HEATING AND COOLING
KNOWHOW AND SOLUTIONS

D3.3 - Topten HACKS Criteria Paper
Water heaters

Source: EC (2019)

Source: https://oekoboiler.com/

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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 (EU, 2018).
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/hacks

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Executive summary

The document provides an overview on dedicated water heaters, 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. It also provides information on how to collect product relevant data for the creation of a corresponding product list of best products.
In the European Union, there are currently over 89 million installed dedicated water heaters (BRG, 2017). In 2016 alone, 9.5 million units were sold, most of which were in the lower energy efficiency classes.
Thanks to the European Energy Label, it is possible using its scale from A+ to F, to identify and compare the energy efficiency of water heaters oil-fired, gas-fired, electric and electric heat pump technologies with one another. The most efficient technology is the heat pump water heater. Depending on the size of the product, they all fall in the highest energy efficiency classes (A or A+).
Finally, the paper also includes information that can be integrated in consumer recommendations on purchase, maintenance and operation of a water heater.
With these 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 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.

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1 Topten selection criteria for water heaters

1.1 Topten.eu: Current selection criteria and products selected

Topten.eu displays water heaters that reach energy class A+ and are measured according to EN 16147: 2011. Currently, only heat pump water heaters are able to comply with the selection criteria.
At the start of the HACKS project, the selection criteria for water heaters on Topten were based on the Coefficient of Performance (COP) values. The COP values are metrics that only apply to heat pump water heaters and that cannot be used to identify water heaters with other technologies (direct electric, gas- or oil-fired). This was done to identify the most efficient products within the class A+ products as all heat pump water heaters fall into the categories A or A+ (the highest class on the energy label for water heaters is A+) and the label for the products was not yet widely available on the market. Water heaters using other technologies than heat pump technologies have not been able to reach those classes.
However, the availability of the energy label for water heaters has become increasingly common in recent years. As it is confusing for consumers when different specifications are used as criteria in parallel and as the EU label is more familiar to consumers, Topten has now changed the criteria to the top class of the EU energy label. An additional benefit is that the validity of the label data is ensured by the market surveillance authorities. The label covers all types of water heaters which allows for the inclusion of other technologies on Topten if ever new technologies are developed that are efficient enough and covers all operating conditions – including no-load operation - which allows the consumers to make truly informed decisions.

1.2 Expected selection criteria at the end of the project in August 2022

As energy class A+ is the highest on the current label according to EU regulation, tightening the selection criteria further in terms of energy efficiency class is not possible. For the last months of the HACKS project, communication with manufacturers and retailers will focus on data and label availability where a great potential is still untapped.

1.3 Best available products

In February 2022, there were 52 models of 22 different brands on the Topten.eu product list for water heaters from the following brand names: alpha innotec, Ariston, Atlantic Suisse AG, Bosch, CTA AG, Delta Solar, Dimplex / Bruderus, Domotec, Elcotherm AG, Heim AG Heizsysteme, Hoval, Makscom Oekoboiler, MHG Heiztechnik, NIBE, Ochsner, Peter Wärmepumpen, Rossato, Stiebel Eltron, Swisstherm, Vaillant, Weishaupt, Windhager.

2 Technical background

2.1 Scope

This criteria paper covers dedicated water heaters. The products covered reflect the scope of the Ecodesign regulation: water heaters with a rated output equal or below 400 kW. The same Ecodesign regulation also regulates hot water storage tanks that are water storage tanks under 2’000 litres. These products are not included in the scope of this criteria paper, but it is recommended that they should be included in the future on Topten as they represent an important part of any heating system.

2.1.1 Technical Terms

Dedicated water heater

Dedicated water heaters are products that only provide hot water for drinking and sanitary use.

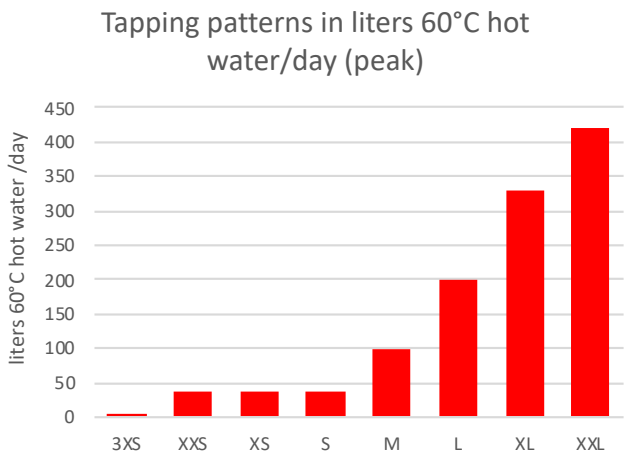
Off-peak water heaters

Off-peak water heaters are water heaters that are energised for a maximum period of 8 consecutive hours between 22:00 and 07:00 of the 24-hour tapping pattern which is during the time where the energy use is its lowest and where in certain markets, the energy price is lower (night tariff).

Load profile

Ecodesign energy efficiency limits depend on the load profile of the water heater. The load profile reflects the "tapping pattern" and provides information on the capacity of the water heater. A pattern is defined in terms of time, temperature and energy-content of hot water draw-offs in typical situations during the peak usage (e.g. on the weekend). During a 2-week measurement cycle, water is drawn from the water heater at regular intervals. The water heater has to be able to maintain the water temperature so that the temperature of the water drawn from it, is constant. Based on this measurement, the manufacturer defines what is the load profile of the product. Special provisions apply to "off-peak" and "smart" appliances.

