order to have a low temperature heating system, the boiler has to be adapted to low temperature application. It is also possible to use a high temperature boiler in low temperature system using special mixing valves but the overall efficiency is lower.

The low temperature application is generally understood to mean the system as a whole, i.e. the sum of the individual components such as heat generator, radiator (heat consumer) and heat distributor (pipes), rather than just the low-temperature boiler as such. The sanitary hot water will have to be provided by a dedicated water heater.

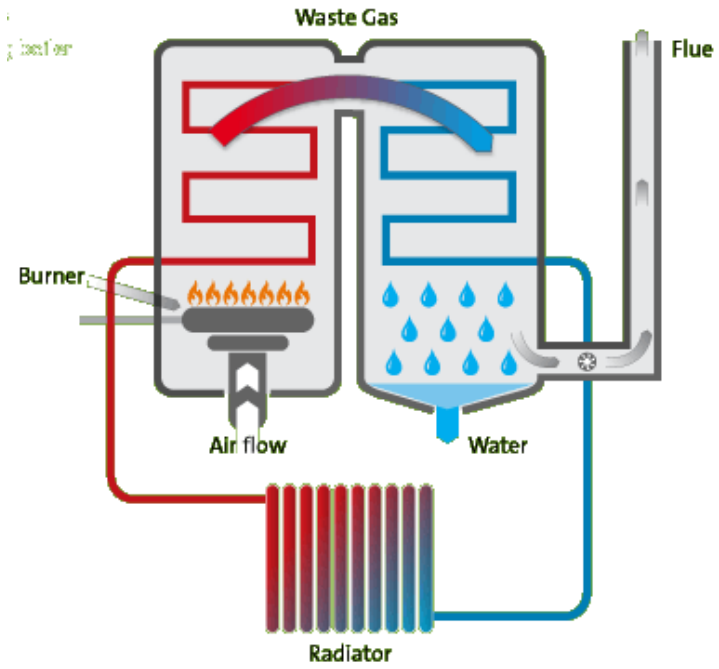
To heat the rooms to the desired room temperature, the best method is with the help of radiant (panels) heating systems. They give off heat to the room over a large area, usually in the form of underfloor heating, less often in wall or ceiling heating. Alternatively, or in combination, special low temperature radiators can be used.

The advantage of the low temperature heating compared to the conventional heating with higher temperature is that it is more efficient use of energy. This advantage is based on the physical principle that the same heating effect/the same heat output can be achieved with a low heating temperature and larger output surfaces as with high heating temperatures with smaller output surfaces. To integrate radiators into a low temperature heating system, the same principle can be used by increasing the circulation speed in the radiator or by using radiators with fan support (fan coils).

2.2.3 Condensing boilers

Condensing boilers are boilers or water heaters fueled by gas or oil. When the fuel is burned, steam is one byproduct of the combustion process, and this steam is condensed into hot water. Energy is extracted from the condensate (latent energy from condensation) and heat is gained from this return flow water, before it is returned to the circuit. While either gas or oil can be used, gas is more efficient since the exhaust of the heated water in a gas system condenses at 57°C, whereas in an oil-based system this does not occur until 47°C. An additional advantage of a gas system is its higher water content resulting from the combustion process. Condensing boilers benefit from low return-temperatures from the heating distribution system. The lower the return temperature, the more condensate the boiler produces.
For all condensing boilers, there is significant energy saving through the efficient use of the combusted fuel: exhaust gas is around 50°C , compared with traditional boilers, whose flue gases escape, with the unused heat content, at 200°C. This condensed vapour leaves the system in liquid form, via a drain.
These boilers achieve high efficiency levels (typically greater than 90% on the higher heating value) by condensing water vapour in the exhaust gases and so recovering its latent heat of vaporisation, which would otherwise have been wasted.

Figure 7 : Representation of a condensing boiler



Source: purmo.com

2.2.4 Flue types

A flue is a duct, pipe, or opening in a chimney for conveying exhaust gases from a fireplace, furnace, water heater, boiler, or generator to the outdoors. Depending on fire and safety regulations (different throughout Europe), a boiler may be installed in a specific room. The type of flue or the existing flue will determine what type of boiler can be installed.

- Open flue – An open flued appliance draws combustion air from its surroundings; exhaust gases rise in a vortex up the open flue. These appliances need an air inlet and should be installed in ventilated rooms, following local rules for safety in combustion.
- Closed flue – When an air duct brings combustion air directly to an appliance, there is no air movement between the room containing the appliance. This makes Room

Sealed appliances intrinsically safe, since products of combustion (POCs) cannot normally escape into the room. Two major types of closed flues are used with Room Sealed appliances:

- Room Sealed (Balanced) flue – Use the natural draught created by the hot exhaust, so the flue is as short as possible, usually sufficiently long to pass through an external wall against or near which the appliance is installed. The balanced flue terminal has both flue outlet and air inlet in close proximity, so any draughts or wind gusts pressure both equally and cancel out in the appliance. Thus, the burner flame and even pilot lights are not affected
- Room Sealed (Fanned) flues use the pressure created by a fan to power the movement of outside air into the appliance and combustion products to external air. Thus, air and flue ducts can be much longer, of smaller diameter, and include changes of direction.

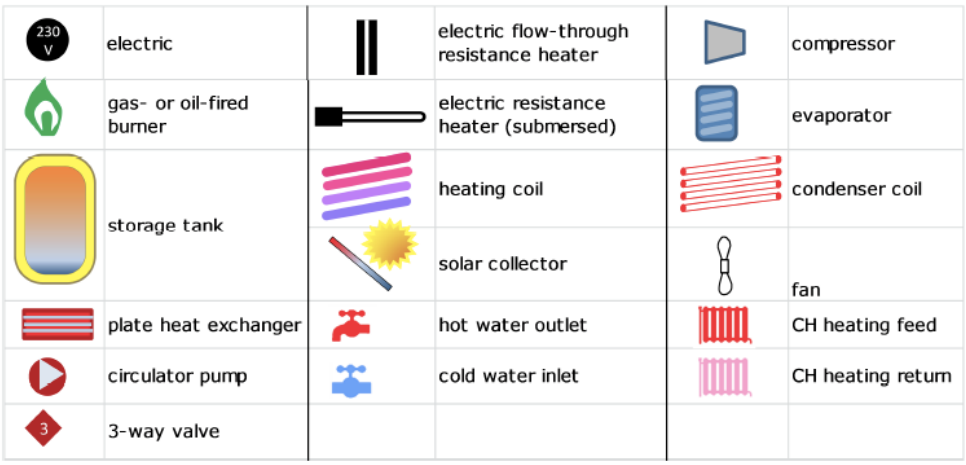
2.2.5 Average product life

The average product life of a boiler is 15 years or more. This can vary strongly from one country to another where specific country research showed, that there were large differences between Member States, ranging from an average boiler life of 8.5 years in the UK up to 33 years in Germany. The average product-life of boilers has not increased over the years. A boiler reaches its end of life due to economic reasons; not because the product breaks down. At a certain point, repair costs become so expensive that it is better to buy a new boiler. Average product life varies from one technology to another. For a gas-fired boilers 18 years is still the average lifetime of the product. The main concern for the replacement of boilers, is the very long lifetime of oil-boilers. They almost never break down and some data sources mention an average product life of over 33 years for jet-burner boilers (EC, 2019). Some models are 100 years old and still operational.

2.2.6 Types of combi systems

The review study for water heaters provides an overview of different combi space heating systems (EC, 2019). There are several types of combi systems and all require additional components to function. In these cases, it is important to take a system approach to the heating system.

