POSITION PAPER

EFFICIENCY OF WATER-BASED SPACE HEATERS

SETTING THE THRESHOLDS FOR THE ECODESIGN REGULATION

Authors: **Marco Grippa**, ECOS & **Gunnar Boye Olesen**, ECOS Expert

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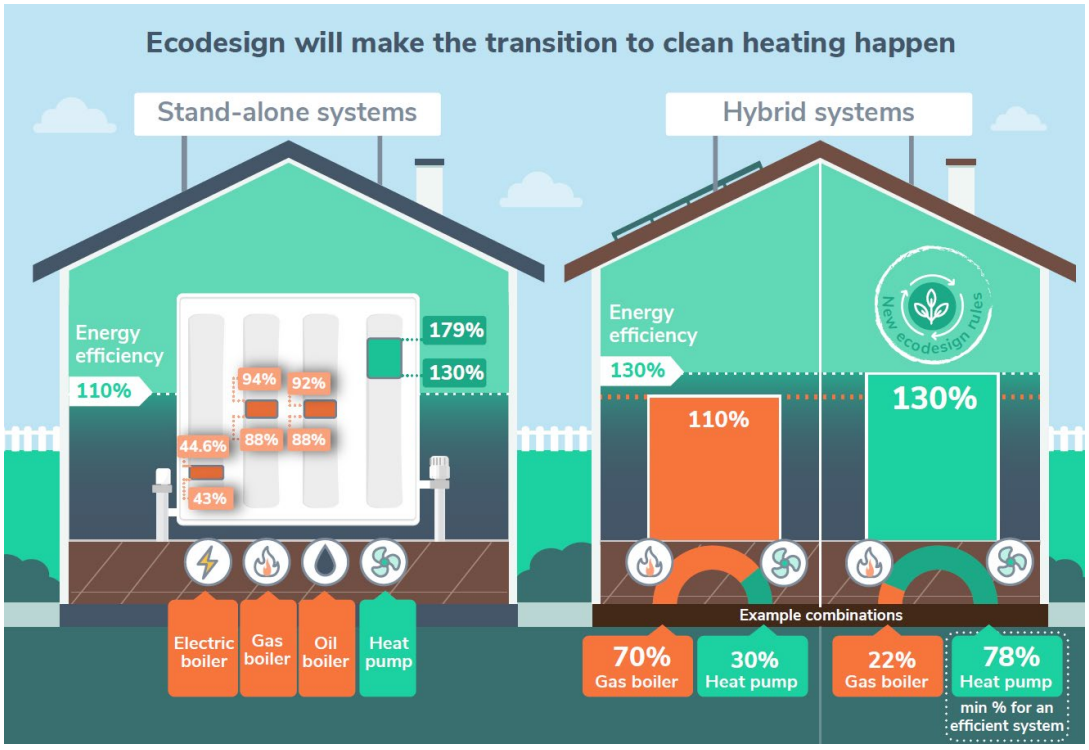
INTRODUCTION

This document gives an overview of energy efficiencies of boilers, heat pumps (HPs), hybrid systems, micro-scale combined heat and power (mCHP), etc. for water-based (hydronic) heating systems. It analyses the technologies covered by the Ecodesign regulation (EU 2013/813), but with efficiencies and limits according to draft revised ecodesign regulation presented in the last Consultation Forum (CF) meeting, held in September 2021 and using the new Primary Energy Factor (PEF) of 2.1.

This is a background document to the Coolproducts campaign's proposal for phasing out fossil fuel heaters by setting an energy efficiency limit of 110% and an additional limit of 130% for hybrid heating systems of heat pumps and fuel boilers. These thresholds will still allow the most efficient fossil fuel equipment such as CHP, but will not allow 'stand-alone' oil and gas boilers and fossil fuel boilers with smaller additions that could increase their efficiency to above 100%, without reaching 110%, e.g., inclusion of Peltier element in CHP gas boiler, as described later in the document.



ENERGY EFFICIENCIES

The ecodesign technologies and their efficiencies are listed in Table 1, including the proposed ecodesign thresholds as well as the maximum efficiencies achievable for each technology.