Figure 1 : Tapping patterns in liters 60° hot water / day (peak)



Source: EC (2019). Review study for water heaters. Task 1.

Table 1: Usage or number of people for each load profile

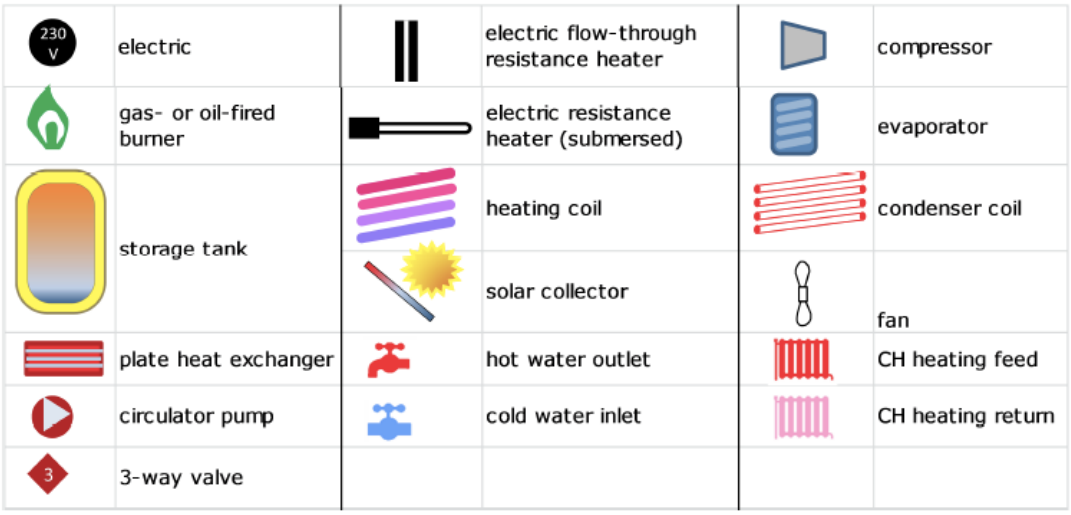
Load profile	**Usage or number of people**
3XS	Handwash
XXS	One sink (for example kitchen sink)
XS	Single point (for example one shower)
S	1-person household
M	2-3-person household (with shower only)
L	4-5-person household (shower with some baths)
XL	4-5-person household (shower and daily baths)
XXL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

Source: EC (2019). Review study for water heaters. Task 1.

2.2 Technical description

It is challenging for consumers to have an overview of the broad range of water heater types. Thanks to the common energy efficiency measurement unit (η_{wh}), it is possible to compare water heaters against one another regardless of their technology. The higher the η_{wh} value, the more efficient the product. The following description of the different water heater types has been extracted from the review study for water heaters and hot water storage tanks.

Figure 2: Legend of components of water heaters

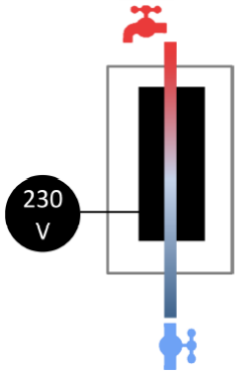


Source: EC (2019). Review study for water heaters. Task 1.

2.2.1 Electric Instantaneous (flow-through) Water Heater (EIWH)

Electric Instantaneous Water Heaters use an electric resistance element to heat up the water in the moment it is needed, i.e. when the user is tapping hot water.
They are compact, don't have any storage energy losses but often require high electric power input (in kW) that is available to households in only limited parts of the EU. They are used predominantly in single-point applications such as under sinks, washbasins or in showers. Maximum tapping patterns are M and usually lower. The traditional EIWH is "hydraulic"; a sophisticated "electronic" EIWH has more control over water temperature and is more efficient.

Figure 3: Schematic representation of an electric instantaneous water heater



Source: EC (2019). Review study for water heaters. Task 1.

Figure 4: EIWH installed under a sink

Source : https://www.reuter.de/clage-klein-durchlauferhitzer-mbh-3-35-kw-230volt-a536766.php

2.2.2 Gas-fired Instantaneous Water Heaters (GIWH)

Gas-fired Instantaneous Water Heaters have a gas burner that heats up sanitary water that runs through a coil when the user is drawing off hot water. Like the EIWHs they are compact,

don’t have storage losses and are used mainly as single point devices for the kitchen sink or bathroom. The gas-grid has no power limits and, with an appropriate design, GIWHs can deal with most tapping patterns and can be used anywhere there is a connection to the gas-grid (or even to smaller gas tanks).
Most GIWHs are “open” combustion devices, which means the combustion air comes from the room and the flue gases go outside through a small chimney in the wall. Older models also emit flue gases to the room but are now largely forbidden for safety reasons. Newer GIWHs are often “closed”, which means that also the combustion air comes from outside. They can also be installed externally for safety reasons.

Figure 5: Schematic representation of a gas-fired instantaneous water heaters

Source: EC (2019). Review study for water heaters. Task 1.