Figure 8: Key of combi heater components

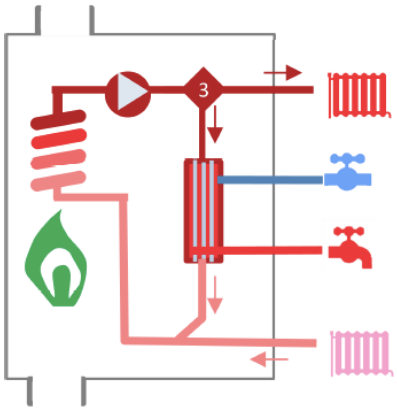


Source: EC, 2019

Instantaneous COMBI

A factory-made combi boiler has a heating loop for central space heating and a heating loop for sanitary hot water. A 3-way valve switches between the two loops, giving priority to the sanitary hot water-loop when tapping. The common elements in both loops are a heat exchanger, heated by a gas or oil-fired burner, and a circulator that pumps the heated water around. In an instantaneous combi the heating water goes through a second heat exchanger that heats up to sanitary hot water. There is no –or little—storage loss. Water heating in a combi can benefit from the residual heat of the space heating function (and vice versa). This is why energy efficiency is often higher than with a dedicated water heater. Disadvantage of a combi may be that it uses the same burner for both space heating and hot water which may lead to considerable over sizing (and unfavourable on-off operation) of the space heating part.

Figure 9: Schematic representation of an instantaneous combi heater

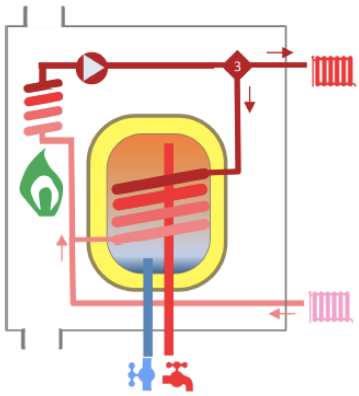


Source: EC, 2019

Storage COMBI (integrated)

Some of the factory-made combi's does not use a small heat exchanger but a storage tank with a heating coil. This shortens the «waiting time» between the user opening the hot water tap and the hot water actually reaching the desired temperature. As both the boiler and the storage tank are in the same casing, the volume of the tank is limited and varies between 30 and 120 litres, depending on the model. Storage COMBIs have storage losses.

Figure 10 : Schematic representation of an integrated storage combi

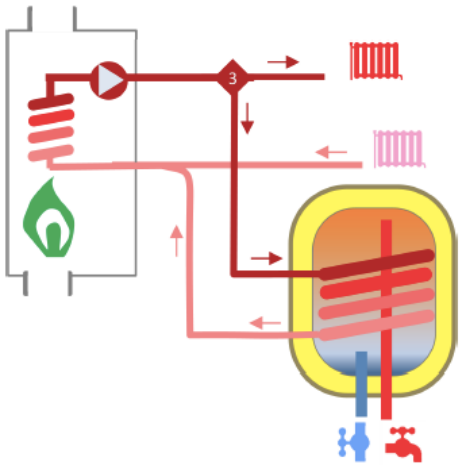


Source: EC, 2019

Indirect cylinder and boiler

In principle, any gas-, oil- or biomass- fired boiler or district heating system that can reach a heating water temperature of 80 °C can be turned into a "combi" by adding an indirect cylinder, i.e. a storage tank with an internal heating coil, and a 3-way valve. The control of the 3-way valve is often already incorporated in the boiler. The layout is the same as for an integrated storage combi, but tank and boiler are separate and thus there is no space restriction for the size of the tank. This solution gives high water comfort and high capacity for households (tanks 80 to 200 liters) but also for commercial services (tapping patterns 3XL, 4XL or higher with tanks of 500-1000 liters or higher). Indirect cylinders have storage losses.

Figure 11: Schematic representation of an indirect cylinder and boiler

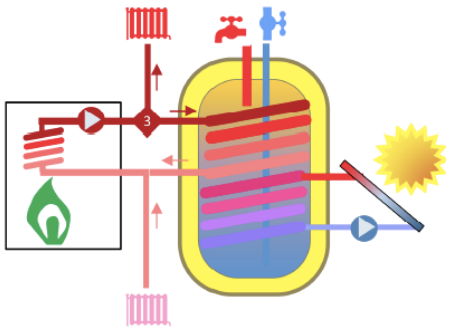


Source: EC, 2019

Combi Solar Water heaters (SOL-COMBI)

For situations where households are connected to gas (or oil), an indirect coil is connected to the boiler and is used as a back-up heater for the solar collectors instead of using an electric resistance element. This means that the "twin coil" solar storage tank has two internal coils: one for the gas-fired boiler loop and one for the solar loop.

Figure 12: Schematic representation of a combi solar water heater



Source: EC, 2019

2.3 Best available technology

The results of various monitoring studies on real-life heat generator efficiencies clearly indicate that the heat generator itself is not the only component that determines the energy efficiency of the heating system. This means that, merely replacing an existing heat generator by a new and more efficient one, does not necessarily imply that the full saving potential of the new generator is achieved. To unlock the full saving potential, a system approach is required. For new buildings this can easily be done, because all necessary components need to be specified and procured. For existing buildings however, this will be more difficult since various system components are already in place, and the preferred approach often is to only replace the heat generator.

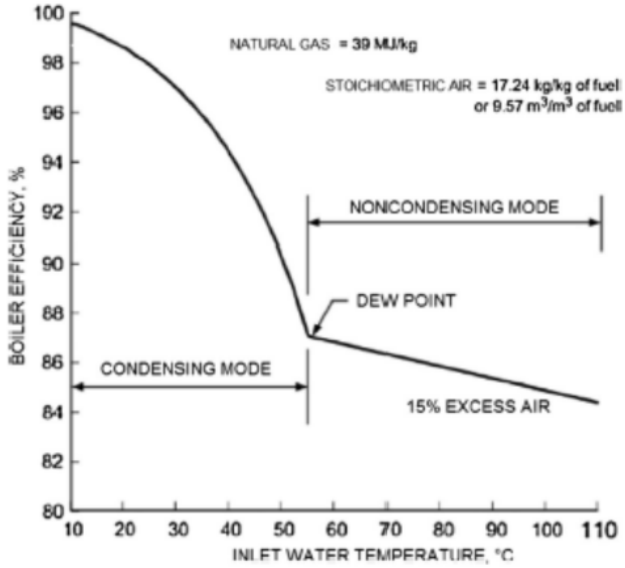
All heating systems, regardless the type of heat generator, will achieve better system efficiencies at low system temperatures. Not only are the heat losses in the distribution system reduced, also the generator efficiency will increase, especially when using **gas-fired condensing boilers** and **heat pumps**. Condensing boilers are the best available technology for gas- and oil-fired boilers. Heat pumps is the best available technology overall showing the best η_s values.

However, in both cases the boilers need to be correctly adjusted so that the interaction between generator efficiency, the design system temperature and the associated supply- or return temperature is optimised. These adjustments are different for the two generator types.

2.3.1 Condensing boilers

Condensing boilers benefit from low return-temperatures. The lower the return temperature, the more condensate the boiler produces. Above return temperatures of 56°C no condensation occurs in the boiler itself (condensate flowing back from the flue ducts or chimney however may be observed, but this condensation does not contribute to the generator efficiency). Below return temperatures of around 56 °C the boiler itself starts producing condensate, simultaneously increasing its efficiency. The efficiency may increase from 87% on Gross Caloric Value of the fuel (GCV) without condensation, to around 97% with full condensation (return temperatures are approaching room temperature levels).

