Eurovent Industry Recommendation / Code of Good Practice

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EUROPEAN INDUSTRY ASSOCIATION

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Seasonal efficiency index STER for polyvalent units

First Edition

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Document history

This Eurovent Industry Recommendation / Code of Good Practice supersedes all of its previous editions, which automatically become obsolete with the publication of this document.

Modifications

This Eurovent publication was modified as against previous editions in the following manner:

Modifications as against	Key changes
1st edition	Present document

Preface

In a nutshell

This document details a newly proposed seasonal energy efficiency parameter, called STER, for polyvalent units. The STER index takes inspiration from the SCOP and SEER indicators but valorises the energy recovery benefits of simultaneous heating and cooling. Chapter 1 explains what a polyvalent unit is (and what it is not) and how it works and justifies why current assessment methods and regulations are not suitable for such units. Chapter 2 defines the standard climate profiles, operating hours, loads, and temperature regimes that are considered. Finally, Chapter 3 outlines the calculation method and formulas for obtaining the STER index and related parameters.

Authors

This document was published by Eurovent and was prepared in a joint effort by participants of the Task Force 'Polyvalent Units' (TF-POL), which represents a vast majority of all manufacturers of these products active on the EMEA market.

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Important remarks

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Contents

1 Introduction

1.1 Preamble

Polyvalent units and their benefits are not properly valorised by existing energy performance assessment methods. For this reason, manufacturers associated under the umbrella of Eurovent have worked on the present proposal for a new, dedicated seasonal efficiency index for these kinds of units, acronymised **STER**. The STER index better reflects the intrinsic characteristics of polyvalent units, especially their ability to produce heating and cooling at the same time. The development of the STER index has been a complicated task, which had to take into account the established SCOP and SEER indices, while also valorising the energy recovery benefits of simultaneous heating and cooling. In what follows, the resulting STER index is detailed and justified.

1.2 What is a polyvalent unit?

For the purposes of this Recommendation, a polyvalent unit is defined as a device capable of providing heating and cooling on two separate and independent water or brine loops using the vapour compression cycle. It has at least two refrigerant circuits, each equipped with three heat exchangers:

- The cold exchanger, which is connected to the cold loop,
- The hot exchanger, which is connected to the hot loop, and
- The source exchanger connected to the source, which can be outdoor air or water.

The source exchanger is reversible, which is to say that it can operate both as condenser and evaporator. It is used to reject the excess heat or absorb the heat to be transferred to the user.

The unit can cool the cold loop, or heat the hot loop, or do both simultaneously. Whenever it heats and cools simultaneously, the unit is recovering energy between the hot and cold loops, instead of rejecting/absorbing that heat to/from the source. If the cooling and heating demands are balanced, the source exchanger is not used at all; this is the situation with maximum energy recovery.

The unit operates on an annual basis and does not require any scheduled change-over from heating to cooling and vice-versa. The production of cooling and heating is controlled based on system demand.

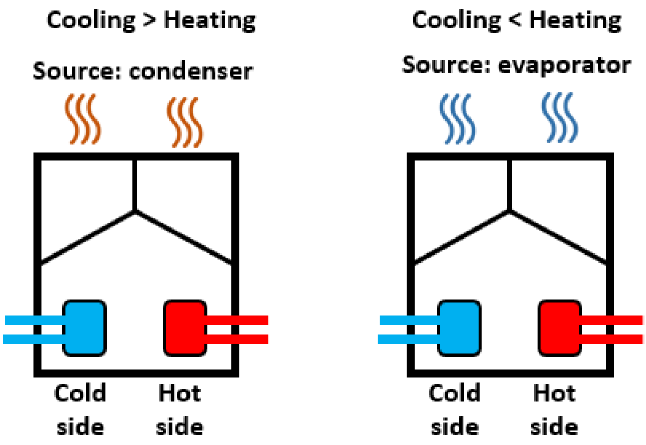

Figure 1: Operation of a polyvalent unit

1.2.1 Naming conventions and disambiguation

To avoid confusion, any mention of 'polyvalent units' in this document refers to 4-pipe units as described above. This should disambiguate them from 2+2-pipe units and other kinds of products marketed as 'multifunctional' or 'multipurpose' units, such as those described below.

1.2.1.1 2+2 pipe units

On the market, polyvalent units are sometimes also called '4-pipe units' or just '4 pipes'. These are not to be confused with what are sometimes called '2+2-pipe units' or '2+2 pipes'.

2+2-pipe units are intended for a 2-pipes comfort system plus domestic hot water (DHW). These units operate as a traditional reversible heat pump for comfort, providing heating in winter and cooling in summer. The additional heat exchanger is dedicated to heat DHW.

In these 2+2-pipe units, there is a seasonal change-over from heating to cooling on the comfort side, and vice versa. The DHW side always operates as condenser. In summer, when there is contemporary demand for comfort cooling and DHW, the unit performs heat recovery. In winter, the unit provides heating for both comfort and DHW, with priority to DHW.

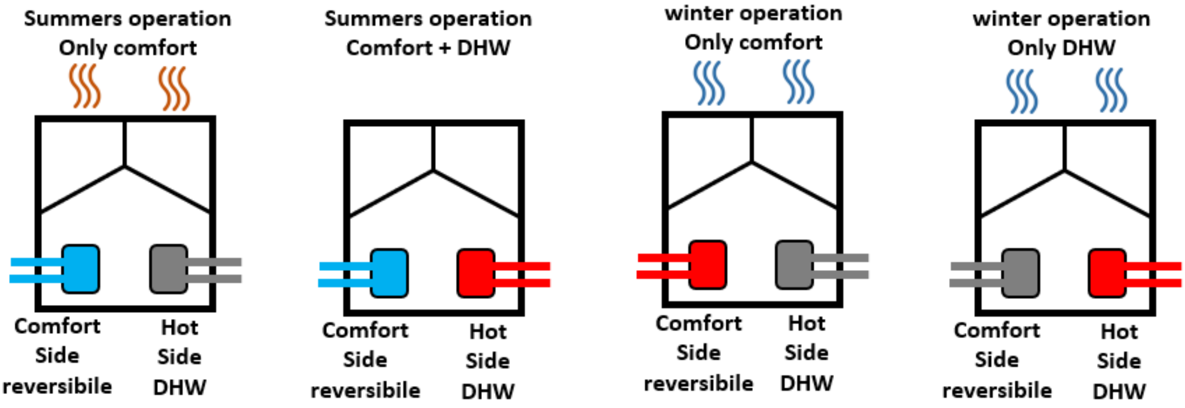

Figure 2: Operation of a 2+2-pipe unit

Nota bene: These kinds of 2+2-pipe units are <u>out of the scope</u> of this work. The annual efficiency index defined in this document does not apply to such units.

1.2.1.2 Multifunctional units

The term 'multifunctional unit' is used on the market to refer to a variety of products. Sometimes 4-pipe and 2+2-pipe units, as defined above, are marketed as 'multifunctional' or 'multipurpose' units. In the ventilation business, the term 'multifunctional unit' is sometimes used to refer, for example, to air handling units with an integrated heat pump that recovers heat from exhaust air to produce DHW. More generally, the term 'multifunctional' is used to refer to products that serve several functions, such as heating, cooling, humidifying, dehumidifying, etc.

These products should not be confused with polyvalent units in the sense of this Recommendation. Despite the similar names, these technologies and their applications are very different.

To avoid confusion, this document will not use the term 'multifunctional units' or 'multipurpose units' to refer to 4-pipe units, preferring the term 'polyvalent units.'

1.2.2 How does a polyvalent unit work?

Having clarified the differences between 4-pipe units and 2+2-pipe units, we can better explain how a polyvalent (or 4-pipe) unit works.

For a unit with two refrigerant circuits, which is the most common configuration, there are seven possible operating conditions. These are illustrated below:

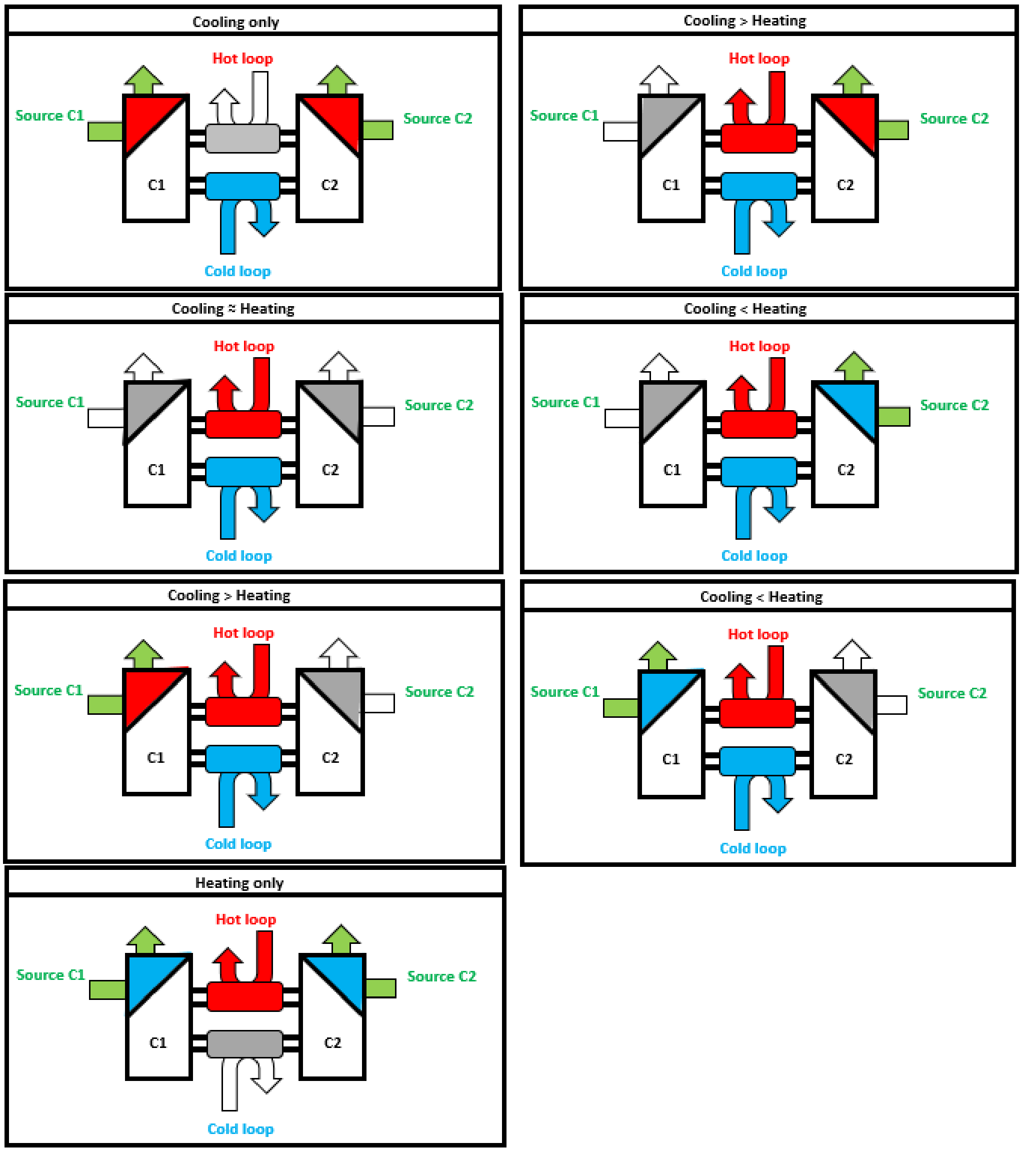

Figure 3: Possible operating conditions of a polyvalent unit

Note that the configuration is the same whether the unit is an air-source or water-source type.