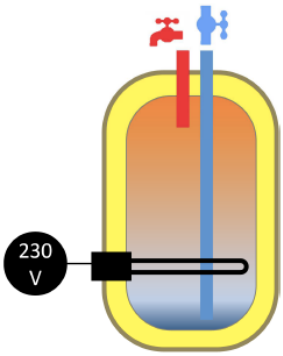
Figure 6: Example of an installed gas-fired instantaneous water heaters

Source : https://www.familyhandyman.com

2.2.3 Electric Storage Water Heaters (ESWH)

Electric Storage Water Heaters use an electric resistance element to heat water in an insulated storage tank. They have a modest electric power input (1.5-3 kW) and can be used anywhere in the EU. They may have tanks as small as 5 liters or even bigger than 500 liters where they keep water at temperatures of 60-80 °C. Despite the insulation the hot water in the tank cools down and must be periodically reheated to maintain the temperature of the water at the same level. These storage losses can be lower when the ESWH does not reheat in periods where there are no hot water draw-offs (at night for example). ESWHs that have this option, with advanced electronics, are called “smart”. The equation that is used to calculate the η_{wh} value takes these features into account.

Figure 7: Schematic representation of an electric storage water heater



Source: EC (2019). Review study for water heaters. Task 1.

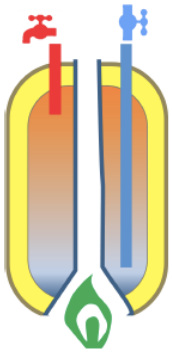
Figure 8: Example of an installed electric storage water heater

Source : https://rointe.com

2.2.4 Gas- or oil-fired fired Storage Water Heaters (GSWH)

Gas- or oil-fired fired Storage Water Heaters have a gas burner that heats up sanitary water in an insulated storage tank. They are used in situations with no or separate space heating. A large tank (150 liters or more) is typical. GSWHs are also subject to storage losses.

Figure 9: Schematic representation of a gas-fired storage water heater

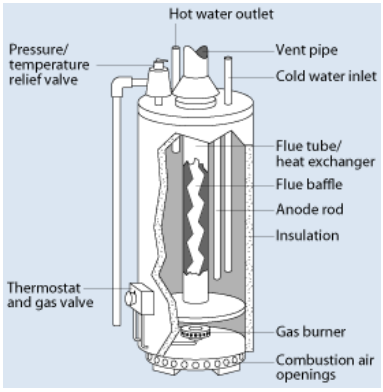


Source: EC (2019). Review study for water heaters. Task 1.

Figure 10: Example of a gas-fired storage water heaters

Source : Ariston.com

Figure 11: Internal view of a gas-fired storage water heater

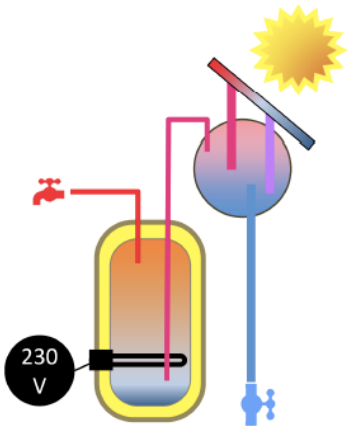


Source : https://www.wikiwand.com

2.2.5 Solar-assisted Electric Storage Water Heaters (ELSOL)

Solar-assisted ESWHs consist of a solar collector to capture the heat from the sun and use thermo-siphon circulation (not needing a circulator pump) to feed an on-the-roof tank, which in turn feeds into an ESWH with a heating element for back-up heating for when there is not enough sun. This configuration is simple, robust and performs well overall Europe.

Figure 12: Schematic representation of a solar assisted electric storage water heater



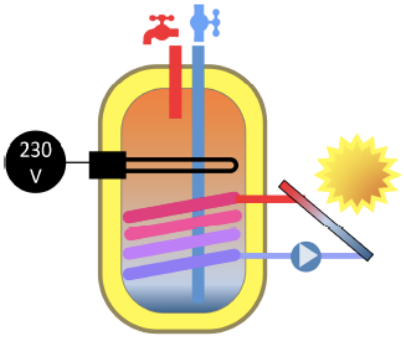
Source: EC (2019). Review study for water heaters. Task 1.

Figure 13: Example of an installed solar assisted electric storage water heater

Source: www.simplysolarspain.com

An alternative configuration uses a single solar storage tank (typically 300 litres) placed inside the house. The tank has an indirect heating coil in the lower part that is heated by the solar collector loop (with small solar circulator). The upper part is used for back-up heating by the electric resistance heater. The collector is a glazed or vacuum tube type that still supplies some solar heat in cloudy and colder weather. It is used in Central and Northern countries in parts where there is no fossil-fuel back-up. Solar water heaters are also subject to storage losses.

Figure 14: Schematic representation of a solar water heating system with an indoor tank.



Source: EC (2019). Review study for water heaters. Task 1.

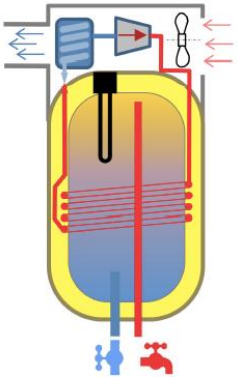
Figure 15: Example of a solar water heating system with an indoor tank.

Source: https://doctorxiasolar.en.made-in-china.com

2.2.6 Heat Pump Water Heaters (HPWH mono)

Dedicated Heat Pump Water Heaters were introduced as mass-product in 2008 to replace ESWHs. They especially targeted the higher load profiles (XL, XXL, 3XL) with tanks from 270 to 450 litres. There are also apartment-style models for M and L load profiles with 80-100 litre tanks. In 2016, the sales of HPWH were 136’000 units and that amount is growing rapidly. The HPWH combines an air-source heat pump with a storage tank. The condenser coil of the heat pump is wrapped around the tank to the other parts (compressor, evaporator, valve, and fan) on top of the tank. Most HPWH have an electric resistance booster. The COP (efficiency) is typically 300-350% and the label rating is minimum “A”. Prices vary, depending on size and manufacturer, between EUR 700 and EUR 3500 and on average EUR 2500 for a 270 litre model (XL/XXL load profile).
The HPWH is installed in unheated or half-heated spaces (garage, utility room) with the exhaust vents expelling the air outdoors. Smaller units can also be installed in heated spaces providing an additional ventilation function.