Figure 13: Effect of return temperature (inlet temperature) on the efficiency of a condensing boiler



Source: EC (2019)

2.3.2 Heat pumps

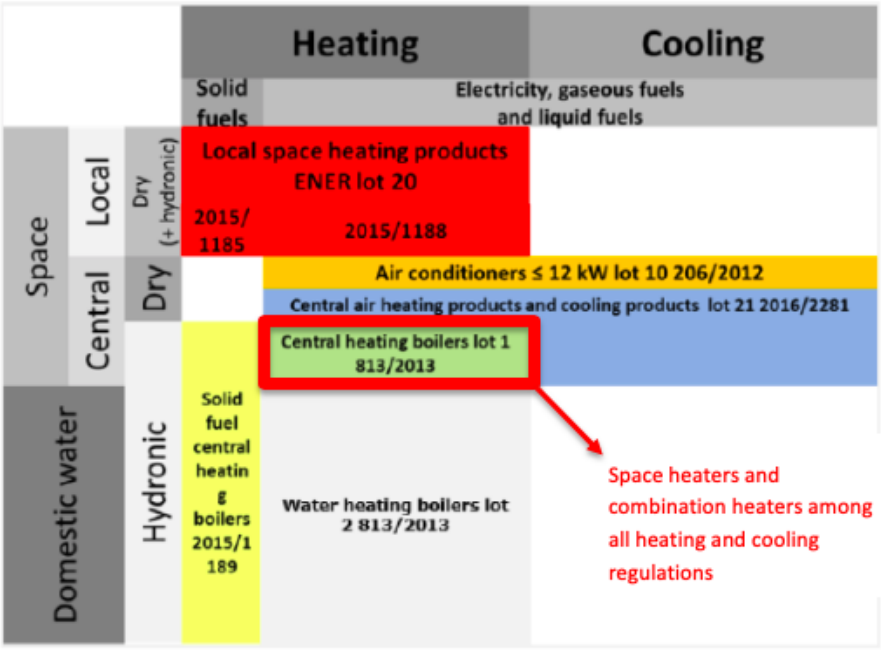
The smaller the temperature different between the outside and the target temperature, the better the COP. If the heating system is a low temperature heating system, the temperature increase from the outside sink to the inside sink is lower.
So contrary to condensing boilers, the heat pump and the supply temperature control system should be optimized to minimize the required increase of temperature on the side of the receiving sink. This means that if the temperature is reduced, it has to be possible to transfer the heat to the room through large surface such as panels or floor heating. For example, it is estimated that a 10°C reduction of the system design temperature (from 50 to 40 °C) can increase the seasonal space-heating efficiency for an average 100 m^2 dwelling by at least 40%.

3 Policy measures, standards and labels

Central heating boilers are the largest Ecodesign and Energy Label regulated product group in terms of energy and other impacts, making up 20% of the total of energy consumption and impacts of Ecodesign and Energy Label regulated products (EC, 2019). One of the key objectives of the two Regulations on heat generators is to improve the efficiency of heat

generators and with it, the overall efficiency of the heating system, resulting in lower energy consumption for space-heating.

Figure 14: Mapping of heating and cooling products according to the European Commission



Source: ECOS (2019)

The Ecodesign and Energy Label regulations for space heaters and combination heaters were published in 2013[4]. Their review started in 2018. The Consultation Forum for these products took place in September 2021. The rescaling of the Energy label for these products has been announced for August 2026. The products benefit from more time to rescale: they have received a derogation from the Energy Label Framework Regulation because they are slow to move to renewable technologies. They have until August 2030 to rescale. However a sooner rescale is preferred by the Commission.

The scope of the Ecodesign and Energy Labelling Regulations on space and combination heaters is different. While the Ecodesign Regulation covers products with a rated output up to 400 kW, the Energy Labelling Regulation covers products with a rated output up to 70 kW.

In both regulations, heaters designed for using gaseous or liquid fuels from biomass are excluded. Heaters using solid fuels are also excluded; these are covered by the Ecodesign and Energy Labelling Regulations with regard to solid fuel boilers (see corresponding criteria paper).

The space heaters covered by the Ecodesign and Energy Label regulations for space heaters and combination heaters can be classified as follows:

- Gaseous fuel boiler space heaters and combination heaters
- Liquid fuel boiler space heaters and combination heaters
- Electric boiler space heaters and combination heaters
- Cogeneration space heaters and combination heaters
- Heat pump space heaters and combination heaters
- Heat pump space heaters with fuel driven combustion unit and combination heaters

[4] Regulations (EU) 811/2013 and (EU) 813/2013 refer to space heaters and combination heaters. Regulations (EU) 812/2013 and (EU) 814/2013 refer to water heaters

3.1 Ecodesign Regulation

Energy efficiency thresholds are based on the seasonal space heating energy efficiency η_s which is the ratio between the space heating demand for a designated heating season, supplied by a heater and the annual energy consumption required to meet this demand, expressed in %. It is based on real-life boiler operation taking part-load efficiency and start-stop losses into account. The higher the η_s value, the more efficient the product.
Each boiler technology has its own minimum energy performance standard. The Regulation foresees an exemption for a specific category of boilers (B1 boilers) commonly operated in apartment houses with common chimneys. This is because retrofitting one condensing boiler would force a retrofit of all the other boilers as well as the common flue system, in order to ensure continued safe operation of the system (also see Chapter 7 on B1 boilers). These boilers are allowed to have an energy efficiency of 75% instead of 86%.

Table 2: Minimum seasonal space heating energy efficiency η_s as of September 2017

Boiler Technology	Seasonal space energy efficiency η_s
Fuel boiler space heaters and fuel boiler combination heaters with rated heat output ≤ 70 kW, with the exception of type B1 boilers with rated heat output ≤ 10 kW and type B1 combination boilers with rated heat output ≤ 30 kW	86%
Type B1 boilers with rated heat output ≤ 10 kW and type B1 combination boilers with rated heat output ≤ 30 kW	75%
Fuel boiler space heaters and combination heaters with rated heat output > 70 kW and ≤ 400 kW	At 100% useful efficiency: 86% At 30% useful efficiency: 94%
Electric boiler space heaters and combination heaters	36%
Cogeneration space heater	100%
Low-temperature heat pumps	125%
Heat pump space heaters and combination heaters, with the exception of low-temperature heat pumps	110%

Source: EC, Regulation (EU) 813/2013 with regard to ecodesign requirements for space heaters and combination heaters.

Combination heaters take the additional water heating energy efficiency factor η_{wh} into account. Similarly to the Ecodesign regulation, for dedicated water heaters (EU No 814/2013), the requirements for the water heating energy efficiency are identical, set according to the tapping patterns and are also technology neutral. Water heaters are distinguished in size classes from 3XS to 4XL with the efficiency requirements rising with the size of the heater. For water heaters as well, the higher the η_{wh}, the more efficient the product.
In addition to the energy efficiency requirements, the Ecodesign regulation on space heaters and combination heaters defines additional compliance criteria aimed at reducing other relevant environmental impacts, including:

- Sound power levels: only relevant for heat pumps. The requirements are size dependant, according to the heat pump's power output. The limit values are given as absolute values of indoor and outdoor sound power levels in A-weighted decibels.
- Nitrogen oxides emissions: relevant for fuel-based space heaters, combination heaters, as well as heat pumps when equipped with supplementary fuel-based heaters.
  For space heaters and water heaters the emission levels are in relation to the fuel input expressed in mg NO_2equ/kWh in terms of Gross Caloric Value (GCV).

- Storage volume – relevant only for hot water storage tanks. The regulation prescribes a minimum load of the storage compartment. This minimum storage is differentiated between the size categories used for water heating efficiency and is given in litres.
- Maximum standing losses – relevant only for hot water storage tanks. The requirements are defined as a power in Watts expressed as a function of the storage capacity.

Table 3: Maximum allowed nitrogen oxides emissions

Type of boiler	Gaseous fuel (input in terms of GCV)	Liquid fuel (input in terms of GCV)
Fuel space heaters and combination heaters	56 mg/kWh	120 mg/kWh
Cogeneration space heater and combination heater with **external** combustion	70 mg/kWh	120 mg/kWh
Cogeneration space heater and combination heater with **internal** combustion	240 mg/kWh	420 mg/kWh
Heat pump heater and combination heater using addition fossil fuel with **external** combustion	70 mg/kWh	120 mg/kWh
Heat pump heater and combination heater using addition fossil fuel with **internal** combustion	240 mg/kWh	420 mg/kWh

Source: EC, Regulation (EU) 813/2013 with regard to ecodesign requirements for space heaters and combination heaters.