1.2.3 Applications of polyvalent units

Polyvalent units are intended for systems with consistent contemporary demand of heating and cooling, like in large buildings with double exposition (e.g., one side is exposed to the south and the other to the north), or buildings with different environments such as hotels, shopping malls, and hospitals.

The polyvalent unit operates in two set points, one on the cold loop and the other on the hot loop, by acting on circuit capacity (staging compressors or modulating the speed) and by changing the operating mode of the circuits. Polyvalent units' main use is the comfort of human beings, but other applications exist as well.

1.3 Policy background[1]

Since polyvalent 4-pipe units, as heat pumps, can provide heat to water-based heating systems for human comfort, they can be classified as space heaters, and therefore fall under the scope of Regulation (EU) 813/2013 (Pdesignh < 400 kW) and Regulation (EU) 811/2013 (Energy Labelling for Pdesignh up to 70 kW).

If Pdesignh > 400 kW, then they also fall under the scope of the Regulation (EU) 2016/2281 as cooling products since these units also provide cold to water-based cooling systems[2].

Neither Regulation (EU) 813/2013 nor Regulation (EU) 2016/2281 currently consider a unit capable of providing simultaneously cold and hot water for human comfort to water-based systems. Since the polyvalent unit has no dedicated assessment method that valorises its heat recovery benefits, and it is compared separately to "simple" hydronic heat pumps on its heating efficiency or "simple" chillers on its cooling efficiency, the polyvalent unit is penalised in terms of seasonal energy efficiency.

Moreover, the minimum seasonal energy efficiencies set by Regulation (EU) 2016/2281 are especially difficult to reach for this kind of unit, for technical reasons that stem from the more complicated and specifically designed refrigerant circuit.

1.4 Full load efficiency parameter for polyvalent units - TER

Polyvalent units are so different from "simple" chillers and heat pumps that, within the Eurovent Certification Programme, a dedicated full load efficiency parameter (called TER) has been created.

This parameter considers the double use achieved from the contemporary production of cold and hot water, by weighting the unit's heat transfer effect between the hot water circuit and cold-water circuit.

For polyvalent units, the TER efficiency index is defined as follows:

$$TER = \frac{(Cooling\ capacity + Heating\ capacity)}{Total\ power\ input}$$

The Eurovent Certification Programme has a rule that the TER must be determined with the water flow rates during cooling-only and heating-only operation for the intended application, like TER_{45} (Water */7°C - Water*/45°C).

The same special function of Polyvalent Units (full heat recovery with possibility to control heating and cooling) can be applied also to water(brine)-to-water(brine) units, but at this stage it seems early to start discussing about this particular type of units and therefore they will not be considered in this document.

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[1] This document refers to legislation applicable at the time of writing and not to ongoing revisions.

[2] Note that even a "simple" reversible hydronic heat pump with Pdesignh > 400 kW falls under Regulation (EU) 2016/2281.

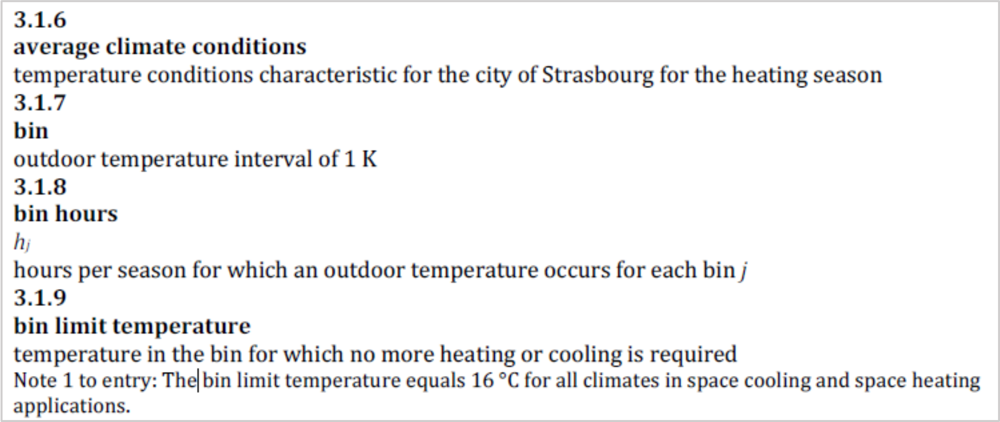
2 Standard conditions

2.1 Climate

2.1.1 Introduction

This section defines the climate profile considered for the STER index.

As stated earlier, the current regulatory framework and existing efficiency indexes (SEER and SCOP) do not fairly represent polyvalent units. The first inconsistency is the climate used as a reference in the EN 14825:2022 standard. Note the following definitions from EN 14825:2022:



3.1.6
average climate conditions
temperature conditions characteristic for the city of Strasbourg for the heating season
3.1.7
bin
outdoor temperature interval of 1 K
3.1.8
bin hours
h_j
hours per season for which an outdoor temperature occurs for each bin *j*
3.1.9
bin limit temperature
temperature in the bin for which no more heating or cooling is required
Note 1 to entry: The bin limit temperature equals 16 °C for all climates in space cooling and space heating applications.

Figure 4: EN 14825:2022 definitions

The definition of the limit temperatures shows that contemporaneity of cooling and heating loads has not been considered. 16°C is the limit temperature both for cooling and heating.

In EN 14825:2022, three different climatic profiles for heating (Warmer "W"; Average "A", Colder "C") are described based on three different locations in Europe. The standard uses one climatic profile to calculate the cooling efficiency index.

Even if we sum the bin hours of the temperature profiles used for the SCOP ("warmer", average"; "colder") and SEER calculation we never reach 8.760 hours.

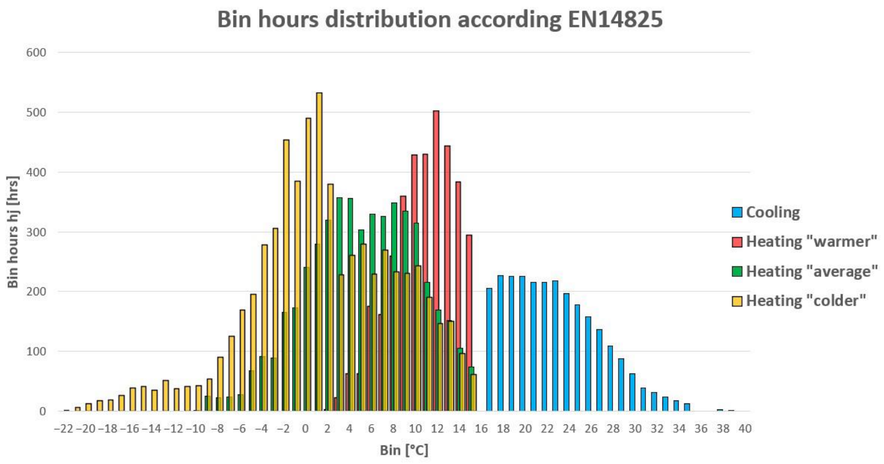


Figure 5: Bin hours distribution according to EN 14825:2022 standard

For this reason, before starting to define a new efficiency index and a calculation method for the seasonal efficiency for polyvalent units, one or more new climatic curves need to be identified. This new climatic profile is required to guarantee reliability and stability of the technical calculations and regulatory proposal. It is not possible to start from the current climatic profiles, because they do not consider the entire year (only cooling or heating seasons), and do not reflect real temperatures bin behaviour.

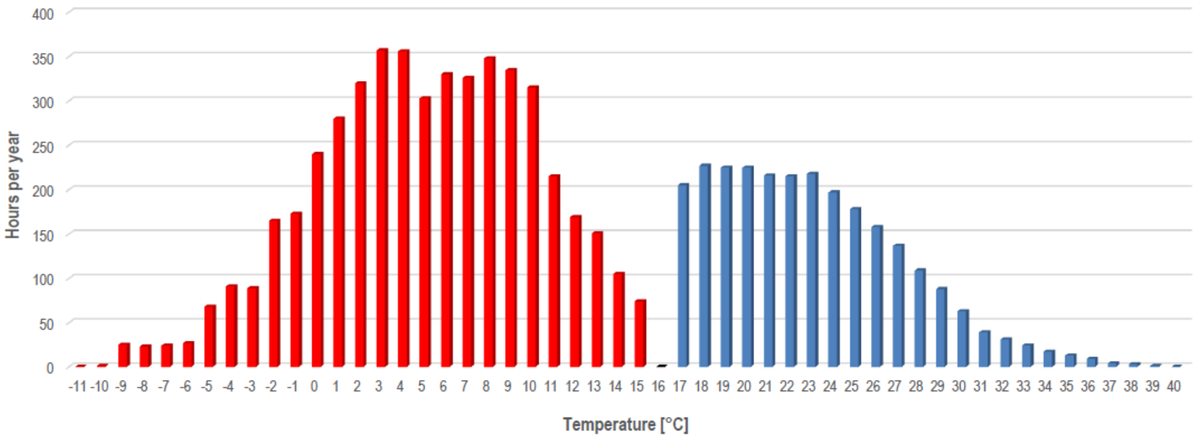


Figure 6: Temperature profiles from Regulations (EU) 813/2013 and (EU) 2016/2281

2.1.2 Proposed climatic profile

Starting from the official European climatic area division, three different temperature profiles have been created:

- Average – A (cf. figure 8)
- Warmer – W (cf. figure 9)
- Colder – C (cf. figure 10)

The final profiles do not represent a specific location but are created from real locations' trend values. The real locations' bin temperatures have been described with an equation and, from the merging of different locations, general and theoretical temperature profiles have been created in order to typify the three different climates. All profiles contain 8.760 hours and could be used in describing different climates for all-year-round operation of HVAC equipment.