Figure 16: Schematic representation of a monobloc heat pump water heater



Source: EC (2019). Review study for water heaters. Task 1.

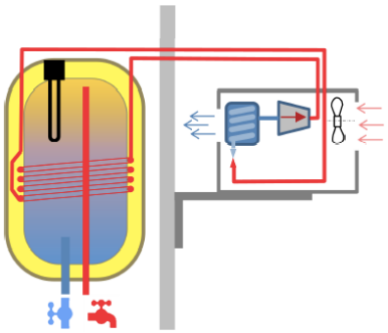
Figure 17: Example of a monobloc heat pump water heater

Source: Nibe.eu

2.2.7 Split Heat Pump Water Heaters (HPWH split)

The HPWH-split unit works like the HPWH-Monobloc but in this case the heat source is outdoor air and the box with the evaporator, compressor and fan is placed not on top of the tank but in a separate outdoor unit. This is a typical configuration in Japan, e.g. for the "Ecocute" types that works with natural refrigerants such as CO_2. In Europe, most heat pumps use refrigerants with high GWP. In recent years, heat pumps with natural refrigerants have appeared on the market. Prices are considerably higher than for the HPWH-Monobloc. Monobloc and split HPWHs as well as GSHPWH (see 2.2.8) have storage losses.

Figure 18: Schematic representation of a split heat pump water heater



Source: EC (2019). Review study for water heaters. Task 1.

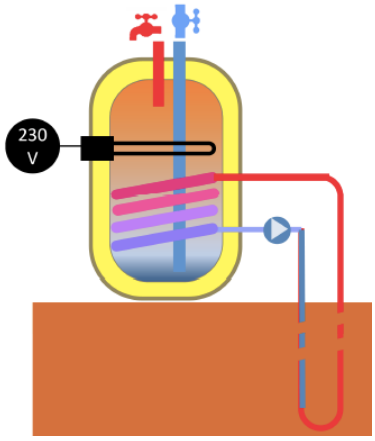
Figure 19: Example of a split heat pump water heater

Source: domotec.ch

2.2.8 Ground Source Water or Water Source Heat Pump (GSHPWH)

With an indirect cylinder and a 3-way valve a water heater can be made from Ground Source or Water Source Heat Pump. These heat pumps are mostly used as a combi, i.e. both for space and sanitary water heating. It works like a SOL-ESWH but instead of having an external loop through a solar collector the loop goes through the heat pump which then exchanges heat with e.g. a soil loop, either horizontally at a depth of 3-5 m or vertically with depths of up to 100 m. The diagram shows the principle; the details of the heat pump (the white box) are not elaborated.

Figure 20: Schematic representation of a ground source heat pump water heater



Source: EC (2019). Review study for water heaters. Task 1.

2.3 Best available technology

The most efficient water heater technology on the market is the heat pump water heater. The efficiency can also be drastically increased by adding solar collectors to the system. All types of storage water heaters can be connected to solar collectors.

2.3.1 Heat pump water heaters

The biggest barrier to heat pump water heaters is the investment cost. Some manufacturers provide a compact solution (for example for single bathrooms) that no longer aims to reach the highest efficiency levels to lower the cost.

Figure 21: Compact wall hung heat pump water heater.

Source: Ariston.com

2.3.2 Electric Storage heaters

The most inefficient water heaters are the electric storage water heaters. Compared to heat pumps that also use electricity to generate heat, electric storage heaters consume 3.5 to 4.5 times more energy. Most energy saving measures have already been implemented for these products (minimal losses from thermal bridges, thermal leakage from insulation, foam insulation options…). Because the equation to calculate η_{wh} takes smart features into account, the use of smart features is the only way to improve the energy class of the product.

2.3.3 Gas instantaneous water heaters (GIWHs)

Their energy efficiency range of these water heaters is very broad. In practice their η_{wh} value ranges from 10% to 91% (for some models sold in Japan).
The most inefficient products are the ones with a pilot light[1]. In a gas-fired storage tank, the heat from the pilot light can at least be used to maintain the heat of the water in the storage tank. To this day, the pilot light is not explicitly forbidden, but it is rare in new equipment. It also raises safety concerns.

2.3.4 Gas storage water heaters

Dedicated gas storage water heaters are relatively rare in Europe. They are often used in (light) commercial applications or residential applications with high hot water consumption/comfort. They exist in non-condensing version and more expensive condensing version[2].

3 Policy measures, standards and labels

The European regulations for water heaters and hot water storage tanks were published in 2013[3]. The review process for both regulations started in 2018 and is still ongoing. A Consultation Forum took place in September 2021 together with space heaters.
Both regulations do not apply to the following types of water heaters:

- Water heaters that are specifically designed for using gaseous or liquid fuels produced from biomass
- Water heaters that use solid fuels (wood, pellets, coal). These products are covered in the EU 2015/1189 Ecodesign regulation and the EU 2015/1187 Energy label regulation (see criteria paper on solid fuel boilers)
- Water heaters that are too small to reach the smallest load profile
- Water heaters that are designed for making hot drinks
- Combination heaters (covered by regulation for "space and combination heaters" (EU) No 813/2013)

The scope of water heaters and hot water storage tanks differs between the Ecodesign and Energy Labelling regulations. Ecodesign covers water heaters with a rated output equal or below 400 kW and storage tanks with a storage volume up to 2000 liters, while the scope of the Energy Label regulation covers water heaters up to 70 kW and hot water storage tanks 500 liters respectively.
The products covered can be classified as follows:

- Water heaters using fossil fuels (oil and gas);
- Electric water heaters;
- Heat pump water heaters;
- Heat pump water heaters with fuel driven combustion unit;
- Storage water heaters;
- Solar water heaters.