3.2 Energy Label

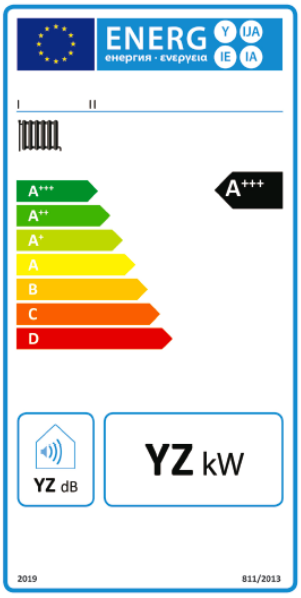
The Energy Label Regulation (EU) No 811/2013 for space heaters and combination heaters ranks products on a scale from A+++ to D. All boilers except for low-temperature heat pump boilers or boilers made for low temperature applications, use the same scale on the energy label. This allows for a comparison of products with one another regardless of the heat generating technology.

Table 4: Energy efficiency classes thresholds for space heaters and low-temperature heat pumps

Energy class	Classes of heaters (excluding low temperature heat pumps)	Classes of low-temperature heat pumps and heat pump space heaters for low-temperature application
A+++	$\eta_s \geq 150$	$\eta_s \geq 175$
A++	$125 \leq \eta_s < 150$	$150 \leq \eta_s < 175$
A+	$98 \leq \eta_s < 125$	$123 \leq \eta_s < 150$
A	$90 \leq \eta_s < 98$	$115 \leq \eta_s < 123$
B	$82 \leq \eta_s < 90$	$107 \leq \eta_s < 115$
C	$75 \leq \eta_s < 82$	$100 \leq \eta_s < 107$
D	$36 \leq \eta_s < 75$	$61 \leq \eta_s < 100$
E	$34 \leq \eta_s < 36$	$59 \leq \eta_s < 61$
F	$30 \leq \eta_s < 34$	$55 \leq \eta_s < 59$
G	$\eta_s < 30$	$\eta_s < 55$

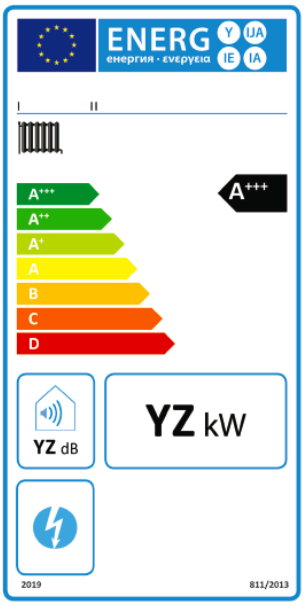
Source: EC, (EU) No 811/2013

Figure 15: Boiler space heaters in seasonal space heating energy efficiency classes A+++ to D



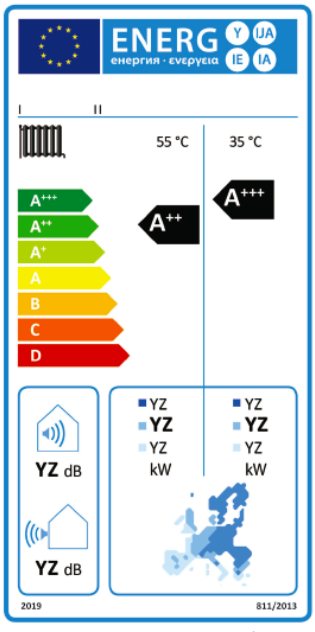
Source: EC, (EU) No 811/2013

Figure 16: Cogeneration space heaters in seasonal space heating energy efficiency classes A+++ to D. The lightning bolt indicates the additional electricity generation functionality.



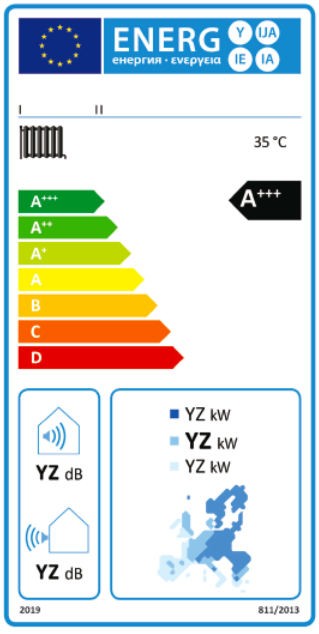
Source: EC, (EU) No 811/2013

Figure 17 : Heat pump space heaters, and heat pump with low temperature application (right scale), in seasonal space heating energy efficiency classes A+++ to D



Source: EC, (EU) No 811/2013

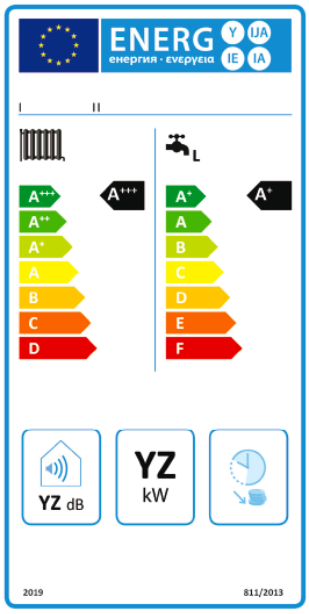
Figure 18 : Low-temperature heat pumps in seasonal space heating energy efficiency classes A +++ to D



Source: EC, (EU) No 811/2013

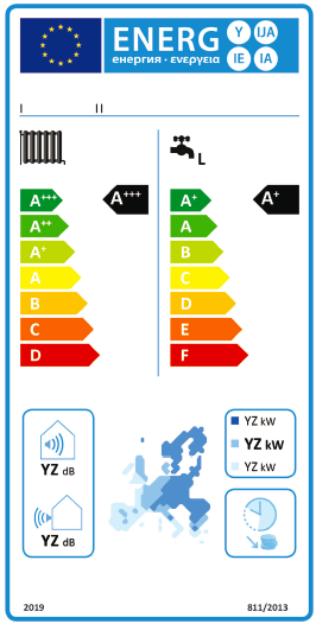
On the label for combination heaters, the double scale refers to the space heating function and the water heating function (the radiator and the tap, as opposed to the double scale on the label for heat pump label with a low temperature application, Figure 17). The tapping patterns is expressed next to the tap pictogram. The scales are different, since the one for water heaters is taken from the Energy label regulation for Water Heaters (EU No 812/2013). The energy class thresholds are based on $\%\eta_{wh}$ and are identical to the one in the Energy Label regulation on water heaters.

Figure 19: Boiler combination heaters in seasonal space heating energy efficiency classes A +++ to D and in water heating energy efficiency classes A + to F



Source: EC, (EU) No 811/2013

Figure 20: Heat pump combination heaters in seasonal space heating energy efficiency classes A +++ to D and in water heating energy efficiency classes A+ to F



Source: EC, (EU) No 811/2013

The pictogram with the clock and coins informs the consumer that the boiler combination heater is able to work only during off-peak hours.

3.3 Policy recommendations

The steps in the revision of the regulation should be coherent with the EU's broader climate objectives and recent reduction targets. It is important that the regulation takes a great step in reducing fossil space heaters and promote the uptake of renewables and heat pumps. The Ecodesign minimum energy efficiency limits should be significantly increased to $\eta_s = 87\%$ in 2023 and to $\eta_s = 105\%$-110% in 2025. Because the regulations have been so delayed, the Commission must set ambitious targets make up for the lost energy savings.
Furthermore, a lot of attention has been put on hydrogen-ready space heating systems[5]. This heating system should not be promoted, and the Commission should not take any regulatory action to promote this system. It is seen as a backdoor to keep fossil fuels longer on the market.

4 Market analysis

4.1 Stock

It is estimated that there are 245 million residential dwellings in the EU in 2014 (including BU, CR and RO). Of these dwellings, 215 million are primary dwellings (households) and almost 30 million are secondary dwellings (weekend- and vacant houses) (EC, 2019).