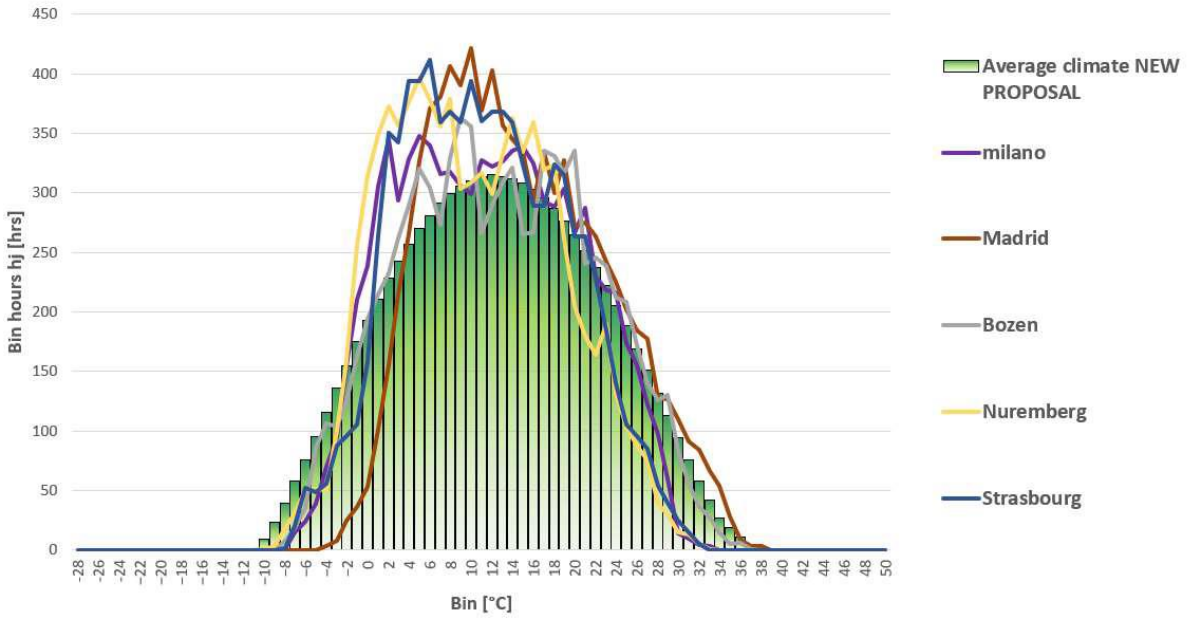


Figure 7: Proposed "average" climatic profile

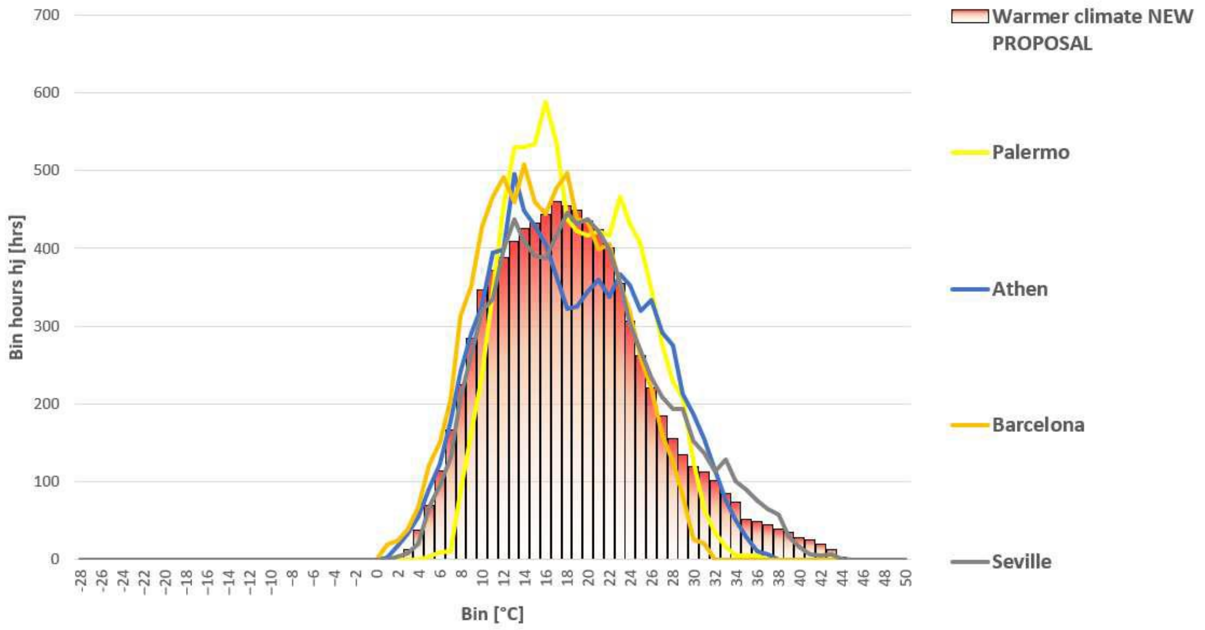


Figure 8: Proposed "warmer" climatic profile

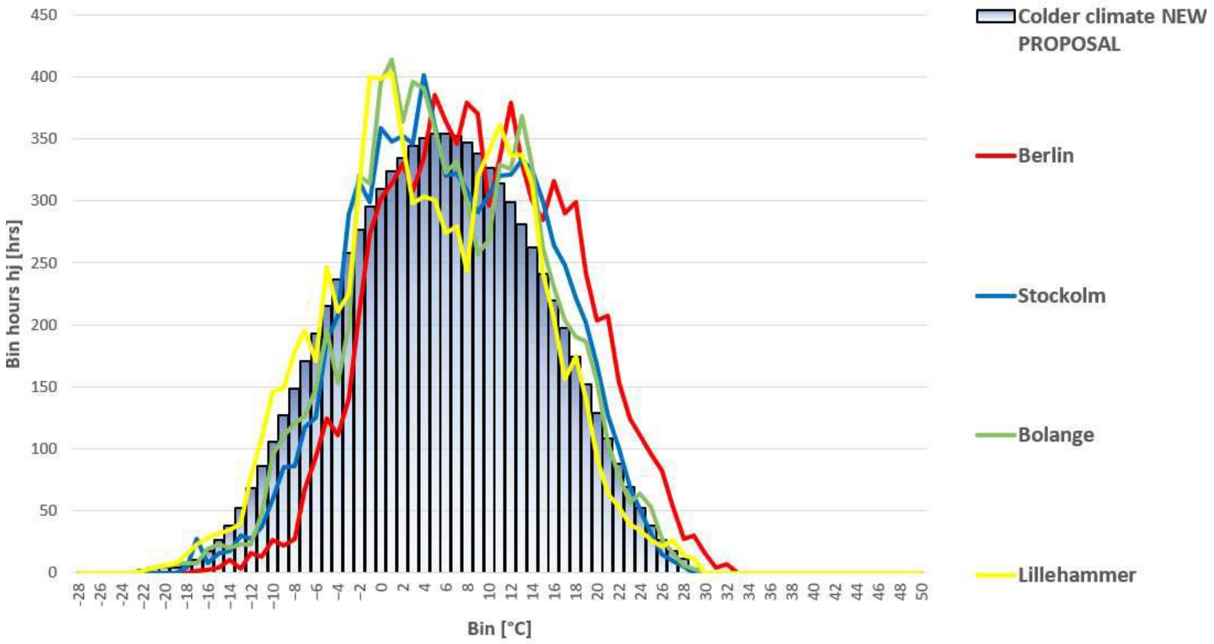


Figure 9: Proposed “colder” climatic profile

The table in Annex I - Detailed bins of the Climatic Profiles shows the bin numbers (j) the corresponding outdoor temperature (Tj in °C) and the number of hours per bin (hj) for the different heating seasons (W, A and C).

2.2 Operating hours

2.2.1 Introduction

This section defines operating hours considered for the STER index.

The following definitions from EN 14825:2022 are used.

Equivalent active mode hours – HTE:
Assumed annual number of hours the unit must provide the design loads for space cooling and heating (Pdesignc / Pdesignh) in order to satisfy the reference annual space cooling/heating demand. Expressed in h.

Thermostat-off mode operating hours – HTO:
Annual number of hours the unit is considered to be in thermostat-off mode, the value of which depends on the designated season, type of unit and operating mode(s). Expressed in h.

Standby mode operating hours – HSB:
Annual number of hours the unit is considered to be in standby mode, the value of which depends on the designated season and type of unit and operating mode(s). Expressed in h.

Off mode operating hours – HOFF:
Annual number of hours the unit is considered to be in off mode, the value of which depends on the designated season, type of unit and operating mode(s). Expressed in h.

Crankcase heater mode operating hours – HCK:
Annual number of hours the unit is considered to be in crankcase heater mode, the value of

which depends on the designated season and type of unit and operating mode(s). Expressed in h.

2.2.2 Proposed operating hours

The values for HTE / HTO / HSB / HOFF established in EN 14825:2022 and used for SCOP and SEER calculations for air-to-air and water-to-air units > 12kW (values reported in ANNEX D of the standard) do not seem suitable for polyvalent units, because the sum of active and other hours does not reach 8.760 hours.

Consequently, the proposal is to follow a logic similar to the one used in ANNEX A of EN 14825:2022 for air conditioners with capacity < 12kW, which starts from 8.760 hours and defines the different parameters accordingly. Given the particular application of polyvalent units, Eurovent suggests combining thermostat-off mode operating hours (HTO) and standby mode operating hours (HSB) in a single value. The following values are proposed:

	Average	Colder	Warmer
	[h]	[h]	[h]
On mode (HTE)	7008	7008	7008
Thoff mode (HTO)	1752	1752	1752

Table 1: Polyvalent units operating hours

2.3 Loads

2.3.1 Introduction

This section defines the loads that need to be used in the calculation of the STER index.

For the calculation of the SCOP index, the heating loads of the building must be defined. For the SEER calculation, the cooling loads of the building must be defined.

For the calculation of the seasonal index STER, both the heating and cooling loads must be defined.

2.3.2 Loads definition

The following approach was chosen to define the loads:

- Define reference design temperatures for cooling and heating loads
- Define OFF temperatures for cooling and heating
- Define a load´s behaviour for different climates

2.3.2.1 Reference design temperatures

Reference design temperatures are defined as the temperature where the loads are set at 100%. The chosen design temperatures are as follows:

			Warmer	Average	Colder
Design temperature cooling	$T_{designc}$	[°C]	40	35	30
Design temperature heating	$T_{designh}$	[°C]	2	-10	-22

Table 2: Design temperatures

These temperatures are aligned with $T_{designh}$ and $T_{designc}$ present in EN 14825:2022:

- Average climate: dry bulb temperature conditions at –10 °C outdoor temperature for 20 °C indoor temperature.
- Colder climate: dry bulb temperature conditions at –22 °C outdoor temperature for 20 °C indoor temperature.
- Warmer climate: dry bulb temperature conditions at +2 °C outdoor temperature for 20 °C indoor temperature.

2.3.2.2 OFF temperatures

The chosen OFF temperatures are as follows:

			All climates
OFF temperature cooling	$T_{off,c}$	[°C]	7
OFF temperature heating	$T_{off,h}$	[°C]	30

Table 3: Off temperatures

2.3.2.3 Load behaviour

For each climate, the loads decrease linearly, considering minimum and maximum design temperatures for the respective climate. The final results are illustrated in the following graphics and charts:

