

D3.2 - Topten HACKS Criteria Paper

Water heaters





Source: EC (2019)

Source: https://oekoboiler.com/

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HACKS coordinator: ADEME – www.ademe.fr European portal <u>www.topten.eu/hacks</u> Project partners and websites

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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 <u>www.topten.eu/hacks</u>



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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

For the time being, Topten.eu only displays heat pump water heaters. Currently, the list and selection criteria on Topten.eu are identical to the list and selection criteria on Topten Switzerland as Topten Switzerland is the only Topten partner presenting these products. The list on Topten.eu will evolve as efficient models from other Topten countries are added to it and as the selection criteria evolve.

The current criteria are based on metrics that only apply to heat pumps (Coefficient of performance, COP, see Chapter 7) and they cannot be used to identify water heaters with other technologies (direct electric, gas- or oil-fired) as is possible with the European labelling system.

The use of the Energy label only, does not sufficiently differentiate heat pump water heaters on the market from one another as they all fall into the classes A or A+ (the highest class on the energy label for water heaters is A+). It is not possible to differentiate products that are much more efficient than the A+ threshold.

For these reasons, the selection criteria on Topten.eu are based on the COP. They are the following:

- Heat pump water heaters must be certified according to the Swiss FWS Quality Label
- The coefficient of performance (COP) must be at least:
 - Air temperature $15^{\circ}C: \ge 2.9$
 - Air temperature 7° C: ≥ 2.9
 - Air temperature 20° C: ≥ 3.2
- The energy consumption must be measured according to EN 16147:2011 (measurement standard for domestic hot water units)

No HACKS partners have a product list for water heaters. Topprodukte.at publishes a list of energy efficient hot water storage tanks¹.

1.2 Expected selection criteria in 2020

For the HACKS project, the selection criteria will be based on the water heating energy efficiency values ($\%\eta_{wh}$). This metric is used to define the energy classes in the Energy Label for water heaters. It is technology neutral, which means that all water heaters have their own η_{wh} and are placed on the same scale. The higher the η_{wh} value, the more efficient the product.

It is proposed to use the following selection criteria on Topten.eu. The selection criteria shall be in accordance with the size of the water heaters (M, L, XL and XXL). So far, no smaller heat pump water heaters have been found on the market (from 3XS to S):

- M: 110 %
- L: 115 %
- XL: 120 %
- XXL: 125 %

The review study for water heaters (EC, 2019) conducted a market research and evaluated the average energy efficiency of water heaters according to their load profile and technology. The efficiency values are taken from anecdotal catalogue data, because robust data was not available. The data took at least 12 months to retrieve. Table 1 shows the results of that exercise and lists the average efficiencies for each technology and load profile (load profile are explained below) of products that were on the market in 2018-

 $^{^{1}\,}https://www.topprodukte.at/de/Auswahlkriterien/topproductscat1/115/topproductscat2/116/topproductscat3/119.html$

2019. Based on the results, it can be expected that there is a bias in these values and that only the efficient products declared their energy efficiency values. The energy efficiency value ($\%\eta_{wh}$) set for the Topten / HACKS selection criteria should therefore not be lower than the ones listed in the table below because these are average products from several years ago.

Efficiency		3XS	XXS	XS	S	М	L	XL	XXL	3XL	4XL
Storage losses	kWh/y	285	329	329	430	567	641	728	810	1022	1302
EIWH hydraulic			30%	32%	30%						
EIWH electronic			38%	35%	38%						
GIWH			40%	45%	55%	65%	65%	65%			
GSWH						42%	48%	51%	52%	55%	56%
ESWH		24%	23%	23%	26%	30%	31%	33%	34%	35%	37%
HPWH outdoor air (split)							92%	92%	92%		
HPWH ventilation air						100%	120%	120%	120%		
GSHP									150%	150%	150%
ELSOL						38%	45%	56%	63%	74%	76%
MEPS in force		32%	32%	32%	32%	36%	37%	37%	37%	37%	38%
Smart water heaters		29%	29%	29%	29%	33%	34%	35%	60%	64%	64%

Table 1: Efficiencies of water heaters technologies according to their load profile

Source: EC (2019). Review Study on Water heaters – Task 5.

<u>Acronyms</u>

- EIWH: Electric Instantaneous (flow-through) Water Heater
- GIWH: Gas- or oil-fired Instantaneous Water Heater
- GSWH: Gas- or oil-fired Storage Water Heater
- ESWH: Electric Storage Water Heater
- HPWH: Heat Pump Water Heater
- GSHP: electric Ground Source Heat Pump (water/brine-t-water)
- ELSOL: Electric-assisted solar with a ESWH as storage

It is easier for larger products to achieve higher energy efficiency values; this is why the MEPS are higher for products with larger load profile. However, it is important to keep in mind that the absolute energy consumption is higher for larger products.

The storage losses are the average storage losses for any water heater with a storage tank or dedicated hot water tanks (not in the scope of this criteria paper).

The MEPS are the MEPS set by the current regulation. They were tightened in September 2018 and will remain so until the revision of the regulation. It is noted that in the table, the η_{wh} values for electric storage water heaters are lower than the MEPS. The reason for this is not explained in the review study. The values are even lower than the MEPS of water heaters with the additional "smart" function² which gives them a bonus in the regulation on Ecodesign (see 2.2.3).

Each partner of the HACKS project shall determine their own selection criteria using a minimum η_{wh} efficiency value for each technology and load profile (i.e. size) they deem is relevant in their market, based on the situation of their domestic market.