[5] 'hydrogen-ready' ('H2-ready') of a boiler using gaseous fuel means that the boiler is technically prepared to be converted, within at the most 2 hours, into a safe and efficient boiler using 100% hydrogen as a fuel and is placed on the market by the manufacturer with a conversion kit containing the components to be replaced, a manual for this replacement and a voucher.

In these 245 million dwellings, there are 120 million installed residential individual central heating boiler systems (2014), of which 113 million in the scope of the boiler regulations (i.e. excluding solid fuel boilers) and 30 million dwellings are heated with collective heating, i.e. heated by approximatively 5 million boiler installations (single boilers supplying heat to several apartments with or without back-up or cascades).
The number of boilers installed in buildings in the tertiary sector amounts to 14 million, including at least 1.7 million gas- or oil-fired boilers under a capacity of 400 kW in "dry" air conditioning systems that supply the heat using air as a medium, while using dedicated chillers supply the cooling side.
In comparison to 2004, the stock in 2014 of gas-fired individual central heating systems increased from 70% to 77.25%, the oil-fired equivalent decreased from 22 to 15%, heat pump boilers increased from 0.4 to 1.2%. The number of dwellings with collective heating decreased from 14 to 12% and those with individual "dry" systems increased from 6 to 7%. Dwellings with no or only local heaters decreased from 22 to 21%.

Table 5:EU Domestic heating stock in 1999, 2004 and 2014, in thousand ('000) dwellings

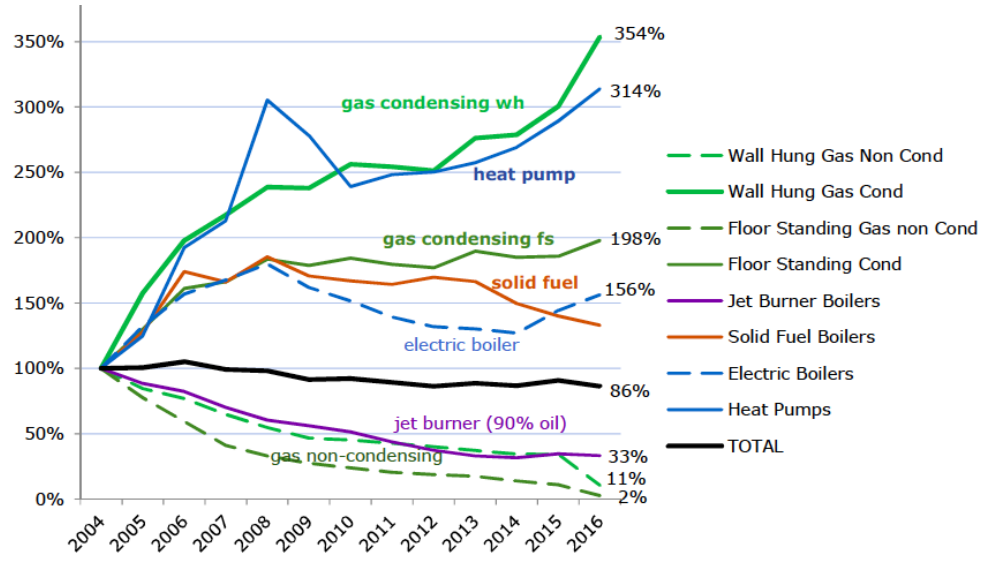
STOCK	1990			2004			2014		
	'000	%	%		%	%	'000	%	%
Individual wet system									
GAS Wall Hung non-condensing	21 880	34%		48 562	48%		46 759	39%	
GAS Wall Hung condensing	446	1%		6 649	7%		35 408	29%	
GAS Floor Standing non-condensing	13 043	20%		15 062	15%		7 620	6%	
GAS Floor Standing condensing	0	0%		0	0%		1 114	1%	
OIL/GAS Jet burner (85-90% oil)	19 224	30%		22 165	22%		18 321	15%	
ELECTRIC CH boilers	937	1%		1 165	1%		976	1%	
ELECTRIC HEAT PUMP CH boilers	129	0%		928	1%		2 998	2%	
SOLID fuel boilers	8 914	14%		6 402	6%		6 912	6%	
Individual wet systems (total)	**64 573**	100%	36%	**100**	100	47%	**120**	100	49%
District	25 738		13%	25 022		11%	27 437		11%
Collective	25 704		13%	30 525		14%	29 741		12%
Individual dry gas/electric	11 300		6%	13 725		6%	17 135		7%
No CH (local heating + no heating)	67 340		35%	49 388		22%	50 148		21%
Total dwellings	**194 659**		100%	**222 589**		100%	**244 569**		100%
Of which total 'wet' (ind.+DH+coll.)	116 015		60%	156 480		72%	177 286		72%

Source: EC, (2019)

4.2 Sales

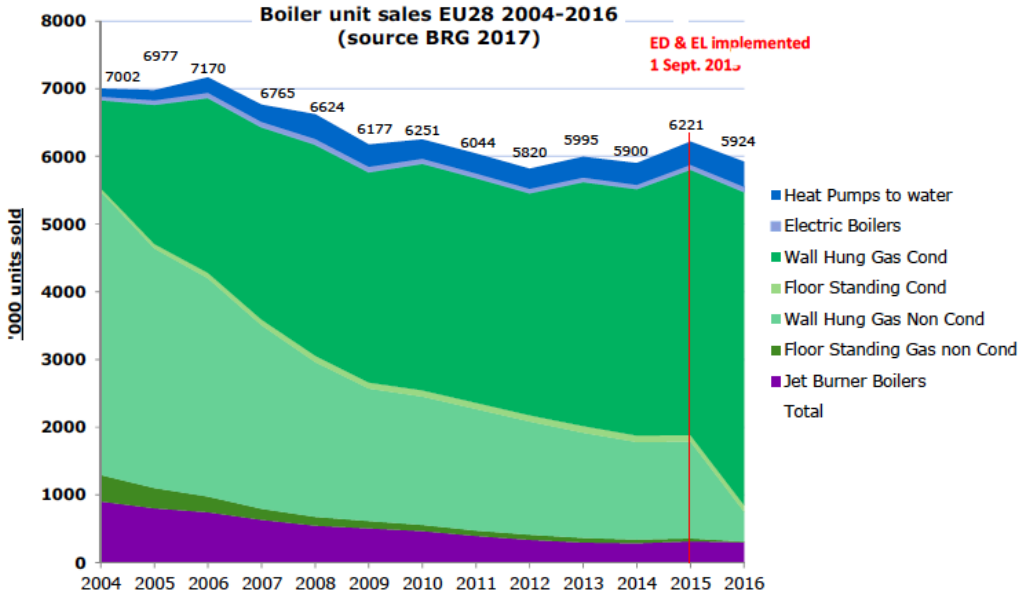
The majority of boiler sales is to replace boilers that have reached their end of life. In 2014 replacement sales were 78% of the total sales (2004: 60%), new housing accounted for 14% (2004: 22%).
First time installations refer to situations where the owner previously had a different heating system (e.g. local heaters or no heating). In 2014 they accounted for 5% (2004: 14%).
In 2016 and according to BRG data, the sales of products in the scope of the boiler regulations amounted to 5.9 million units reaching a total value of EUR 4.9 billion. Among these were over 5.2 million gas-fired boilers and 0.3 million were oil-fired boilers valued in total at EUR 3.6 billion and0.37 million hydronic heat pumps for EUR 1.3 billion. Electric boilers represented less than 0.1 million units.

Figure 21: EU28 Boiler unit sales trend 2004-2016 by type (2004 = 100%)



Source: EC (2019), BRG (2017)

Figure 22: EU28 Boiler unit sales from 2004 to 2016 by type per thousand ('000) units



Source: EC (2019), BRG (2017)

Of these 5.9 million units approximatively,

- 4.9 million are condensing gas- or oil-fired boilers (gas represent 4.75 million and oil 0.15 million) with an average declared seasonal space heating efficiency η_s of 91-93%,
- 0.6 million non-condensing gas- or oil-fired boilers with a η_s of 75%
- 0.26 million are air-to-water heat pumps with a η_s of 145%,
- 0.06 million are ground-source heat pumps with a η_s of 158%
- 0.07 million are electric boilers with a η_s of 35%

Condensing boilers took over the market share of non-condensing boilers and are now almost 90% of the boiler market.