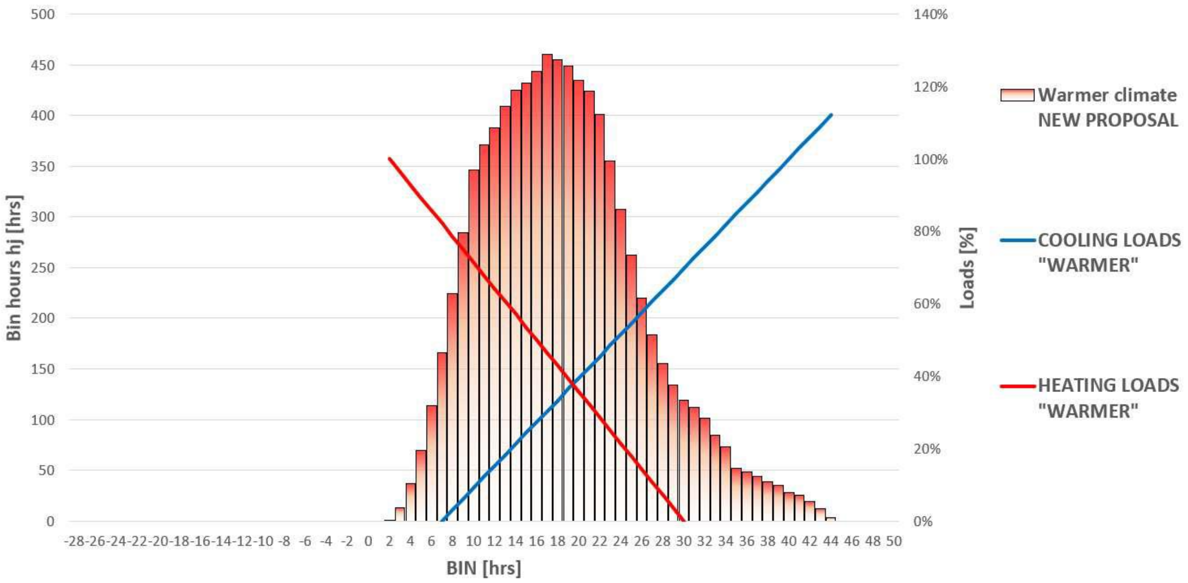


Figure 10: "Warmer" climate load behaviour

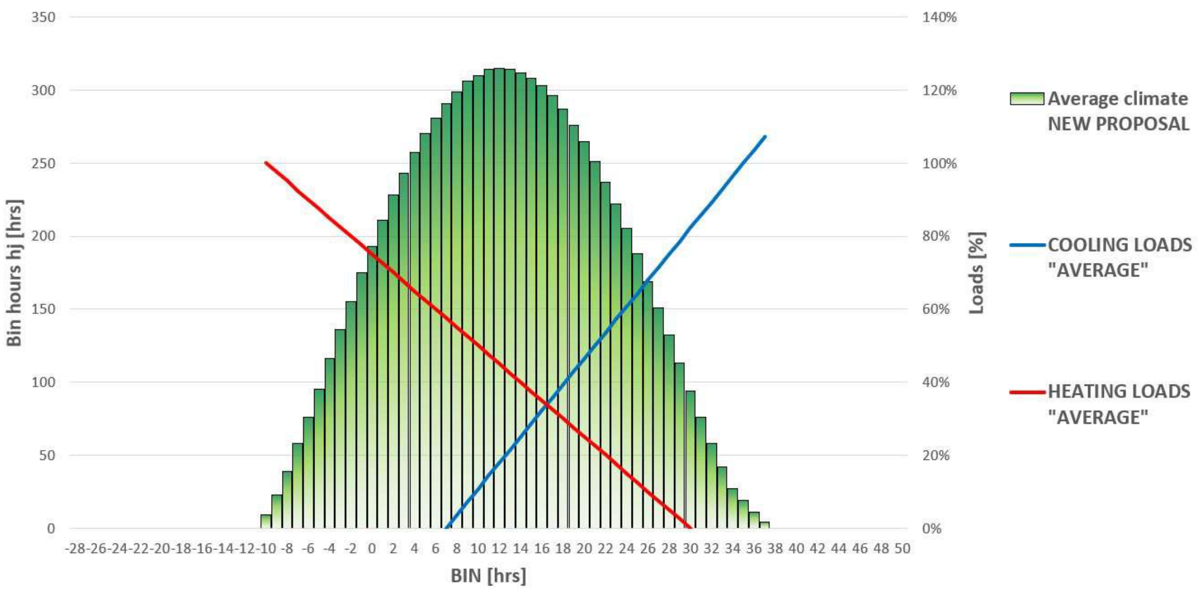


Figure 11: "Average" climate load behaviour

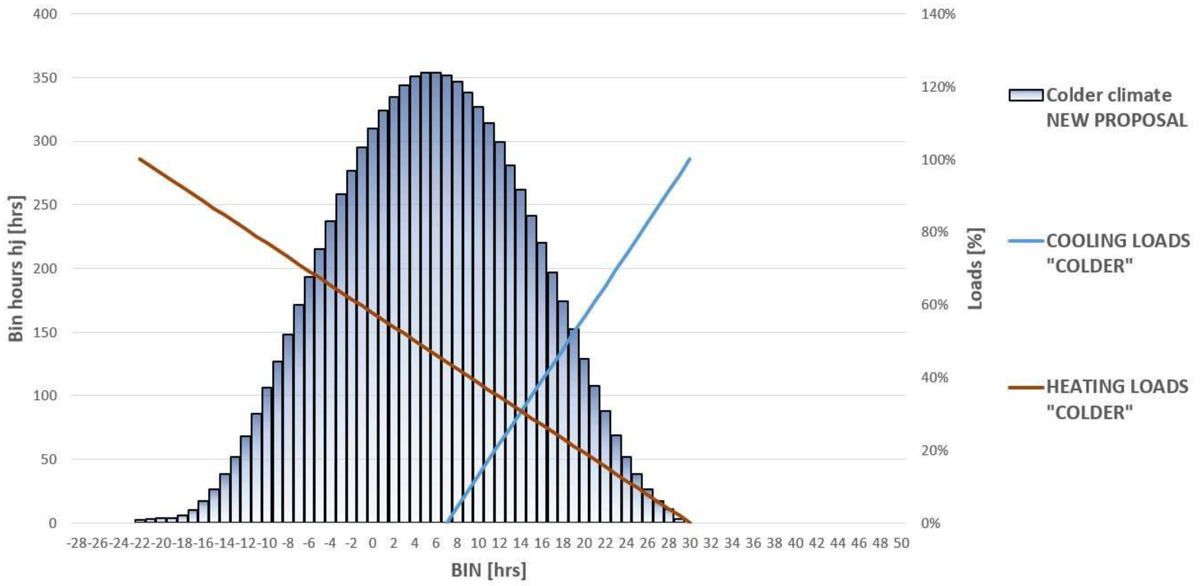


Figure 12: "Colder" climate load behaviour

The loads are characterised in the Annex II - Load Profile Values.

With the load distribution defined, we can define 11 points for 3 climates that will be used for the calculations of partial loads.

	Outdoor Heat Exchanger	Part Load Ratio [%]					
	Dry bulb temperature	Average		Warmer		Colder	
		Cooling	Heating	Cooling	Heating	Cooling	Heating
A	-7	0,0%	92,5%	n.a	n.a	0,0%	71,2%
B	2	0%	70%	0%	100%	0%	54%

C	7	0,0%	57,5%	0,0%	82,1%	0,0%	44,2%
D	12	17,9%	45,0%	15,2%	64,3%	21,7%	34,6%
E	20	46,4%	25,0%	39,4%	35,7%	56,5%	19,2%
F	25	64,3%	12,5%	54,5%	17,9%	78,3%	9,6%
G	30	82,1%	0,0%	69,7%	0,0%	100,0%	0,0%
H	35	100%	0%	85%	0%	n.a	n.a
I	TOL	pl(TOL)	pl(TOL)	pl(TOL)	pl(TOL)	pl(TOL)	pl(TOL)
J	Tbiv	pl(TBiv)	pl(TBiv)	pl(TBiv)	pl(TBiv)	pl(TBiv)	pl(TBiv)
K	-15	n.a	n.a	n.a	n.a	0%	87%

Table 4: Part Load Ratio

2.4 Temperatures

2.4.1 Introduction

Before entering in the details of the calculation method, we identify some missing boundary conditions to reach valid and solid results. Considering what is currently used for the SCOP and SEER calculations and what is in EN 14825:2022, the following points still need to be clarified:

- Working temperatures
- Temperature control type
- Waterflow control type
- Bivalent temperatures

Each of these points will be discussed in next sections.

2.4.2 Working temperatures

2.4.2.1 Definitions

EN14825:2022 in chapter 6.4 describes four levels of working temperatures for heating:

- Low temperature (LT) application: 30/35°C
- Intermediate temperature (IT) application: 40/45°C
- Medium temperature (MT) application: 47/55°C
- High temperature (HT) application: 55/65°C

Currently for the SCOP calculation for air-to-water(brine) heat pumps, only LT/MT/HT applications are used. It is mandatory to declare at least the SCOP LT (which is the "base" level), but if a unit can achieve a higher temperature level, then the declaration must switch to SCOP MT or SCOP HT.

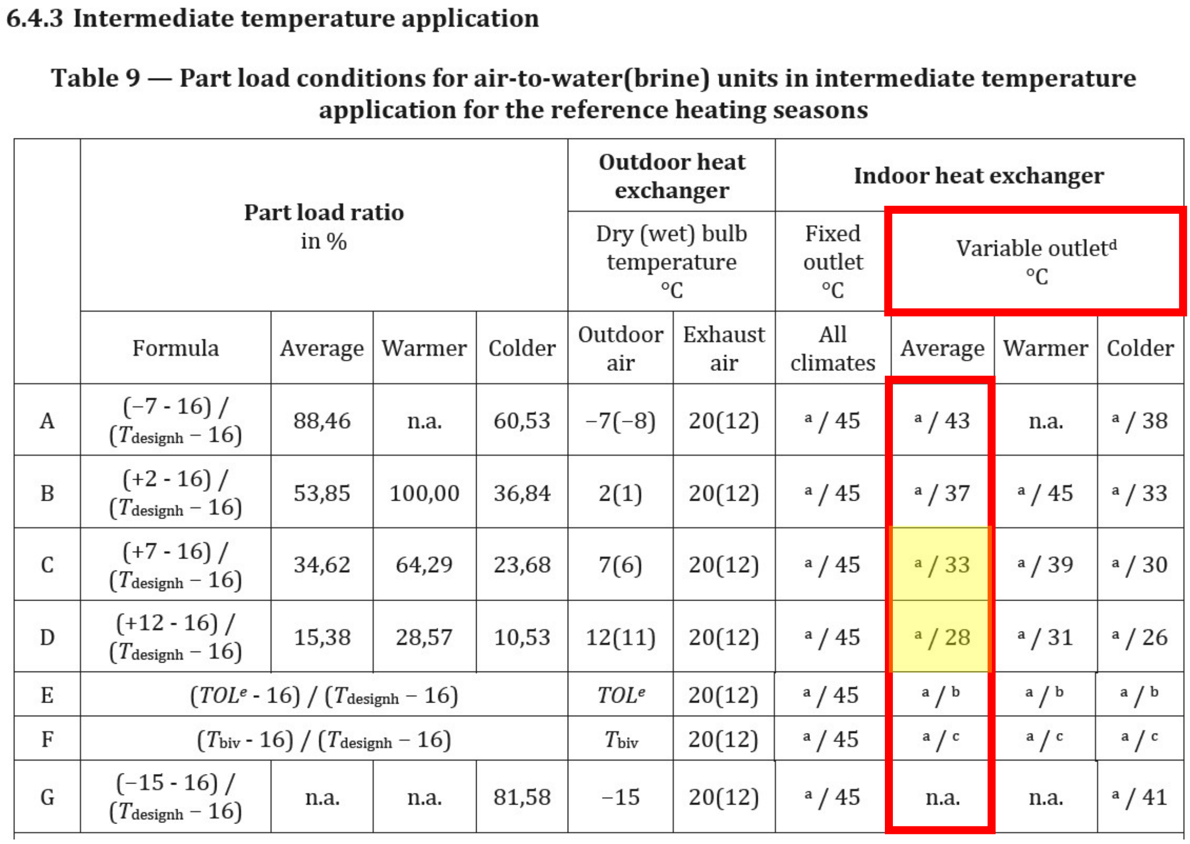
EN 14825:2022 in chapter 4.4 describes two levels of working temperatures for cooling:

- Fan coil Application temperatures: 12/7°C
- Cooling Floor application temperatures: 23/18°C

2.4.2.2 Water temperature for heating in polyvalent units

The typical application of a polyvalent unit fits with the intermediate temperature level (IT). Indeed, the most common application by far is for fan coils and air handling units.

Using the water profile 40/45°C, according to the IT definition of EN14825:2022, makes the test of the units with variable out temperature and fixed flow almost impossible due to the huge temperature reduction prescribed by the rules. See the table below taken from EN 14825:2022.