3.1 Ecodesign Regulation (EU) No 814/2013

In the Ecodesign regulation the minimum energy performance standards are technology neutral. The water heating energy efficiency (η_{wh}) is the essential parameter for indicating the

[1] The pilot light is the flame that lights the burner when the gas-fired hot water system needs to heat up. The light is on at all times.

[2] See criteria paper on space and combination heaters for information on the condensing and non-condensing technology.

[3] Ecodesign regulations (EU) 814/2013 and Energy Label regulation (EU) 812/2013 for water heaters.

efficiency of the hot water generation. The requirements for the water heating energy efficiency are technology neutral and set according to the heater's load profile. The higher the η_{wh} value, the better the energy efficiency. The heaters have been distinguished in classes from 3XS to 4XL with the efficiency requirements rising with the size of the heater.

Table 2: Minimum energy performance standards for water heaters as of September 2018

Declared load profile	3XS	XXS	XS	S	M	L	XL	XXL	3XL	4XL
Water heating energy efficiency	32%	32%	32%	32%	36%	37%	37%	37%	37%	38%
Smart water heaters	29%	29%	29%	29%	33%	34%	35%	60%	64%	64%

Water heaters with the "smart control" functionality are allowed to be slightly less efficient. A smart water heater automatically adapts the water heating process to individual usage conditions with the aim of reducing energy consumption.

In addition to the energy efficiency requirement, the regulation defines additional compliance criteria aimed at reducing other relevant environmental impacts such as the sound power levels which is only relevant for heat pumps. The requirements are size-dependent, according to the heat pump's load profile. The limit values are given as absolute values of indoor and outdoor sound power levels in (dB)A-weighted decibels.

The regulation also sets a long list of information requirements that shall be provided by the supplier in instruction manuals for installers and end-users, on the free access websites of manufacturers, their authorized representatives and importers, and on the technical documentation:

- Information identifying the model(s), including equivalent models, to which the information relates;
- All results of the calculations of the technical parameters needed to calculate the η_{wh} value, including the η_{wh} value.
- Information relevant for disassembly, recycling and/or disposal at end-of-life.

3.2 The Energy Label regulation (EU) No 812/2013

The Energy Label allows for the comparison of all water heater technologies on the same scale. Unlike air conditioners where split devices are listed on a different scale than mobile units making the comparison impossible for consumer, this system is very straightforward for consumers.

The energy label for water heaters ranges from A+ to F. It is only the label for packages (combinations) of water heater and solar devices that ranges from A+++ to G.

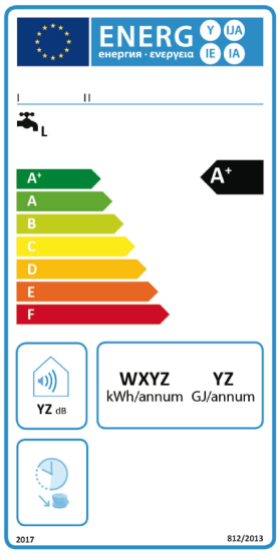
The class intervals however depend on the load profile of the water heater. This makes the comparison in between sizes difficult.

Table 3: Energy class limits of the water heater energy label according to the load profiles.