The most common boiler-type sold is the gas-fired wall hung boilers (wh). These boilers have gained popularity over the years compared to the floor standing boilers (fs).

Table 6: EU-28 Boiler sales 2014 per country (excluding MT, CY, LU), per thousand units ('000s)

	Gas wh non-cond	Gas wh cond	Gas fs non-cond	Gas fs cond	Oil jet burner	Electr. boilers	Electr. heat pump	TOTAL
Austria	20.6	21.7	1.1	2.7	4.9	-	15.4	**66**
Belgium	24.7	149.9	2.6	6.1	20.3	-	9.4	**213**
Bulgaria	2.1	1.1	0.0	0.0	0.2	1.9	0.5	**6**
Croatia	9.7	4.9	0.1	0.2	1.7	7.4	0.9	**25**
Czech Republic	31.9	36.3	4.5	0.6	0.3	12.9	8.1	**95**
Denmark	-	19.5	0.0	0.5	1.3	-	5.7	**27**
Estonia	1.0	0.6	0.2	0.0	0.3	0.4	1.7	**4**
Finland	-	-	-	-	2.6	3.4	14.4	**20**
France	212.0	300.5	11.5	18.6	53.3	4.9	78.8	**679**
Germany	98.0	376.4	11.0	36.4	69.0	-	58.4	**649**
Greece	10.9	6.1	0.0	0.0	5.4	0.1	5.4	**28**
Hungary	36.7	24.5	1.7	0.2	0.2	-	1.0	**64**
Ireland	1.7	29.1	0.1	0.4	28.2	0.5	1.5	**61**
Italy	535.8	276.5	10.1	10.3	13.9	-	24.0	**871**
Latvia	2.2	1.3	0.1	0.1	0.1	-	0.6	**4**
Lithuania	3.6	4.6	0.6	0.0	0.2	0.2	0.8	**10**
Netherlands	5.2	399.4	-	0.8	0.2	-	7.3	**413**
Poland	95.0	89.1	2.2	2.8	3.2	0.5	8.0	**201**
Portugal	9.3	2.0	0.1	0.3	1.4	-	2.3	**15**
Romania	169.4	18.9	0.7	0.3	0.9	7.5	0.6	**198**
Slovakia	10.4	19.8	4.4	0.3	0.2	2.7	0.8	**39**
Slovenia	0.3	3.1	0.1	0.1	2.6	0.6	3.4	**10**
Spain	156.0	110.5	1.8	1.6	26.3	-	7.4	**304**
Sweden	-	0.8	-	0.1	0.2	5.7	45.0	**52**
United Kingdom	4.3	1750.4	1.0	14.4	50.3	7.2	18.5	**1846**
TOTAL EU	**1 441**	**3 647**	**54**	**97**	**287**	**56**	**320**	**5900**
Norway	-	-	**0.1**	-	**0.05**	**1.6**	**6.3**	

Source: EC (2019)

Table 7 gives the EU 2014 sales-split of the heat pumps that are in the scope of the regulation. It shows that over two thirds are made up of air-based heat pumps and less than one third is ground-source heat pumps.

Table 7: EU Heat pump boiler unit sales in 2014 per Member State and output power class

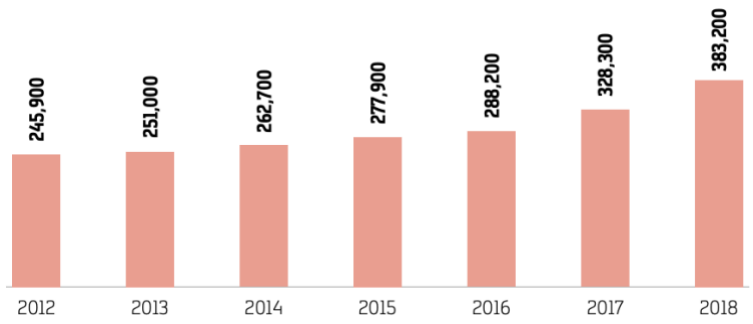
	Heat Pump Outside Air-Water						Heat Pump Ground source						Both
Classes Output (kW)	<5	5<10	10<15	15<20	>20	EU Total	<5	5<10	10<15	15<20	>20	EU Total	EU Total
Average per class (kW)	4	7.5	12.5	17.5	25		4	7.5	12.5	17.5	25		
Austria	1236	6180	2369	309	206	**10300**	165	1763	1786	494	494	**4702**	**15002**
Belgium	1848	3311	2387	116	39	**7701**	289	782	477	85	68	**1701**	**9402**
Bulgaria	29	108	186	29	9	**361**	0	27	94	25	6	**152**	**513**
Croatia	60	443	165	57	27	**752**	5	48	60	25	14	**152**	**904**
Czech Republic	416	4122	948	640	276	**6402**	68	1240	215	91	38	**1652**	**8054**
Denmark	310	1170	1200	211	111	**3002**	600	551	960	150	140	**2401**	**5403**
Estonia	0	25	78	28	0	**131**	48	432	624	304	192	**1600**	**1731**
Finland	71	930	266	125	110	**1502**	2061	6230	1460	450	900	**11101**	**12603**
France	10151	26825	23925	9425	2175	**72501**	187	884	317	1724	289	**3401**	**75902**
Germany	1588	25408	10322	1481	902	**39701**	805	6601	4347	2498	1850	**16101**	**55802**
Greece	212	3392	1378	159	159	**5300**	4	34	21	12	11	**82**	**5382**
Ireland	70	812	364	140	14	**1400**	18	16	31	4	12	**81**	**1481**
Italy	1800	8400	6400	2200	1200	**20000**	45	275	324	131	127	**902**	**20902**
Latvia	0	32	13	2	0	**47**	28	231	143	78	72	**552**	**599**
Lithuania	4	64	26	3	3	**100**	35	294	182	99	91	**701**	**801**
Netherlands	3225	753	172	108	43	**4301**	1725	375	225	75	100	**2500**	**6801**
Poland	240	600	516	840	205	**2401**	275	2255	1430	1254	286	**5500**	**7901**
Portugal	90	417	1688	34	23	**2252**	0	3	6	24	18	**51**	**2303**
Romania	5	115	70	10	0	**200**	0	31	199	56	16	**302**	**502**
Slovakia	0	176	325	34	6	**541**	4	81	66	16	5	**172**	**713**
Slovenia	99	2175	726	0	0	**3000**	13	264	124	0	0	**401**	**3401**
Spain	124	2418	3162	310	186	**6200**	90	180	450	45	135	**900**	**7100**
Sweden	0	3600	3420	581	500	**8101**	2712	11235	8136	969	1550	**24602**	**32703**
United Kingdom	2490	7936	2023	934	2179	**15562**	390	315	480	135	180	**1500**	**17062**
													0
EU TOTAL sales	**24068**	**99412**	**62129**	**17776**	**8373**	**211758**	**9567**	**34147**	**22157**	**8744**	**6594**	**81209**	**292967**
EU TOTAL MW	96	746	777	311	209	2139	38	256	277	153	165	889	3028
EU Average kW/unit						**10.1**						**10.9**	**10.3**

Source: EC (2019)

4.2.1 Sales of heat pump space heaters in the EU

The 2020 report of the heating market by the European Heating Industry (ehi) shows a steady increase in heat pump sales that really started to take off in 2016 (cf. figure 23).

Figure 23: Sales of electric heat pumps in selected European markets that represent of 90% of sales in Europe : Austria, Blegium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom.