Technologies	Minimum efficiency	Maximum efficiency	Information source	Comments
Electric resistance heaters	43%	44,6%	Theoretical	No envelope loss, 1 W standby
Gas boilers	88%	94%	Market data	for Viessmann Vitodens 100-W, BTHF 3,2-32 kW
Oil boilers	88%	92%	Market data	for Vaillant VKO356/3-7 - 22,1 kW
Electrically driven heat pumps	130%	179%	Market data	for Hoval AG Belaria pro comfort , air/water, 8,7 kW
Gas fired CHP	100%	122%	Theoretical	Boiler efficiency as above gas boiler, 25% electric output of gas use
Oil fired CHP	100%	120%	Theoretical	Boiler efficiency as above oil boiler, 25% electric output of oil use
Gas fired HPs	115%	161%	Theoretical	Combining above CHP with above heat pump
Oil fired HPs	115%	159%	Theoretical	Combining above CHP with above heat pump
Hybrids of electric HPs and gas boiler	110%	161%	Theoretical	Combining 70% above HP, 30% above gas boiler
Hybrids of electric HPs and oil boiler	110%	160%	Theoretical	Combining 70% above HP, 30% above oil boiler

Table 1. Heating technology and their energy efficiency thresholds.

For the most known technologies – boilers and electric heat pumps – the calculations of the maximum efficiencies are for the Best Available Technologies (BATs) based on the market according to an internet market search. The efficiencies are for the models mentioned in the right column in the table above and with efficiencies adjusted to follow calculations proposed in the draft ecodesign regulation presented to the latest CF. See information sources in Annex.

For the least known technologies, including micro-CHP and fuel-fired heat pumps, it has not been possible to identify BATs on the market. Instead, calculations are based on general assumptions stated in the right column in the above table.

For the market data, it is possible that more efficient equipment will appear on the market. Regarding the theoretical examples with combinations and hybrids, their performance depends on the combined control equipment, where a simple combination can give low efficiency values than stated while an advanced, optimising control can give higher efficiencies. Optimisation with controls is beyond the scope of this document.

While all of the above technologies - except fossil fuel and electric resistance boilers - will still be on the market as per the Coolproducts proposal, a number of possible hybrid alternatives (with above 100% efficiency) will remain, although they will not make a large transition away from fossil fuels, if allowed on the market.

In Table 2, we present hybrid heating technologies (as combinations of common appliances) that just meet the proposed thresholds as stated in the last Consultation Forum (100% for CHP, 110% for hybrids), as well as two combinations of technologies that meet the limits proposed by Coolproducts (130% for hybrids, 110% for others including CHP).

Moreover, solar thermal systems are only considered in the energy labelling framework when combined with other sources, they are not included in the ecodesign regulations.

Hybrid technologies above 100%	Ecodesign minimum efficiency	Calculated efficiency	Information sources
Hybrid gas boiler(70%) + Electric HP (30%) low eff.	110%	110%	Combining 90% eff. Gas boiler with HP with SCOP = 3
Hybrid gas boiler(22%) + Electric HP (78%) low eff.	110%	130%	Combining 90% eff. Gas boiler with HP with SCOP = 3
CHP(22%) + gas backup boiler(78%)	100%	100%	Combining 94% efficiency gas boiler with CHP 25% electric and 95% total efficiency
CHP(58%) + gas backup boiler (42%)	100%	110%	Combining 94% efficiency gas boiler with CHP 25% electric and 95% total efficiency
Peltier effect CHP in gas boiler	100%	100%	Assuming 4% efficient Peltier elements capturing 88% of useful heat flow

Table 2. Hybrid heating technology and their energy efficiency thresholds.

The table above shows how a small, low-efficiency heat pump, covering just 30% of heat demand and combined with a relatively low efficiency condensing boiler, can reach the proposed 110% efficiency limit for hybrid heaters according to the draft ecodesign regulation.

For the same equipment, it will only be possible to meet the efficiency limit proposed by Coolproducts if the heat pump provides at least 78% of the heat. It might be the case that some households (such as poorly insulated buildings, very cold climates, space limitations among others) encounter difficulties to replace boilers with 'stand-alone' heat pumps, thus hybrid heaters have a role to play on the market, but only if they provide a massive reduction in gas use, as put forward in the Coolproducts proposal.