² A smart water heater automatically adapts the water heating process to individual usage conditions with the aim of reducing energy consumption

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 the following 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 thw product. Special provisions apply to "off-peak" and "smart" appliances.

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

Tapping patterns in liters 60°C hot



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

Table 2: 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
М	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 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

230 V	electric		electric flow-through resistance heater		compressor
Ó	gas- or oil-fired burner		electric resistance heater (submersed)		evaporator
	storage tank		heating coil		condenser coil
			solar collector	A	fan
	plate heat exchanger	ä	hot water outlet		CH heating feed
	circulator pump		cold water inlet		CH heating return
3	3-way valve				

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 Figure 4: EIWH installed under a sink







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

Source : <u>https://www.reuter.de/clage-klein-</u> 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-firedFigure 6: Example of an installed gas-fired instantaneousinstantaneous water heaterswater heaters





Source: EC (2019). Review study for water heaters. Task 1. 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 storageFigure 8: Example of an installed electric storage waterwater heaterheater







Source: EC (2019). Review study for water heaters. Task 1. Source : <u>https://rointe.com</u>

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 representationFigure 10: Example of a gas-firedof a gas-fired storage water heaterstorage water heaters





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



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

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



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



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

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



indoor tank.

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

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

Heat Pump Water Heaters (HPWH mono) 2.2.6

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 liters. There are also apartment-style models for M and L load profiles with 80-100 liter 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 liter 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 Figure 17: Example of a monobloc heat pump water heater pump water heater



Source: EC (2019). Review study for water heaters. Task 1. 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 CO₂. 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 Figure 19: Example of a split heat pump water heater water heater





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





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

2.3 Best available technology

The most efficient water heater technology 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 are the investment costs. 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. These smaller tanks can cost as low as EUR 460.

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 light³. 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 version⁴.

3 Policy measures, standards and labels

The regulations for water heaters and hot water storage tanks were published in 2013⁵. The review process for both regulations started in 2018.

Both regulations do not apply to the following types of water heaters:

³ 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.

⁴ See criteria paper on space and combination heaters for information on the condensing and non-condensing technology.

⁵ Ecodesign regulations (EU) 814/2013 and Energy Label regulation (EU) 812/2013 for 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 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.

Declared load profile	3XS	XXS	XS	s	м	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%

Table 3: Minimum energy performance standards for water heaters as of September 2018

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 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 result 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. ٠

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 device 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.

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

Table 4: Energy class limits of the water heater energy label according to the load profiles.

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

Figure 22: Energy label for conventional water heaters that Figure 23: Energy label for heat pump water heaters. use electricity, oil or gas



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

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

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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.

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

3.3 Policy recommendations

The review study for water heaters is in process and the final version of the preparatory study was published in October 2019⁶. In the upcoming review, it is recommended that the energy class allows for a better differentiation of highly efficiency products with one another. At the moment, water heater heat pumps do not have much incentives to improve: this is not acknowledged by the energy label since the models cannot be better than A+.

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.

⁶ The review study is available on the website of the review study: <u>https://www.ecohotwater-review.eu/documents.htm</u>

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.

	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
ІТ	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
РТ	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

Table 5: EU primary water heater stock in 2014 per thousand ('000) dwellings

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



According to new 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 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 and 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 <u>European Journal</u>.

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 heaters⁷. Additional attributes shall be added to include the other water heating technologies.

Table 6: Attributes on Topten.eu for heat pump water heaters

Attribute	Example	
Brand	CTA AG	
Model	C M B E WP 260	
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 ⁸	
Air ducts	Yes	
Content (I)	260	
Height (cm)	196	
Width (cm)	62	
Depth (cm)	62	
Weight (kg)	98	
PV option	Yes	
FWS certificate	FWS (Metrotherm – Metroair Aqua201)	
Link to manufacturer	http://www.cta.ch	

Source : Topten.eu

The following attributes will be removed:

• FWS certificate

 $^{^{7}}$ Each attribute is explained on the selection criteria page on Totpen.eu.

 $^{^{8}}$ At an ambient air temperature of 20°C, the water heater can bring water that is at 10°C to 52.5°C.

5.1.2 New attributes

Attribute	Unit
η _{wh} average	%
η_{wh} cold	%
η _{wh} warm	%
Annual energy consumption average	kWh/annum
Annual energy consumption cold	kWh/annum
Annual energy consumption warm	kWh/annum
Water heater type	List with the different technology types
COP A15/W55	х.х
COP A7/W55	х.х

Table 7: Proposal of new attributes for the water heater product list

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.

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.

		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			
СОР		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	

Table 8: Comparison of life-cycle costs in between an electric storage water heater and a heat pump water heater

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) for instance 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 countries⁹.

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.

⁹ In Austria, Belgium, Czech Republic, Denmark, Finland, Germany, the Netherlands, Poland, Slovakia, Sweden, Switzerland, the United Kingdom and France. <u>https://www.ehpa.org/quality/quality-label/participating-countries/</u>

8 References and links

8.1 Useful links

- Topten.eu product lists: <u>https://www.topten.eu/private/products/electric_water_heaters</u>
- Topten.eu selection criteria: <u>https://www.topten.eu/private/selection-criteria/electric-water-heaters</u>
- 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 <u>https://www.ecohotwater-review.eu/documents.htm</u>

European Commission. (2018). Guidelines accompanying Regulations (EU) No 811 & 812/2013, Regulations (EU) No 813 & 814/2013 and Regulations (EU) 2015/1187 & 1189.