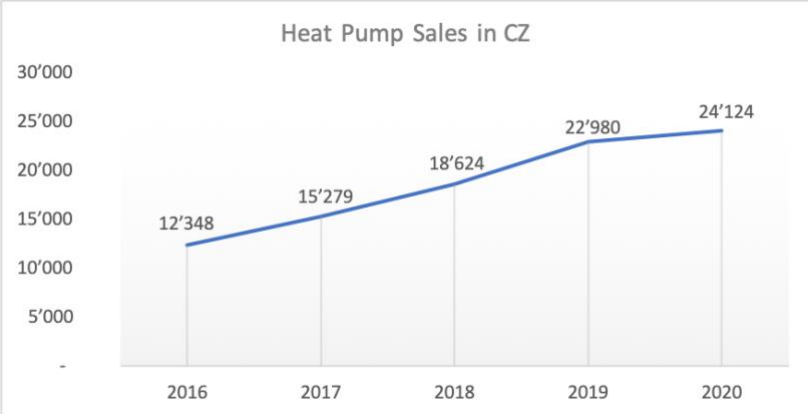


Source: ehi (2020)

Surveys made to the national HACKS partners show that this trend continues in recent years despite the precarious financial situation of many private households due to the Covid-19 pandemic:

- **Belgium:** 2019 with 11’800 sales, 2020 with 15’500 sales (+30 % compared to 2019), 2021 with 17’000 sales of heat pumps (+10 % compared to 2020). Source: ATTB
- **Czech Republic:** The sales numbers almost double (+95 %) from 2016 to 2020. A further increase can realistically be expected after the end of the pandemic due to recovering markets.

Figure 24: Sales of heat pumps in the Czech Republic from 2016 to 2020



Data Source: https://vytapeni.tzb-info.cz/tepelna-cerpadla/19284-tepelna-cerpadla-v-letech-1981-2018-druhy-vyvoj-prodeje-vykony-tepelne-faktory. Graph : Topten.eu

- **Italy** reports a stock of 2.1 million heat pumps in 2019 with sales numbers of 230’000 heat pumps for that year (11 % of stock in 2019)
- **Lithuania:** 2019 with 21’000 sales, 2020 with 22’000 sales (+5 % compared to 2019); for 2022, the forecast is 24’000 units. With a current stock of 180’000 heat pumps on the national market, that would mean yearly sales equal to 13 % of the total stock
- **Poland:** In Poland, the greatest increase in sales is for air-to-water heat pumps for central heating, sales of which increased by around 91% in 2019 compared to 2018; in 2019, approximately 20,300 units were sold (Source: PORT PC). The sales numbers for all heat pump types can be seen in table 8. From 2018 to 2020, the sales increased by over 80%.

Table 8: Changes in sales of different types of heat pumps in Poland during 2018-2019

HEAT PUMP TYPE	Sales in 2018 (units)	Sales in 2019 (units)	Sales in 2020 (units)
Air-to-water heating	10 640	20 296	42 220
VRF system	4 850	5 575	
Air-to-water for hot water only	9 840	10 250	8 650
Brine-to-water	5 381	6 190	5 260
Direct evaporation in soil-to-water	380	450	270
Water-to-water	70	70	
Total:	31 161	42 831	56 400
Compared to previous year		137%	132%

Source: Heat pump market in Poland in 2010-2019. PORT PC (2020)

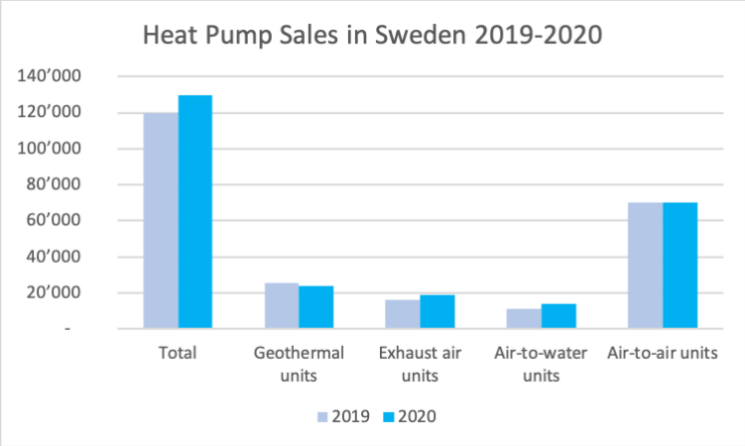
- **Portugal** reports a stock of 38’700 heat pumps in 2020
- **Spain:** The national report highlights the positive development in sales of aerothermal heat pumps (all types of air-to-water equipment up to medium

capacity). In 2020, such air-to-water equipment accounted for around 13.5% of the total machine market in terms of value. This is mainly due to a growth in the aforementioned year of more than 22% in Multi-task Air-Water equipment, clear evidence of the boom in this technology as a combined heating, air-conditioning and domestic hot water production system.

No data is yet available for 2021

- **Sweden** covered the national heat pump market stock in an official 2016 survey and totalled around 1'300'000 units[6]. From the sales of 2017-2021[7], with adjustments for the percentage of new pumps that replace old ones, we can estimate around 1'800'000 units in the beginning of 2022. This includes AtA units and exhaust air units.

Figure 25: Sales of heat pumps in Sweden from 2019 to 2020



Data Source: Svenska Kyl & Värmepumpföreningen, 2021. Graph : Topten.eu

Figure 25 shows an increase in sales for heat pumps in Sweden of 8 % at an already very high level.

- **United Kingdom**: 2019 with 27'000 sales[8], 2020 with 37'000 sales[9] (+37 % compared to 2019), 2021 with 67'000 sales of heat pumps[10] (+81 % compared to 2020); compared to 2019, the 2021 sales are an increase of almost 150%. With a current stock of <250'000 heat pumps on the national market[7], that would mean yearly sales equal to more than 25 % of the total stock.

The difference by country is also clearly visible in the sales numbers of efficient heaters by country for 2018 as presented in the ehi 2020 report: while in some countries, the heat pumps cover 0 % (Netherlands) or barely 1 % of the yearly sales numbers (UK) of "efficient

[6] Source: Energimyndigheten, 2016

[7] Sales for 2021 are not yet official so numbers have been interpolated from sales of the preceding years

[8] Source: https://energysavingtrust.org.uk/the-future-of-heating-in-the-uk-heat-pumps-or-hydrogen/

[9] Source: https://www.greenpeace.org.uk/resources/briefing-uk-poor-record-on-heat-pumps/

[10] Estimate based on Source: https://www.heatpumps.org.uk/uk-heat-pump-market-set-to-almost-double-this-year/

heaters", in other countries like Sweden heat pump technologies come up to 93 % of sales for efficient heaters (EHI, 2020).

5 How to gather data

In the framework of the HACKS project, Topten.eu serves as a reference and starting point for national Topten product lists.
National product lists should reflect market availability of most efficient products for each country. The following procedure is recommended for data gathering:

- Check what products are listed on topten.eu
- Check which of those products are available in your country
- Check national products which are only available in your country to see if they comply with the selection criteria. Inform Topten.eu about them so they can be added to the topten.eu list.

Although the Ecodesign Regulation requires suppliers to provide information in the technical documentation of the products, the information required to make the best product list was in the most cases not declared (% η_s); however, the information is becoming increasingly available in recent updates. This information should also be added to the EPREL database but is not yet accessible to the public.
For the time being, direct contact with manufacturers to request this data is the most effective way to gather data.

5.1 Attributes

The following attributes are shown on Topten because the following product information is important to the consumer in choosing a heat pump. The information is also useful to policymakers to have an understanding of the state of the market.