	3XS	XXS	XS	S	M	L	XL	XXL
A+++	$\eta_{wh} \geq 62$	$\eta_{wh} \geq 62$	$\eta_{wh} \geq 69$	$\eta_{wh} \geq 90$	$\eta_{wh} \geq 163$	$\eta_{wh} \geq 188$	$\eta_{wh} \geq 200$	$\eta_{wh} \geq 213$
A++	$53 \leq \eta_{wh} < 62$	$53 \leq \eta_{wh} < 62$	$61 \leq \eta_{wh} < 69$	$72 \leq \eta_{wh} < 90$	$130 \leq \eta_{wh} < 163$	$150 \leq \eta_{wh} < 188$	$160 \leq \eta_{wh} < 200$	$170 \leq \eta_{wh} < 213$
A+	$44 \leq \eta_{wh} < 53$	$44 \leq \eta_{wh} < 53$	$53 \leq \eta_{wh} < 61$	$55 \leq \eta_{wh} < 72$	$100 \leq \eta_{wh} < 130$	$115 \leq \eta_{wh} < 150$	$123 \leq \eta_{wh} < 160$	$131 \leq \eta_{wh} < 170$
A	$35 \leq \eta_{wh} < 44$	$35 \leq \eta_{wh} < 44$	$38 \leq \eta_{wh} < 53$	$38 \leq \eta_{wh} < 55$	$65 \leq \eta_{wh} < 100$	$75 \leq \eta_{wh} < 115$	$80 \leq \eta_{wh} < 123$	$85 \leq \eta_{wh} < 131$
B	$32 \leq \eta_{wh} < 35$	$32 \leq \eta_{wh} < 35$	$35 \leq \eta_{wh} < 38$	$35 \leq \eta_{wh} < 38$	$39 \leq \eta_{wh} < 65$	$50 \leq \eta_{wh} < 75$	$55 \leq \eta_{wh} < 80$	$60 \leq \eta_{wh} < 85$
C	$29 \leq \eta_{wh} < 32$	$29 \leq \eta_{wh} < 32$	$32 \leq \eta_{wh} < 35$	$32 \leq \eta_{wh} < 35$	$36 \leq \eta_{wh} < 39$	$37 \leq \eta_{wh} < 50$	$38 \leq \eta_{wh} < 55$	$40 \leq \eta_{wh} < 60$
D	$26 \leq \eta_{wh} < 29$	$26 \leq \eta_{wh} < 29$	$29 \leq \eta_{wh} < 32$	$29 \leq \eta_{wh} < 32$	$33 \leq \eta_{wh} < 36$	$34 \leq \eta_{wh} < 37$	$35 \leq \eta_{wh} < 38$	$36 \leq \eta_{wh} < 40$
E	$22 \leq \eta_{wh} < 26$	$23 \leq \eta_{wh} < 26$	$26 \leq \eta_{wh} < 29$	$26 \leq \eta_{wh} < 29$	$30 \leq \eta_{wh} < 33$	$30 \leq \eta_{wh} < 34$	$30 \leq \eta_{wh} < 35$	$32 \leq \eta_{wh} < 36$
F	$19 \leq \eta_{wh} < 22$	$20 \leq \eta_{wh} < 23$	$23 \leq \eta_{wh} < 26$	$23 \leq \eta_{wh} < 26$	$27 \leq \eta_{wh} < 30$	$27 \leq \eta_{wh} < 30$	$27 \leq \eta_{wh} < 30$	$28 \leq \eta_{wh} < 32$
G	$\eta_{wh} < 19$	$\eta_{wh} < 20$	$\eta_{wh} < 23$	$\eta_{wh} < 23$	$\eta_{wh} < 27$	$\eta_{wh} < 27$	$\eta_{wh} < 27$	$\eta_{wh} < 28$

Source: EC, (EU) No 812/2013.

Figure 22: Energy label for conventional water heaters that use electricity, oil or gas



Source: EC, (EU) No 812/2013.

Figure 23: Energy label for heat pump water heaters.

The label shows a European map with three indicative temperature zones.

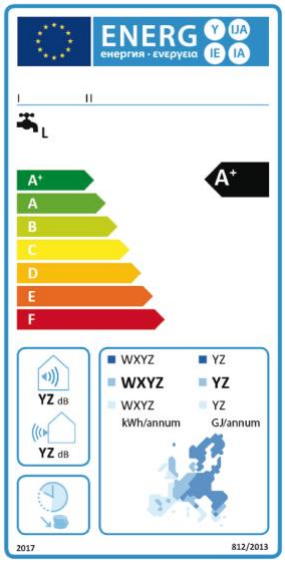
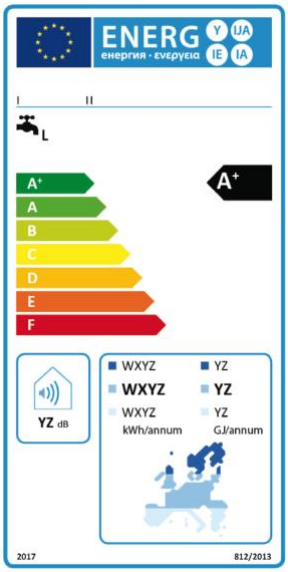


Figure 24: Energy label for solar water heaters.

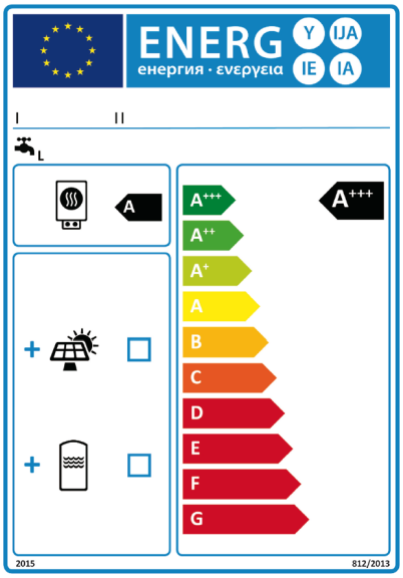
The label for solar water heaters shows a European map displaying three indicative solar irradience zones



Source: EC, (EU) No 812/2013.

Figure 25: Energy label for packages of water heaters and solar devices.

The label shows the energy efficiency of the water heater and whether a hot water storage tank or a solar collector is included in the package. The overall energy efficiency of the package is shown on the right side of the label.



Source: EC, (EU) No 812/2013.

3.3 Policy recommendations

The review study for water heaters was published in October 2019[4]. In the upcoming review, it is recommended that the energy class allows for a better differentiation of highly efficiency

[4] The review study is available on the website of the review study: https://www.ecohotwater-review.eu/documents.htm

products with one another. At the moment, any technical water heater improvements would not be recognised by the energy label: the best class being A+, all further differentiation is not possible.

3.3.1 Policy recommendations on a national level

On a national level, market penetration of highly efficient technology can be strongly promoted with the use of subsidy programmes. These programmes lower the investment costs for the consumer and help overcome the initial hurdle that comes with the purchase of more efficient products.
Another measure is the ban of less efficient solutions. In Switzerland for example, the installation of new electric storage water heaters in new or refurbished residential buildings has been banned.