6.4.3 Intermediate temperature application

Table 9 — Part load conditions for air-to-water(brine) units in intermediate temperature application for the reference heating seasons

	Part load ratio in %				Outdoor heat exchanger		Indoor heat exchanger			
					Dry (wet) bulb temperature °C		Fixed outlet °C	Variable outlet^d °C		
	Formula	Average	Warmer	Colder	Outdoor air	Exhaust air	All climates	Average	Warmer	Colder
A	$(-7 - 16) / (T_{designh} - 16)$	88,46	n.a.	60,53	−7(−8)	20(12)	^{a} / 45	^{a} / 43	n.a.	^{a} / 38
B	$(+2 - 16) / (T_{designh} - 16)$	53,85	100,00	36,84	2(1)	20(12)	^{a} / 45	^{a} / 37	^{a} / 45	^{a} / 33
C	$(+7 - 16) / (T_{designh} - 16)$	34,62	64,29	23,68	7(6)	20(12)	^{a} / 45	^{a} / 33	^{a} / 39	^{a} / 30
D	$(+12 - 16) / (T_{designh} - 16)$	15,38	28,57	10,53	12(11)	20(12)	^{a} / 45	^{a} / 28	^{a} / 31	^{a} / 26
E	$(TOL^e - 16) / (T_{designh} - 16)$				TOL^e	20(12)	^{a} / 45	^{a} / ^{b}	^{a} / ^{b}	^{a} / ^{b}
F	$(T_{biv} - 16) / (T_{designh} - 16)$				T_{biv}	20(12)	^{a} / 45	^{a} / ^{c}	^{a} / ^{c}	^{a} / ^{c}
G	$(-15 - 16) / (T_{designh} - 16)$	n.a.	n.a.	81,58	−15	20(12)	^{a} / 45	n.a.	n.a.	^{a} / 41

The choice of temperature application is strictly related to water temperature control (fixed outlet or variable outlet) and with waterflow control (fixed waterflow control or variable waterflow control).

Using 30/35°C level temperature (LT) would align the proposed STER index with SCOP and Regulation (EU) 813/2013. It is however not a representative application of the working mode of polyvalent units.

Therefore, is proposed to adopt the intermediate temperature level (IT) (40/45°C) but with fixed temperature outlet declaration.

2.4.2.3 Water temperature for cooling in polyvalent units

In cooling mode, the conclusion is much easier. Due to the typical application of polyvalent units and what is currently defined for the SEER declarations, the Eurovent proposal is to proceed with 12/7°C fan coils or air handling units application only, with the possibility for the manufacturer to choose between fixed outlet (FO) or variable outlet (VO).

2.4.3 Temperature control type

2.4.3.1 Outlet temperature control type

The choice is to proceed with the fixed outlet water temperature only.

This decision is backgrounded by several in-field tests and calculations that show that variable outlet may not be representative of this particular application and that the usage of a variable outlet calculation method could create misleading results and inconsistent values of the STER index.

Consider the following example. At points D and E (12°C and 20°C of outdoor air temperature, OAT) for LT application in average climate with variable outlet calculation, we have water Cold/Hot at 11°C/29°C and 10°C/28°C. At these points, the efficiency in heat recovery mode is so high (lift of compressors is low) that the index may be affected too positively.

Moreover, variable outlet for heating may not make sense for this application. If we consider residential heat pumps connected with underfloor heating, it is reasonable that at 16°C OAT, the Leaving Water Temperature (LWT) requested could be around 24°C. But considering the same boundary of EN 14825:2022 in SCOP and applying it to a polyvalent unit, it means that we have to produce water at 24°C with 25°C of OAT, which does not make much sense due to the fact that in those conditions, a polyvalent unit is providing heating mainly for post-heating AHU or for DHW production.

Moreover, as stated earlier, the most typical application for polyvalent units is fan coils and AHUs, and this distribution system does not accept water at 24°C.

2.4.4 Bivalent temperature - Tbiv

The bivalent temperature is defined in EN 14825:2022 (chapter 3.1.13) as follows.

> **Bivalent temperature – Tbiv:**
> Lowest outdoor bin temperature at which the unit is declared to have a capacity able to meet 100% of the heating load without supplementary heater, whether it is integrated in the unit or not. Below this temperature, the unit may still provide capacity, but additional supplementary heating is necessary to fulfil the full heating load.

The introduction of a variable bivalent temperature (which is chosen from each heat pump supplier for each individual unit) caused a lot of confusion on the market and in the comparison of various units.

Moreover, variable Tbiv has been defined to guarantee maximum flexibility for the SCOP index to better suit to all possible situations. But in the end, it is the manufacturer of the unit that declares the SCOP changing the Tbiv at will, and so there is no added value for final users.

Nevertheless, it is mandatory to define a bivalent temperature to avoid problems of oversizing units and modulation control.

For the previous reasons, it was decided to maintain the bivalent temperature but fixing it for all three proposed climates, therefore limiting the confusion and allowing perfect comparison between units.

Consider the Tbiv for heat pumps defined in EN 14825:2022:

- Average climate: the dry bulb temperature is +2 °C or lower;
- Colder climate: the dry bulb temperature is –7 °C or lower;
- Warmer climate: the dry bulb temperature is +7 °C or lower.

Therefore, the proposal is to fix the following values:

		Warmer	Average	Colder
Tbiv	[°C]	2	-7	-15

Table 5: Bivalent temperatures

2.4.5 Operation limit temperature - TOL

The last parameter that needs to be defined before describing the calculation method, is the minimum operation limit temperature TOL, which is defined in EN 14825:2022 as follows:

> **Operation limit temperature – TOL:**
> Outdoor bin temperature below which the unit will not be able to deliver any capacity and the declared capacity is equal to zero.

Consider the TOL for heat pumps defined in EN 14825:2022 and valid for the SCOP calculation:

- Average climate: the dry bulb temperature is −7 °C or lower;
- Colder climate: the dry bulb temperature is −15 °C or lower;
- Warmer climate: the dry bulb temperature is +2 °C or lower.

The proposal is to keep the same values.

3 Calculation method

3.1 Calculation of the seasonal total efficiency $\eta_{s,tot}$

The seasonal total efficiency $\eta_{s,tot}$ expressed in %, is defined as follows:

$$\eta_{s,tot} = \frac{1}{CC} \times STER - \sum F_i$$

Where:

- CC is the coefficient for electricity generation efficiency
- STER is the seasonal coefficient of performance
- Σ F(i) is the correction calculated according to following Formula: Σ F (i)= F (1) + F (2)
  where
  F(1) is the correction that accounts for a negative contribution to the seasonal total energy efficiency of heaters due to adjusted contributions of temperature controls, equal to 3%.
  F(2) is a parameter related to water source units and so the proposal is to not consider it.

3.2 Calculation of STER

STER is defined as the reference annual cooling and heating demand Q_{tot} divided by the annual energy consumption for cooling and heating Q_{totE} according to the following formula:

$$STER = \frac{Q_{tot}}{Q_{totE}}$$

Where:

- Q_{tot} is the reference annual cooling and heating demand, expressed in kWh
- Q_{totE} is the annual energy consumption for cooling and heating, expressed in kWh.

3.2.1 Calculation of the reference annual total demand Q_{tot}

The reference annual cooling and heating demand Q_{tot} is expressed in kWh and is calculated as follows.

$$Q_{tot} = [P_{designC} \cdot H_{CE} + P_{designH} \cdot H_{HE}]$$

Where:

- $P_{designH}$ is the design heating load of the building the unit is suitable for as declared by the manufacturer, expressed in kW;
- $P_{designC}$ is the design cooling load of the building the unit is suitable for as declared by the manufacturer, expressed in kW;
- H_{CE} is the number of equivalent active mode hours for cooling, expressed in h;
- H_{HE} is the number of equivalent active mode hours for heating, expressed in h.

3.2.2 Calculation of the annual energy consumption Q_{totE}

The annual energy consumption Q_{totE}, expressed in kWh, includes the energy consumption during active mode, thermostat-off mode, standby mode, off mode and that of the crankcase heater based on the following formula.

$$Q_{totE} = \frac{Q_{tot}}{STER_{on}} + H_{SB} \times P_{SB} + H_{CK} \times P_{CK} + H_{off} \times P_{off}$$

Where:

- Q_{tot} is the reference annual cooling and heating demand, expressed in kWh
- H_{TO}, H_{SB}, H_{CK}, H_{OFF} are the numbers of hours the unit is considered to work in thermostat-off mode, standby mode, crankcase heater mode and off mode respectively, expressed in h.
- P_{TO}, P_{SB}, P_{CK}, P_{OFF} are the power inputs during thermostat-off mode, standby mode, crankcase heater mode and off mode respectively, expressed in kW
- $STER_{on}$ is the active mode seasonal coefficient of performance, expressed in kWh/kWh.

The energy consumption during active mode is derived from the calculation of the $STER_{on}$. For the determination of $STER_{on}$, see the next section.

3.2.2.1 Calculation of $STER_{on}$

$STER_{on}$ is determined as follows. For simplicity, only the case with electric supplementary heating has been considered:

$$STER_{on} = \frac{\sum_{j=1}^{n} h_j \left[P_{tot}(T_j)\right]}{\sum_{j=1}^{n} h_j \left[\frac{P_{tot}(T_j) - elbu(T_j)}{TERbin(T_j)} + elbu(T_j)\right]}$$

Where:

- T_j is the bin temperature
- j is the bin number
- n is the total number of bins
- $P_{tot}(Tj)$ is the sum of cooling and heating loads of the building for the corresponding bin temperature T_j, expressed in kW; given by the sum of the heating load $P_{designh}(T_j)$ and cooling load $P_{designc}(T_j)$
- h_j is the number of bin hours occurring at the corresponding bin temperature T_j
- $TERbin(T_j)$ is the TER value of the unit for the corresponding bin temperature T_j
- $elbu(T_j)$ is the required capacity of an electric supplementary heater

The heating load $P_h(T_j)$ is determined by multiplying the design load value ($P_{designh}$) with the part load ratio for each corresponding bin.

The cooling load $P_c(T_j)$ is determined by multiplying the design load value ($P_{designc}$) with the part load ratio for each corresponding bin.

The part load ratio $pl(T_j)$ has been defined in the relevant table present in Annex II - Load Profile Values.

The $TERbin(T_j)$ values and capacity values at each bin are determined via linear interpolation of the TERbin and capacity values at part load conditions A, B, C, D, E, F, G, H, I, J and K where applicable. Interpolation of TERbin and capacities is done between the two closest part load conditions (see chapter 2.3.2.3 for partial loads point definition).

3.2.2.2 Calculation procedure for TERbin values

Calculations follow the same logic of the calculation used for COPbin and EERbin. For part load conditions A to K, where applicable, there are two possibilities:

- If both resulting capacities are within ± 10% of the required cooling and heating loads (e.g. between 9,9 kW and 8,1 kW for a required cooling load of 9 kW), the required loads are considered achieved. The resulting total capacity and TER are considered as P_{tot} and TERd. The TERd value of the unit shall be used as TERbin
- If the resulting capacities are higher and cannot reach cooling and/or heating loads within a tolerance (±10%), the unit has to cycle. This may occur with fixed capacity or staged or variable units. In such cases, a degradation factor (C_d) must be used to calculate the TERbin value from the TERd.

In this latter case, the capacity ratio (CR) is required. CR is the ratio of the load over the declared capacity (P_d) of the unit at the same temperature conditions. Due to the characteristic of the products, the power input needs to be calculated for all 3 working modes:

- Total heat recovery (THR)
- Chiller (CH)
- Heat pump (HP)

3.2.2.3 Calculation procedure for TERbin values

Total heat recovery mode

To provide a robust procedure for calculating the TERbin, the suggestion is to start evaluating if and which loads (cooling or heating) can be fully recovered and will be considered as the "base load" for the calculations of THR mode.