5.1.1 Topten attributes – February 2022

Attribute name	Example
Provider	Swisstherm AG
Series	AWI 8 Dynamic AC
Efficiency class at 35°C	A++
Efficiency class at 55°C	A++
η_s 35 °C	189 %
η_s 55 °C	137 %
Type	Air-water
Heat output A2/W35 (kW)	10,0
COP A2/W35*	4,12
COP A7/W55*	4,95
COP A-7/W55*	3,90
Inverter technology	Yes
Smart Grid Ready	Yes
Noise level external (dB)	52
Noise level internal (dB)	48
Refrigerant	R410A
Height inside (cm)	107

Width inside (cm)	68
Depth inside (cm)	75
EHPA or CH quality label	CH-HP 00865
Link to manufacturer	http://www.swisstherm.ch

*COP (Coefficient of Performance) is the coefficient of performance or the ratio of heat output (heat output delivered to the heating circuit) to electrical output (power expended). An example: for a heating capacity of 10 kW (e.g. 1st test condition) and an electrical capacity of 2 kW, the COP value is 5 (10 kW / 2 kW = 5). This means that the electrical power used is transformed in 5 times more usable heat output. The COP value of heat pumps listed on Topten was determined by the "heat output" test conditions described below.

6 Input for Consumer Recommendations

On the Topten websites, each product list is accompanied by a recommendation page targeting consumer with recommendations on choosing the right product and how to use it. Below are some examples of what can be included.

6.1.1 Fundamental questions to consider when assessing to change your heating system

Is my current system a low temperature system that uses low temperature floor heating or low temperature radiators?

If no, the outcome will be somewhat more expensive and less efficient. For the installation of a heat pump, there exist "renovation heat pumps" that can deliver heating temperatures of over 60°C. There are also "bivalent" system, that include an additional boiler or heating element for especially cold days. This, however, usually only makes sense in large, existing buildings and requires an assessment of the heating capacity of the heat pump.

What heating capacity shall I install?

In new buildings, the HVAC designer or the installer must calculate the heating capacity (or have it calculated). In existing, older buildings it can be estimated from the past energy consumption (1,000 litres of oil have a calorific value of about 10,000 kWh). Estimating the heating requirement is crucial to choose the right boiler: if the power is undersized, the boiler will not heat the house enough or the consumer will incur additional heating expenses (such as electric local space heater). An oversized boiler, on the other hand, leads to higher purchase costs, higher energy consumption and low efficiency.

6.1.2 Recommendation on the steps to take when changing your space or combination heater

- Your HVAC designer or installer is the best person to rely on when choosing the right product for your home. Once you receive a quote, it is also recommended to ask another expert to assess the offer, especially with regards to the sizing of the boiler.
- Read the label: An A or higher rating means the heater is one of the most efficient heaters on the market and can therefore reduce running costs. You can increase your energy-saving advantages by combining different technologies. When using solar power, you can even reach an A+++ rating!

- When choosing, consider the noise level: The amount of noise a heater makes while operating is rated in decibels (dB). To give you some idea of what the scale means, a conversation at home is rated at 50 dB and a motor-cycle at 100 dB.
- Check your indoor temperature. An increase of 1°C will increase your energy bill by 7%.
- Ideally, ventilate your home with fully open windows twice a day for 5 to 10 minutes. Keep your windows closed the rest of the time during the heating season. Check or control the indoor humidity level, in order to prevent mold formation or dry air problems. In winter the internal humidity should be in the range 30-50%.
- Use your heating controls to adapt the temperature levels to your presence. For instance, when not at home, the temperature can be lowered and avoid unnecessarily heating the home.

7 Terminology

Coefficient of Performance (COP)

The ratio of the heating capacity in Watts to the effective power input in Watts at given rating conditions. In many catalogues the report the COPs accoding to the type of input air:

- Exhaust ventilation air: standard A20/W55 (air is at 20°C and water is heated to 55°C)
- Mixed air: A15/W55
- Outdoor air: A7/W55

The efficiency of a heat pump, the coefficient of performance, highly depends on the temperature level of the heat source and the desired temperature of the heat output. The COP refers to a single steady-state condition where the temperature of the source and the temperature of the sink are described in the standard. These values are not adequate to describe the real efficient over the heating season.

EHPA Quality Label

The label is for heat pump units. It shows to end consumers which units or model ranges are of high quality. The products that receive this label undergo tests according to the international standard EN14511 (space heater heat pump) and EN16147 (standard for domestic hot water heat pump). The ehpa label is available in 12 countries[11].
The minimum SCOP values for space heating heat pumps with their label are the following:

- Brine to Water: 4.30
- Water to Water: 4.30
- Air to Water: 3.50
- Direct exchange ground coupled to water: 4.30
- Exhaust air to water: 3.50
- Air to air: 3.40

[11] In Austria, Belgium, Czech Republic, Denmark, Finland, Germany, the Netherlands, Poland, Slovakia, Sweden, Switzerland, and the United Kingdom. https://www.ehpa.org/quality/quality-label/participating-countries/

Global warming potential (GWP)

The measure of how much 1 kg of the refrigerant applied in the vapour compression cycle is estimated to contribute to global warming, expressed in kg CO 2 equivalents over a 100-year time horizon.

Ozone Depletion Potential (ODP)

The amount of degradation to the stratospheric ozone layer an emitted refrigerant causes relative to trichlorofluoromethane (CFC-11). ODPs in this document refer to "Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer, Twelfth Edition, annexes A, B, C and F".

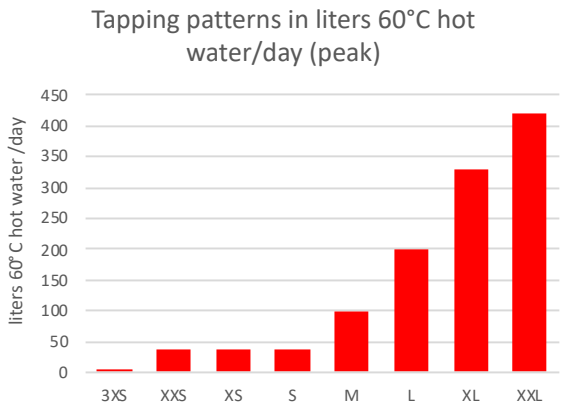
Seasonal space heating energy efficiency (η_s)

The ratio between the space heating demand for a designated heating season, supplied by the heater and the annual consumption required to meet this demand, expressed in %.

Tapping Patterns

Ecodesign energy efficiency limits depend on the capacity of the water heater. The capacity is expressed in "tapping patterns". A pattern is defined in terms of time, temperature and energy-content of hot water draw-offs in typical situations. A pattern relates to peak usage (e.g. on the weekend); the average usage will be 40% lower. The graph relates to litres of 60° C water (at cold water of 10 °C). For showering at 40 °C the capacity, in litres, would be 66% higher. Special provisions apply to 'off-peak' and 'smart' appliances.

Figure 26 : Tapping patterns in liters 60° hot water / day (peak)



Preparatory on Water heatersT1

Amount of people per tapping patterns

Tapping pattern	Usage or number of people
3XS	Handwash
XXS	One sink (for example kitchen sink)
XS	Single point (for example one shower)
S	1 person household
M	2-3 person household (with shower only)
L	4-5 person household (shower with some baths)
XL	4-5 person household (shower and daily baths)
XXL	> 5 person household, 2-family house

Type B1 boiler

A fuel boiler space heater incorporating a draught diverter, intended to be connected to a natural draught flue that evacuates the residues of combustion to the outside of the room containing the fuel boiler space heater, and drawing the combustion air directly from the room. These boiler benefit from an exemption in the Ecodesign regulation for space heaters.

8 References and links

8.1 Useful links

- Topten.eu product lists: https://www.topten.eu/private/products/heat_pumps
- Topten.eu selection criteria: https://www.topten.eu/private/selection-criteria/selection-criteria-heat-pumps
- Tool for calculating the energy efficiency of packages of space, water and combination heaters.
  https://ec.europa.eu/energy/sites/ener/files/documents/LabelTool_AllHeaters.zip

8.2 References

Commission Delegated Regulation (EU) No 811/2013 of 18 February 2013 supplementing Directive 2010/30/EU with regard to energy labelling of space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device1;

Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU with regard to energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device2;

Commission Regulation (EU) No 813/2013 of 2 August 2013 implementing Directive 2009/125/EC with regard to ecodesign requirements for space heaters and combination heaters;

Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC with regard to ecodesign requirements for water heaters and hot water storage tanks

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