4 Market analysis

4.1 Stock

In 2014, according to BRG (BRG Building solutions), 89 million EU dwellings (36% of total) used dedicated water heaters as a primary source of sanitary hot water. Apart from that, there are around 53 million secondary dedicated water heaters, used as single tap solution e.g. for the kitchen or bathroom sink.
District heating equipment to supply water heating solutions (24 million dwellings) is not regulated under Ecodesign or Energy Label legislation.
For the non-household sector, it is estimated that the number of hot water tapping points is approximately one-third of that of the household sector.

Table 4: EU primary water heater stock in 2014 per thousand ('000) dwellings

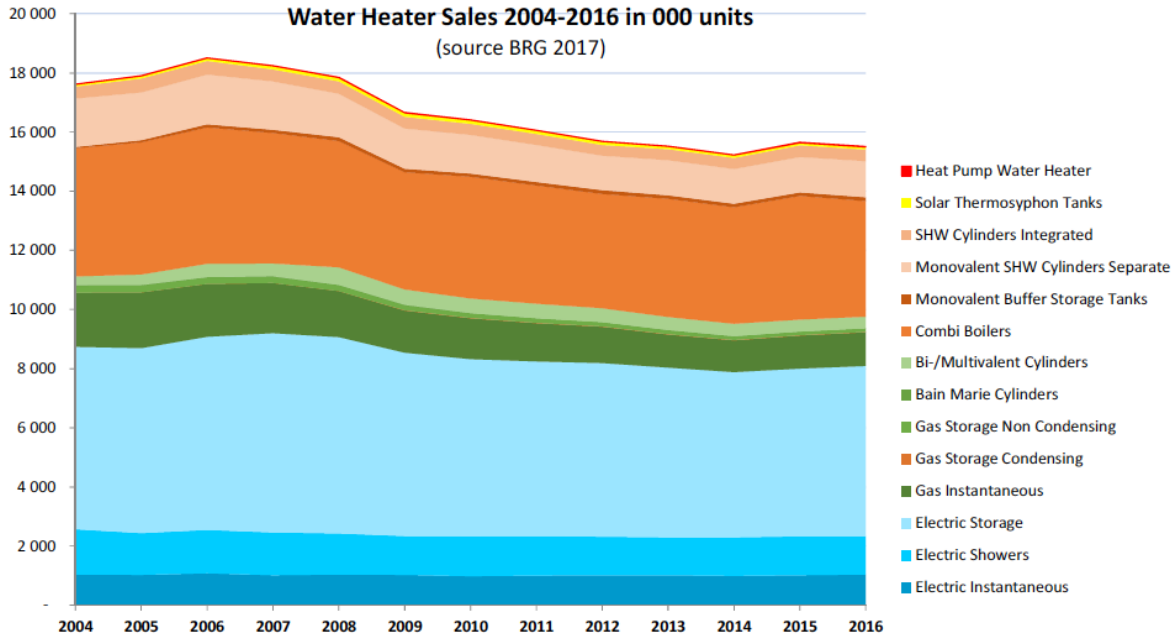
	EIWH	GIWH	ESWH	GSWH	SOL	HPWH	Total WHs
AT	75	40	1'099	12	10	66	**1'302**
BE	28	471	1'173	85	15	20	**1'792**
BG	98	0	2'955	3	1	0	**3'057**
CZ	32	1	728	122	7	1	**891**
DE	6'261	840	1'947	785	24	133	**9'990**
DK	0	1	518	3	0	21	**543**
EE	3	2	249	0	0	0	**254**
ES	55	6'734	7'294	115	131	7	**14'336**
FI	12	0	1'311	0	0	0	**1'323**
FR	0	1'118	14'654	546	38	194	**16'549**
GR	18	6	3'058	13	1'738	0	**4'833**
HR	30	34	1'280	7	2	1	**1'355**
HU	1	176	1'496	447	4	1	**2'125**
EI	51	51	161	37	3	0	**303**
IT	0	2'069	6'925	674	86	7	**9'760**
LT	5	2	388	0	0	0	**395**
LV	2	1	317	2	0	0	**322**
NL	4	74	310	83	48	20	**540**
PL	591	794	2'525	264	0	39	**4'212**
PT	1	4'203	927	34	104	19	**5'288**
RO	0	352	4'621	23	0	1	**4'997**
SI	1	3	278	0	1	50	**333**
SK	55	14	496	116	2	0	**683**
SV	20	0	1'336	0	12	0	**1'368**
UK	988	186	1'045	215	19	4	**2'457**
EU	8'331	17'172	57'091	3'586	2'245	584	**89'008**

Source: BRG 2017

4.2 Sales

Total EU water heater sales, including combi-boilers, dropped 15% after the 2007 financial crisis, i.e. from 18.5 million units in 2006 to 15.6 million units in 2016. Sales have stabilized at this level. Dedicated water heaters represent approximatively 60% of unit sales (9.5 million units). The highest growth in sales was for the (monobloc) heat pump water heater, where 136'000 units were sold in 2016, which is 109'000 more than in 2007. Sales of solar thermal panels are declining at a rate of over 6% per year. The largest sales drop, on aggregate 50% over the last decade, comes from gas-fired storage water heaters (GSWHs).

Figure 26: Water heater sales from 2004 to 2016 in '000 units



Source: BRG (2017).

According to Eurostat statistics, the total 2015 residential energy consumption for all water heating, including combi-heaters and excluding water heating from solid fuel boilers, is around 1978 PJ (47.2 Mtoe) in primary energy. When adding an extra one-third for non-household applications, this amounts to 2637 PJ (62.9 Mtoe) primary energy.