Before explaining the procedure for TERbin calculation, the following values are defined:

P_{dC}^{THR} is the declared cooling capacity of the unit in total heat recovery mode (W/W) at the same temperature conditions as for part load conditions A to K where applicable, expressed in kW

P_{dH}^{THR} is the declared heating capacity of the unit in total heat recovery mode (W/W) at the same temperature conditions as for part load conditions A to K where applicable, expressed in kW

P_{dE}^{THR} is the declared electrical power input of the unit in total heat recovery mode (W/W) at the same temperature conditions as for part load conditions A to K where applicable, expressed in kW

All previous values are declared by the producer and are linked to the following formula:

$$TER_d = \frac{P_{dC}^{THR} + P_{dH}^{THR}}{P_{dE}^{THR}}$$

Two CR (capacity ratio) values for polyvalent units can be defined, one for the heating loads in total heat recovery mode and one for cooling loads in total heat recovery mode.

<u>Capacity ratio in heating mode</u>:

$$CR_{heating}^{THR} = \frac{pl(T_j) \times P_{designH}}{P_{dH}^{THR}}$$

Where:

- $P_{designH}$ is the design heating load of the building the unit is suitable for, as declared by the manufacturer, expressed in kW
- pl(Tj) is the part load ratio as given in chapter 2.3.2.3.
- P_{dH}^{THR} is the declared capacity of the unit at the same temperature conditions as for part load conditions A to K where applicable, expressed in kW.

Capacity ratio in cooling mode:

$$CR_{cooling}^{THR} = \frac{pl(T_j) \times P_{designC}}{P_{dC}^{THR}}$$

Where:

- $P_{designC}$ is the design cooling load of the building the unit is suitable for, as declared by the manufacturer, expressed in kW
- pl(Tj) is the part load ratio as given in chapter 2.3.2.3.
- P_{dC}^{THR} is the declared capacity of the unit at the same temperature conditions as for part load conditions A to K where applicable, expressed in kW.

The unit will recover the smaller of the 2 loads (cooling or heating) and so it is always possible to define:

$$CR_{THR} = min\left[CR_{heating}^{THR}; CR_{cooling}^{THR}\right]$$

Following a similar logic used for the calculations of COPbin and EERbin for SCOP and SEER, where capacity ratio CR_{THR} is lower than 1, a degradation factor should be taken into account, which will decrease the efficiency of the unit considering the start and stop cycles of compressors.

The degradation coefficient (C_d) is determined for each part load with following formula:

$$C_d^{THR} = 1 - \frac{P_{Coff}^{THR}}{P_{Con}^{THR}}$$

Where:

- P_{Coff}^{THR} is the effective power input during compressor-off state in THR mode
- P_{Con}^{THR} is the effective power input measured during the corresponding part load test in THR mode.

For the determination of the C_d values, it is suggested to use a factor of 0.9 (same standard values prescribed for SCOP).

From the C_d^{THR} value, a power input can be defined which considers the inefficiency of the unit, P_{EI}^{THR}. The inefficiencies of the unit in THR are accounted in CR_{THR} time fraction, inefficiencies during the other part of the time (1 - CR_{THR}) are accounted in the other working modes.

$$P_{EI}^{THR} = P_{dE}^{THR} \times (1 - C_d^{THR})$$

And so calculate the total power input in THR mode:

$$P_E^{THR} = (P_{dE}^{THR} \times CR_{THR}) + (P_{EI}^{THR} \times CR_{THR})$$

Chiller mode

In this case, the electrical power input for cooling mode needs to be evaluated. If the units should not work in chiller mode to fulfil the loads, the final factor P_E^{CH} drops to zero.

As for THR, a degradation factor for chiller mode needs to be defined:

$$C_d^{CH} = 1 - \frac{P_{Coff}^{CH}}{P_{Con}^{CH}}$$

Where:

- P_{Coff}^{CH} is the effective power input during compressor-off state in chiller mode;
- P_{Con}^{CH} is the effective power input measured during the corresponding part load test in chiller mode.

For the determination of the C_d values, it is suggested to use a factor of 0.9 (same standard values prescribed for SCOP).

From C_d^{CH} value, the capacity P_{EI}^{CH} can be defined, considering the inefficiencies of the unit:

$$P_{EI}^{CH} = P_{dE}^{CH} \times (1 - C_d^{CH})$$

Where P_{dE}^{CH} is defined as the declared power input of the unit in chiller mode (A/W) at the same temperature conditions as for part load conditions A to K where applicable, expressed in kW.

Then the capacity ratio for chiller mode should be defined:

$$CR_{CH} = \frac{\left[pl(t_j) \times P_{designC}\right] - (P_{dC}^{THR} \times CR_{THR})}{P_{dC}^{CH}}$$

Where:

- P_{dC}^{CH} is the declared capacity of the unit at the same temperature conditions as for part load conditions A to K-7 where applicable, expressed in kW.

Note that if the cooling load is fulfilled completely from THR mode, CR_{CH} drops to zero.

It is possible to define the total power input in chiller mode as:

$$P_E^{CH} = (P_{dE}^{CH} \times CR_{CH}) + (P_{EI}^{CH} \times CR_{CH})$$

If CR_{CH} is zero, then all this addendum of the total power input is zero.

Heat pump mode

In this case, the electrical power input for the heat pump mode needs to be evaluated. If the units should not work in heat pump mode to fulfil the loads, final factor P_E^{HP} drop to zero.

As for THR and CH mode, a degradation factor needs to be defined:

$$C_d^{HP} = 1 - \frac{P_{Coff}^{HP}}{P_{Con}^{HP}}$$

Where:

- P_{Coff}^{HP} is the effective power input during compressor-off state in heat pump mode
- P_{Con}^{HP} is the effective power input measured during the corresponding part load test in heat pump mode.

For the determination of the C_d values, it is suggested to use a factor of 0.9 (same standard values prescribed for SCOP).

From C_d^{HP} value, the capacity P_{EI}^{HP} can be defined, considering the inefficiencies of the unit:

$$P_{EI}^{HP} = P_{dE}^{HP} \times (1 - C_d^{HP})$$

Where P_{dE}^{HP} is defined as the declared power input of the unit in heat pump mode (A/W) at the same temperature conditions as for part load conditions A to K where applicable, expressed in kW.

Then the capacity ratio for heat pump mode should be defined:

$$CR_{HP} = \frac{\left[pl(t_j) \times P_{designH}\right] - (P_{dH}^{THR} \times CR_{THR})}{P_{dH}^{HP}}$$

Note that if the heating load is fulfilled completely from THR mode, CR_{HP} drops to zero.

It is possible to define the total power input in heat pump mode as:

$$P_E^{HP} = (P_{dE}^{HP} \times CR_{HP}) + (P_{EI}^{HP} \times CR_{HP})$$

If CR_{HP} is zero, then all this addendum of the total power input is zero.

3.2.2.4 TERbin calculation

The efficiency of the units for each point A to K, where applicable, can be defined:

$$TER_{bin} = \frac{P_{tot}}{P_E}$$

$$P_{tot} = P_{designC} + P_{designH}$$

$$P_E = P_E^{THR} + P_E^{CH} + P_E^{HP}$$

Annex I - Detailed bins of the Climatic Profiles

		Warmer (W)	Average (A)	Colder (C)
j	Tj	hjW	hjA	hjC
#	[°C]	[h]	[h]	[h]
1	-28	0	0	0
2	-27	0	0	0
3	-26	0	0	0
4	-25	0	0	0
5	-24	0	0	0
6	-23	0	0	0
7	−22	0	0	2
8	−21	0	0	3
9	−20	0	0	4
10	−19	0	0	4
11	−18	0	0	6
12	−17	0	0	10
13	−16	0	0	17
14	−15	0	0	26
15	−14	0	0	38
16	−13	0	0	52
17	−12	0	0	68
18	−11	0	0	86
19	−10	0	9	106
20	−9	0	23	127
21	−8	0	39	148
22	−7	0	58	171
23	−6	0	76	193
24	−5	0	95	215
25	−4	0	116	237
26	−3	0	136	258
27	−2	0	155	277
28	−1	0	175	295
29	0	0	193	310
30	1	0	211	324
31	2	1	228	335
32	3	13	243	344
33	4	37	257	351
34	5	70	270	354
35	6	114	281	354
36	7	166	291	352
37	8	224	299	347
38	9	284	306	338
39	10	346	310	327
40	11	371	314	314
41	12	388	315	299
42	13	409	314	281
43	14	425	312	262
44	15	432	308	241
45	16	444	303	220
46	17	460	296	197
47	18	455	287	174
48	19	449	276	152
49	20	435	265	129
50	21	424	251	108
51	22	401	237	88
52	23	355	222	69
53	24	307	205	52
54	25	262	188	38
55	26	220	169	26
56	27	184	151	17
57	28	155	132	11
58	29	134	113	3
59	30	119	94	0
60	31	112	76	0

61	32	101	58	0
62	33	85	42	0
63	34	73	27	0
64	35	52	19	0
65	36	48	11	0
66	37	44	4	0
67	38	39	0	0
68	39	35	0	0
69	40	28	0	0
70	41	25	0	0
71	42	19	0	0
72	43	12	0	0
73	44	3	0	0
74	45	0	0	0
75	46	0	0	0
76	47	0	0	0
77	48	0	0	0
78	49	0	0	0
79	50	0	0	0