The table above also shows how a very small, but efficient micro-CHP module can make a gas boiler reach the 100% efficiency limit proposed for CHP. With the efficiency limit put forward by Coolproducts, a hybrid system will be allowed on the single market only if the CHP unit is above 50% of the gas demand (in the above example 58%).

The last line of the above table shows data for a simple, low-efficient CHP using Peltier elements (converting heat directly to electricity, using temperature differences) with an efficiency of 4%. These elements are available on the market and available to install in a simple CHP without moving parts and without refrigerants, but with low efficiency. The gas driven CHP unit with Peltier elements is not readily available on the market, but as the technology exists, it might be introduced as a way to reach 100% efficiency according to ecodesign calculations in a low-cost way, but without saving much gas.

In the draft proposal for the energy labelling regulation, it is possible to increase efficiency for packages of heaters, controls and solar heating. The efficiency increases are up to:

- For control equipment 5% is maximum added to the efficiency.
- For solar heating typical not more than 25% multiplied to the efficiency in average climate, a much higher factor could be multiplied[1].

If the same were applied in ecodesign, it would be possible for fossil fuel boilers to reach 100% efficiency in the calculations, but not 110%, except for combinations with large solar heating systems.

[1] To provide an example, the solar heating can only increase efficiency as much as 25% with a large solar heater (15 m2) and a large, well-insulated tank (700 ltr, class B) assisting a smaller gas boiler (9 kW). In most cases, solar heating will only increase efficiency by 10-12% (15 m2 solar heater, 700 ltr, tank with 18 kW boiler).

ANNEX

Sources and calculations for Table 1:

- Electrical boiler: The efficiency is calculated with the assumptions that 100% of electricity is converted to heat water. With PEF = 2,1 this gives an efficiency of 47,6% from which should be subtracted F(1) = -3%, resulting in 44,6% as the maximal efficiency
- Gas boiler: efficiency of best boiler without controls according to https://kedellisten.dgc.dk/
- Oil boiler: efficiency without controls according to https://www.glo24.de/Vaillant-Paket-332-7-icoVIT-exclusiv-VKO-356-3-7-VRC-700-6-Zubehoer-0010029865. A search has shown that this boiler has the highest efficiency among the oil boilers identified.
- Electrical driven heat pump, efficiency changed from PEF = 2,5 to PEF = 2,1, with F(1)=-3%, F(2)=0, F(3)=-1%, heating via radiators, forward design temp 55'C, best air-water heat pump from ttps://www.topten.eu/private/product/view/HovalAGBelariaprocomfort15aw. According to this source, water-water heat pumps are indicated as more efficient, but very few consumers have access to ground water cooling, so they are not included here.
- Gas fired CHP is assumed to have same combustion efficiency and envelope loss as above gas boiler, provided that 94% of fuel is becoming useful heat and electricity and that 25% of fuel is converted to electricity while remaining 69% is becoming useful heat.
- Oil fired CHP is assumed to have same combustion efficiency and envelope loss as above oil boiler provided that 92% of fuel is becoming useful heat and electricity and that 25% of fuel is converted to electricity while remaining 67% is becoming useful heat.
- Gas fired heat pumps: calculated as combination of above-mentioned gas fired CHP and above-mentioned BAT electric heat pump with SCOP=3,9, F(1)=-3%, F(3)=-3%, assuming all produced electricity is used in the heat pump.
- Oil fired heat pump: Calculated as combination of above-mentioned oil fired CHP and above-mentioned BAT electric heat pump with SCOP=3,9, F(1)=-3%, F(3)=-3%, assuming all electricity is used in the heat pump.
- Hybrid of electric heat pumps and gas boiler: It is assumed that 70% of heat is from heat pump with above-mentioned efficiency and that 30% of heat is from gas boiler with above-mentioned efficiency, the stated efficiency is a weighted average of these efficiencies (weights 70:30).
- Hybrid of electric heat pump and oil boiler: It is assumed that 70% of heat is from heat pump with above-mentioned efficiency and that 30% of heat is from oil boiler with above-mentioned efficiency, the stated efficiency is a weighted average of these efficiencies (weights 70:30).