5 How to gather data

Topten.eu serves as reference and starting point for national Topten product lists.
National Topten 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 is in most cases not declared. This information should be added to the EPREL database which should soon be accessible to the public by the end of 2020.
For the time being, direct contact with manufacturers to request this data will probably be the most effective way to gather data. The product information is determined by measuring the energy consumption according to the harmonized European measurement standard that are published in the European Journal.

5.1 Attributes

5.1.1 Existing attributes

The following attributes correspond to the attributes that are displayed on Topten.eu for heat pump water heaters[5].

Table 5: Attributes on Topten.eu for heat pump water heaters (February 2022)

Attribute	Example
Brand	CTA AG
Model	C M B E WP 260
η_{wh} **average**	145 %
η_{wh} **cold**	145 %
η_{wh} **warm**	145 %
Annual energy consumption average	1'159 kWh/year
Annual energy consumption cold	1'159 kWh/year
Annual energy consumption warm	1'159 kWh/year
COP A20 measured	4.2
Electric heating (kW)	1.5
Additional heat exchanger	No
Load profile	XL
Sound power level (dB)	56
Temperature source/water (°C)	A20 W10-52.2[6]
Air ducts	Yes
Content (l)	260
Height (cm)	196
Width (cm)	62
Depth (cm)	62
Weight (kg)	98
PV option	Yes
Link to manufacturer	http://www.cta.ch

Source: Topten.eu

5.1.2 New attributes

Table 6: Proposal of new Topten attributes for the water heater product list (when needed)

Attribute	Unit
Water heater type	List with the different technology types
COP A15/W55	x.x
COP A7/W55	x.x

6 Input for Consumer Recommendations

Cost-savings over the lifetime of the product with an efficient product

Using the energy label to assess the energy efficiency of their water heaters is a good way for consumers to compare all technologies with one another and save over the lifetime of the product.

[5] Each attribute is explained on the selection criteria page on Totpen.eu.

[6] At an ambient air temperature of 20°C, the water heater can bring water that is at 10°C to 52.5°C.

Consumers that generate their warm water using electricity can save substantially when choosing a heat pump water heater instead of common electric water heaters even though the purchase price is higher.

Table 7: Comparison of life-cycle costs in between an electric storage water heater and a heat pump water heater

		Electric water heater (300l)	Heat pump water heater (300l)	
Total thermal energy	kWh/day	12.3		
Of which 15% heat loss	kWh/day	1.8		
85% useful heat	kWh/day	10.5		
COP		1	2.8	2.9
Electrical power to cover storage losses	W	77	27	27
Energy consumption per day	kWh	12.3	4.4	4.2
Energy consumption per year	kWh	4'490	1'603	1'548
Energy saving	kWh		2'886	2'941
Electricity costs over 15 years*	EUR	8'755	3'127	3'019
Electricity savings	EUR		5'628	5'736
Purchase price	EUR	2'000	4'000	4'000
Total costs	EUR	10'755	7'127	7'019

*Source: Topten.ch. *Cost of electricity assuming that the night tariff is mainly used: 13cts/kWh.*

Sizing of the water heater:

When choosing it is important not to oversize the water heater. This will lead to high heat losses and low efficiency. Water heaters between 200 - 300 liters are usually sufficient in one-family homes; this corresponds to the average hot water requirement of 4 - 6 persons. For two apartments 300 - 400 liters is a reasonable size (see section 2.1.1 on load profile).

Health issues and energy efficiency

The energy efficiency of the heat pump (COP) is better when the temperature difference between the heat source (ambient air) and hot water is the smallest. It is not necessary to set the thermostat on the highest maximum temperature. However, when the temperature is below 55°C, legionella bacteria can grow in the water heater and be dangerous to the users. A so-called legionella circuit (heating up to 60 to 65°C once a week) can be used to prevent this.

Installation of the water heater

If the water heater is in the basement, its efficiency will be increased if the ambient air temperature is not unnecessarily lowered by having for example an open window. This is especially relevant for heat pump water heaters as the temperature difference in between the ambient air and water should be as small as possible. It is also important that the air remains dry so that condensation does not get deposited on the heat exchangers.

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 COPs are reported according 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

Global warming potential (GWP)

The measure of how much 1 kg refrigerant in a vapour compression cycle is estimated to contribute to global warming, expressed in kg CO_2 equivalents over a 100-year time horizon.

EHPA Quality Label

The label is a private quality label for heat pump units. It shows 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 13 countries[7].
The website lists the product that fulfil the label's selection criteria, but the exact values are not displayed. There are no minimum COP values for domestic hot water heat pumps.

Exhaust air heat pump

Exhaust air heat pumps use energy from indoor air to provide heating, sanitary hot water. They can either use indoor air or be connected to a forced ventilation system. Most often, these systems are used for sanitary hot water preparation, not heating, due to limited heating capacity, but increasingly being marketed as a heating solution.

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

8 References and links

8.1 Useful links

- Topten.eu product lists: https://www.topten.eu/private/products/electric_water_heaters
- Topten.eu selection criteria: https://www.topten.eu/private/selection-criteria/electric-water-heaters
- 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 device;
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
European Commission. (2019). Review study of ecodesign and energy labelling for water heaters and tanks. Available at https://www.ecohotwater-review.eu/documents.htm
European Commission. (2018). Guidelines accompanying Regulations (EU) No 811 & 812/2013, Regulations (EU) No 813 & 814/2013 and Regulations (EU) 2015/1187 & 1189.