Annex II - Load Profile Values

	Cooling loads			Heating loads		
	Warmer	Average	Colder	Warmer	Average	Colder
-28	n.a	n.a	n.a	n.a	n.a	n.a
-27	n.a	n.a	n.a	n.a	n.a	n.a
-26	n.a	n.a	n.a	n.a	n.a	n.a
-25	n.a	n.a	n.a	n.a	n.a	n.a
-24	n.a	n.a	n.a	n.a	n.a	n.a
-23	n.a	n.a	n.a	n.a	n.a	n.a
-22	n.a	n.a	0,00%	n.a	n.a	100,00%
-21	n.a	n.a	0,00%	n.a	n.a	98,08%
-20	n.a	n.a	0,00%	n.a	n.a	96,15%
-19	n.a	n.a	0,00%	n.a	n.a	94,23%
-18	n.a	n.a	0,00%	n.a	n.a	92,31%
-17	n.a	n.a	0,00%	n.a	n.a	90,38%
-16	n.a	n.a	0,00%	n.a	n.a	88,46%
-15	n.a	n.a	0,00%	n.a	n.a	86,54%
-14	n.a	n.a	0,00%	n.a	n.a	84,62%
-13	n.a	n.a	0,00%	n.a	n.a	82,69%
-12	n.a	n.a	0,00%	n.a	n.a	80,77%
-11	n.a	n.a	0,00%	n.a	n.a	78,85%
-10	n.a	0,00%	0,00%	n.a	100,00%	76,92%
-9	n.a	0,00%	0,00%	n.a	97,50%	75,00%
-8	n.a	0,00%	0,00%	n.a	95,00%	73,08%
-7	n.a	0,00%	0,00%	n.a	92,50%	71,15%
-6	n.a	0,00%	0,00%	n.a	90,00%	69,23%
-5	n.a	0,00%	0,00%	n.a	87,50%	67,31%
-4	n.a	0,00%	0,00%	n.a	85,00%	65,38%
-3	n.a	0,00%	0,00%	n.a	82,50%	63,46%
-2	n.a	0,00%	0,00%	n.a	80,00%	61,54%
-1	n.a	0,00%	0,00%	n.a	77,50%	59,62%
0	n.a	0,00%	0,00%	n.a	75,00%	57,69%
1	n.a	0,00%	0,00%	n.a	72,50%	55,77%
2	0,00%	0,00%	0,00%	100,00%	70,00%	53,85%
3	0,00%	0,00%	0,00%	96,43%	67,50%	51,92%
4	0,00%	0,00%	0,00%	92,86%	65,00%	50,00%
5	0,00%	0,00%	0,00%	89,29%	62,50%	48,08%
6	0,00%	0,00%	0,00%	85,71%	60,00%	46,15%
7	0,00%	0,00%	0,00%	82,14%	57,50%	44,23%
8	3,03%	3,57%	4,35%	78,57%	55,00%	42,31%
9	6,06%	7,14%	8,70%	75,00%	52,50%	40,38%
10	9,09%	10,71%	13,04%	71,43%	50,00%	38,46%
11	12,12%	14,29%	17,39%	67,86%	47,50%	36,54%
12	15,15%	17,86%	21,74%	64,29%	45,00%	34,62%
13	18,18%	21,43%	26,09%	60,71%	42,50%	32,69%
14	21,21%	25,00%	30,43%	57,14%	40,00%	30,77%
15	24,24%	28,57%	34,78%	53,57%	37,50%	28,85%
16	27,27%	32,14%	39,13%	50,00%	35,00%	26,92%
17	30,30%	35,71%	43,48%	46,43%	32,50%	25,00%
18	33,33%	39,29%	47,83%	42,86%	30,00%	23,08%
19	36,36%	42,86%	52,17%	39,29%	27,50%	21,15%
20	39,39%	46,43%	56,52%	35,71%	25,00%	19,23%
21	42,42%	50,00%	60,87%	32,14%	22,50%	17,31%
22	45,45%	53,57%	65,22%	28,57%	20,00%	15,38%
23	48,48%	57,14%	69,57%	25,00%	17,50%	13,46%
24	51,52%	60,71%	73,91%	21,43%	15,00%	11,54%
25	54,55%	64,29%	78,26%	17,86%	12,50%	9,62%
26	57,58%	67,86%	82,61%	14,29%	10,00%	7,69%
27	60,61%	71,43%	86,96%	10,71%	7,50%	5,77%
28	63,64%	75,00%	91,30%	7,14%	5,00%	3,85%
29	66,67%	78,57%	95,65%	3,57%	2,50%	1,92%
30	69,70%	82,14%	100,00%	0,00%	0,00%	0,00%
31	72,73%	85,71%	n.a	0,00%	0,00%	0,00%
32	75,76%	89,29%	n.a	0,00%	0,00%	0,00%

33	78,79%	92,86%	n.a	0,00%	0,00%	0,00%
34	81,82%	96,43%	n.a	0,00%	0,00%	0,00%
35	84,85%	100,00%	n.a	0,00%	0,00%	0,00%
36	87,88%	103,57%	n.a	0,00%	0,00%	0,00%
37	90,91%	107,14%	n.a	0,00%	0,00%	0,00%
38	93,94%	n.a	n.a	0,00%	0,00%	0,00%
39	96,97%	n.a	n.a	0,00%	0,00%	0,00%
40	100,00%	n.a	n.a	0,00%	0,00%	0,00%
41	103,03%	n.a	n.a	0,00%	0,00%	0,00%
42	106,06%	n.a	n.a	0,00%	0,00%	0,00%
43	109,09%	n.a	n.a	0,00%	0,00%	0,00%
44	112,12%	n.a	n.a	0,00%	0,00%	0,00%
45	n.a	n.a	n.a	0,00%	0,00%	0,00%
46	n.a	n.a	n.a	0,00%	0,00%	0,00%
47	n.a	n.a	n.a	0,00%	0,00%	0,00%
48	n.a	n.a	n.a	0,00%	0,00%	0,00%
49	n.a	n.a	n.a	0,00%	0,00%	0,00%
50	n.a	n.a	n.a	0,00%	0,00%	0,00%

Annex III - Measurement of electric power input during thermostat-off mode

Electric power input during thermostat-off mode shall be measured as follows.

After the unit has been running for 30 min in heat recovery mode at any of the testing points D, E or F, the cooling and heating loads are reduced down to 0% until all compressors stop.

The time-averaged power input of the unit is measured over a time period of 60 min starting 10 min after the last compressor stops.

In order to measure a power input that is consistent with the definition of the effective power input:

- if the liquid pump(s) - either on cooling side or heating side, or on both sides - is an integral part of the unit, the available static pressure shall also be measured and the total thermostat-off power input be corrected from the power input of the liquid pump(s) to provide this available static pressure, as described in 4.1.4 of EN 14511-3:2022. In case the correction obtains a larger value than the measured value for the electric power input during thermostat-off mode, then the electric power input during thermostat-off mode is set to zero.
- if the liquid pump(s) - either on cooling side or heating side, or on both sides - is not an integral part of the unit, the thermostat-off power input shall be corrected from the fraction of the pump(s) power input that is necessary to overcome the internal static pressure difference as described in 4.1.4 of EN 14511-3:2022.

In case of variable water flow rate, the water flow may be reduced to its minimum value declared by the manufacturer either on cooling side or heating side, or on both sides.

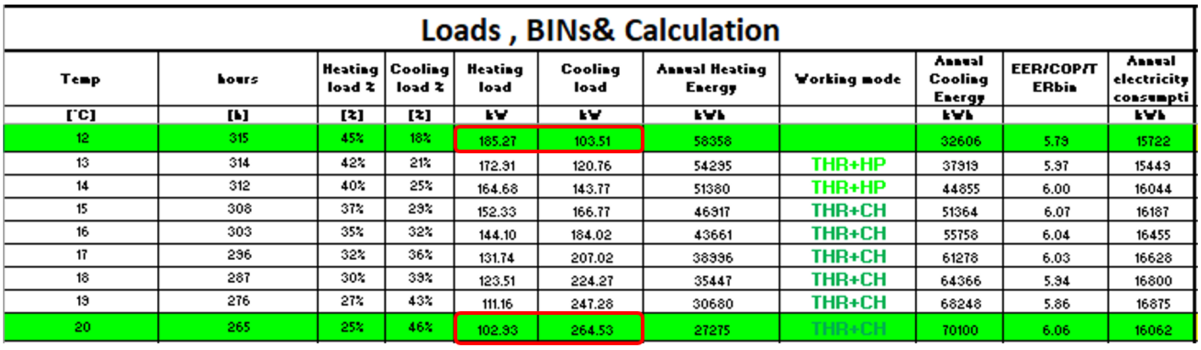
Annex IV - STER interpolation incongruence

In the STER spreadsheet, the calculation of the points between the declared ones is made by interpolation.

If in these points there is the change from THR+HP to THR+CH or vice versa, it can happen that the unit won't follow the load properly.

In the following example the change of the mode happens between T_air = 12°C and 20°C, in fact:

- T_air = 12°C -> heating load > cooling load
- T_air = 20°C -> cooling load > heating load

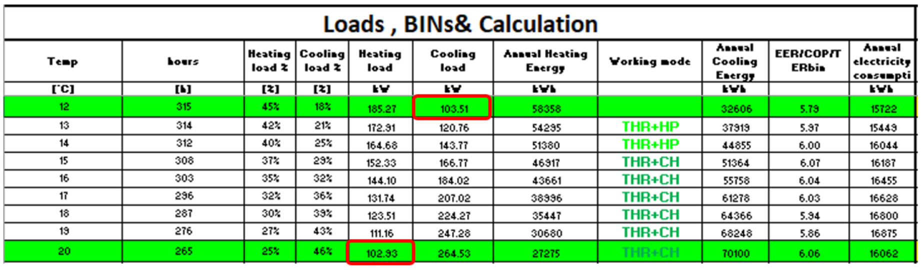


Loads , BINs& Calculation

Temp	hours	Heating load %	Cooling load %	Heating load	Cooling load	Annual Heating Energy	Working mode	Annual Cooling Energy	EER/COP/T ERbin	Annual electricity consumpti
[°C]	[h]	[%]	[%]	kW	kW	kWh		kWh		kWh
12	315	45%	18%	185.27	103.51	58358		32606	5.79	15722
13	314	42%	21%	172.91	120.76	54295	THR+HP	37919	5.97	15449
14	312	40%	25%	164.68	143.77	51380	THR+HP	44855	6.00	16044
15	308	37%	29%	152.33	166.77	46917	THR+CH	51364	6.07	16187
16	303	35%	32%	144.10	184.02	43661	THR+CH	55758	6.04	16455
17	296	32%	36%	131.74	207.02	38996	THR+CH	61278	6.03	16628
18	287	30%	39%	123.51	224.27	35447	THR+CH	64366	5.94	16800
19	276	27%	43%	111.16	247.28	30680	THR+CH	68248	5.86	16875
20	265	25%	46%	102.93	264.53	27275	THR+CH	70100	6.06	16062

Therefore, the THR mode satisfies at Ta = 12°C the cooling load (103,51 kW) and at Ta = 20°C the heating load (102,93).

But, due to the interpolation, between 12-20°C there is missing load in cooling and in heating, so the unit is supposed to work at the same time in THR, CH and HP modes, while in the reality this is not possible.



Loads , BINs& Calculation

Temp	hours	Heating load %	Cooling load %	Heating load	Cooling load	Annual Heating Energy	Working mode	Annual Cooling Energy	EER/COP/T ERbin	Annual electricity consumpti
[°C]	[h]	[%]	[%]	kW	kW	kWh		kWh		kWh
12	315	45%	18%	185.27	103.51	58358		32606	5.79	15722
13	314	42%	21%	172.91	120.76	54295	THR+HP	37919	5.97	15449
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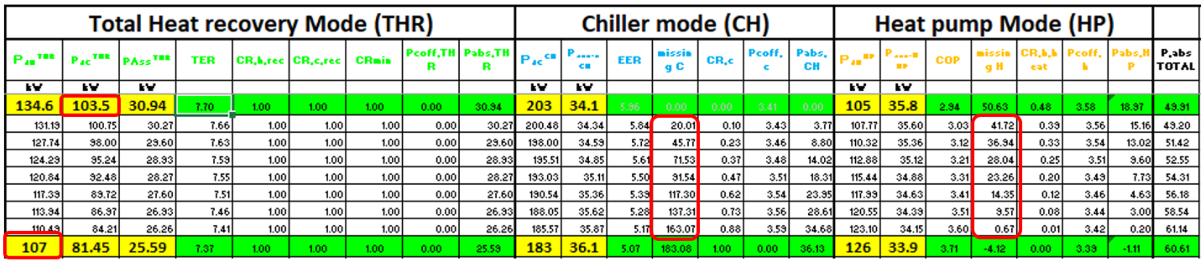
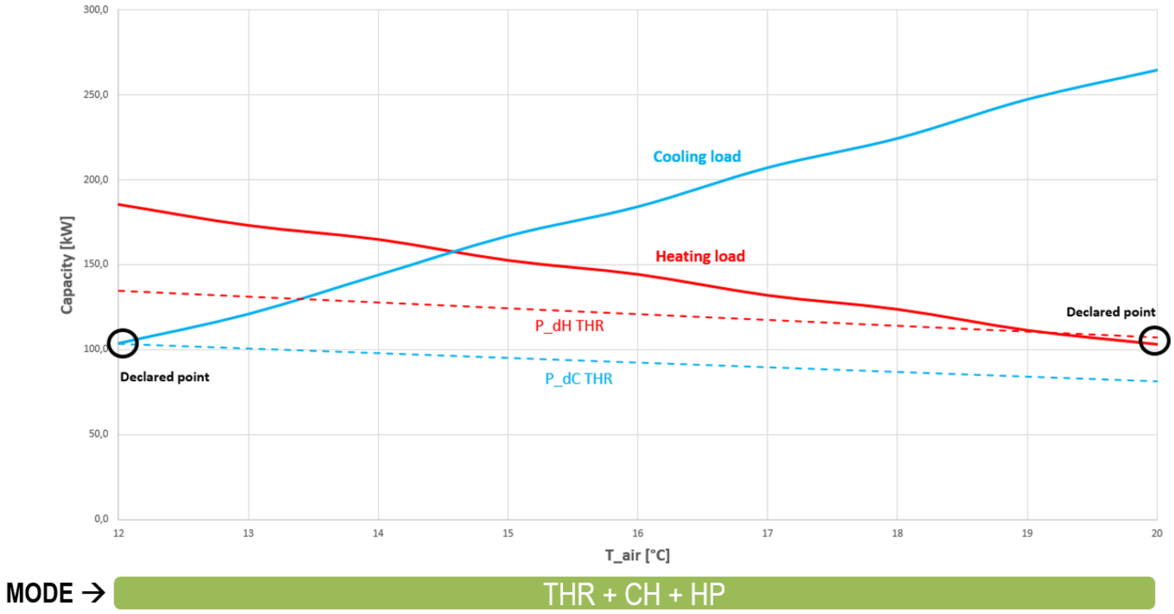
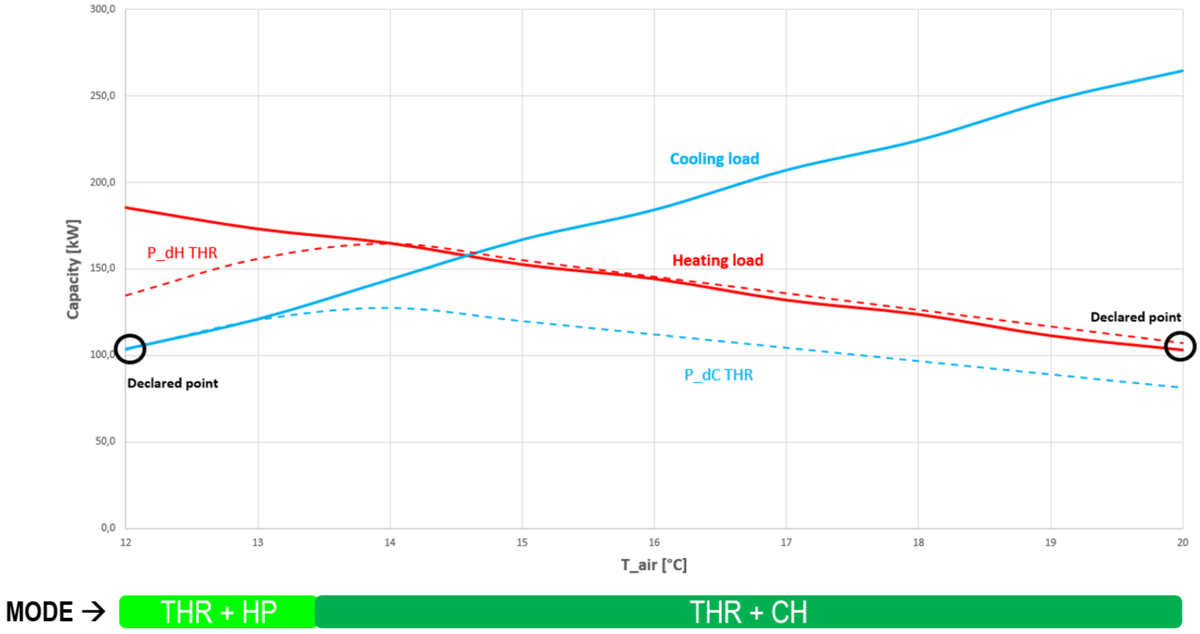


Total Heat recovery Mode (THR)									Chiller mode (CH)							Heat pump Mode (HP)								
P_{dh}^{THR}	P_{dc}^{THR}	$PAss^{THR}$	TER	CR,h,rec	CR,c,rec	CRmin	Pcoff,THR	Pabs,THR	P_{dc}^{CH}	P [illegible] CH	EER	missing C	CR,c	Pcoff,c	Pabs,CH	P_{dh}^{HP}	P [illegible] HP	COP	missing H	CR,h,heat	Pcoff,h	Pabs,HP	P,abs TOTAL
kW	kW	kW							kW	kW						kW	kW						
134.6	103.5	30.94	7.70	1.00	1.00	1.00	0.00	30.94	203	34.1	5.96	0.00	0.00	3.41	0.00	105	35.8	2.94	50.63	0.48	3.58	18.97	49.91
131.19	100.75	30.27	7.66	1.00	1.00	1.00	0.00	30.27	200.48	34.34	5.84	20.01	0.10	3.43	3.77	107.77	35.60	3.03	41.72	0.39	3.56	15.16	49.20
127.74	98.00	29.60	7.63	1.00	1.00	1.00	0.00	29.60	198.00	34.59	5.72	45.77	0.23	3.46	8.80	110.32	35.36	3.12	36.94	0.33	3.54	13.02	51.42
124.29	95.24	28.93	7.59	1.00	1.00	1.00	0.00	28.93	195.51	34.85	5.61	71.53	0.37	3.48	14.02	112.88	35.12	3.21	28.04	0.25	3.51	9.60	52.55
120.84	92.48	28.27	7.55	1.00	1.00	1.00	0.00	28.27	193.03	35.11	5.50	91.54	0.47	3.51	18.31	115.44	34.88	3.31	23.26	0.20	3.49	7.73	54.31
117.39	89.72	27.60	7.51	1.00	1.00	1.00	0.00	27.60	190.54	35.36	5.39	117.30	0.62	3.54	23.95	117.99	34.63	3.41	14.35	0.12	3.46	4.63	56.18
113.94	86.97	26.93	7.46	1.00	1.00	1.00	0.00	26.93	188.05	35.62	5.28	137.31	0.73	3.56	28.61	120.55	34.39	3.51	9.57	0.08	3.44	3.00	58.54
110.43	84.21	26.26	7.41	1.00	1.00	1.00	0.00	26.26	185.57	35.87	5.17	163.07	0.88	3.59	34.68	123.10	34.15	3.60	0.67	0.01	3.42	0.20	61.14
107	81.45	25.59	7.37	1.00	1.00	1.00	0.00	25.59	183	36.1	5.07	183.08	1.00	0.00	36.13	126	33.9	3.71	-4.12	0.00	3.39	-1.11	60.61

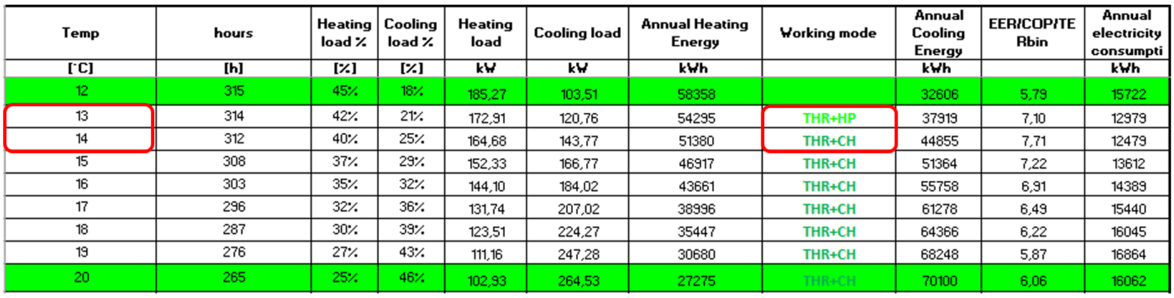
In fact, from T_air = 12°C to 20°C the capacity in THR mode is constantly decreasing and not following the load like it is supposed to do.



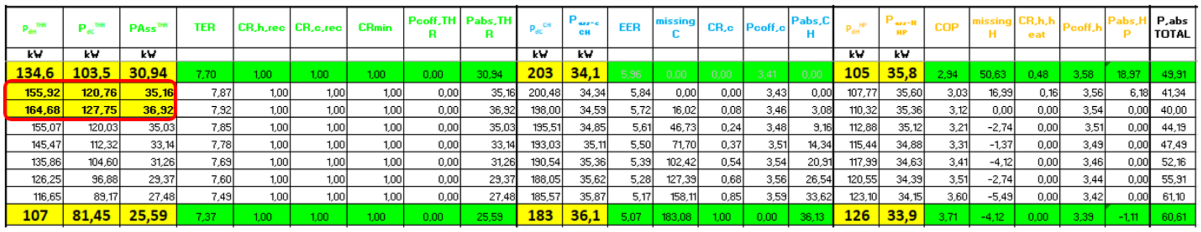
In the reality the unit in THR must work like this:



To solve this problem, it is necessary to understand at which temperatures there is the change THR+HP / THR+CH and calculate the capacities of the unit in THR mode.



Temp	hours	Heating load %	Cooling load %	Heating load	Cooling load	Annual Heating Energy	Working mode	Annual Cooling Energy	EER/COP/TE Rbin	Annual electricity consumpti
[°C]	[h]	[%]	[%]	kW	kW	kWh		kWh		kWh
12	315	45%	18%	185,27	103,51	58358		32606	5,79	15722
13	314	42%	21%	172,91	120,76	54295	THR+HP	37919	7,10	12979
14	312	40%	25%	164,68	143,77	51380	THR+CH	44855	7,71	12479
15	308	37%	29%	152,33	166,77	46917	THR+CH	51364	7,22	13612
16	303	35%	32%	144,10	184,02	43661	THR+CH	55758	6,91	14389
17	296	32%	36%	131,74	207,02	38996	THR+CH	61278	6,49	15440
18	287	30%	39%	123,51	224,27	35447	THR+CH	64366	6,22	16045
19	276	27%	43%	111,16	247,28	30680	THR+CH	68248	5,87	16864
20	265	25%	46%	102,93	264,53	27275	THR+CH	70100	6,06	16062



P_{dH}^{THR}	P_{dc}^{THR}	$PAss^{THR}$	TER	CR,h,rec	CR,c,rec	CRmin	Pcoff,THR	Pabs,THR	P_{dc}^{CH}	$P_{arr\text{-}c}$ CH	EER	missing C	CR,c	Pcoff,c	Pabs,CH	P_{dH}^{HP}	$P_{arr\text{-}H}$ HP	COP	missing H	CR,h,heat	Pcoff,h	Pabs,HP	P,abs TOTAL
kW	kW	kW							kW	kW						kW	kW						
134,6	103,5	30,94	7,70	1,00	1,00	1,00	0,00	30,94	203	34,1	5,96	0,00	0,00	3,41	0,00	105	35,8	2,94	50,63	0,48	3,58	18,97	49,91
155,92	120,76	35,16	7,87	1,00	1,00	1,00	0,00	35,16	200,48	34,34	5,84	0,00	0,00	3,43	0,00	107,77	35,60	3,03	16,99	0,16	3,56	6,18	41,34
164,68	127,75	36,92	7,92	1,00	1,00	1,00	0,00	36,92	198,00	34,59	5,72	16,02	0,08	3,46	3,08	110,32	35,36	3,12	0,00	0,00	3,54	0,00	40,00
155,07	120,03	35,03	7,85	1,00	1,00	1,00	0,00	35,03	195,51	34,85	5,61	46,73	0,24	3,48	9,16	112,88	35,12	3,21	-2,74	0,00	3,51	0,00	44,19
145,47	112,32	33,14	7,78	1,00	1,00	1,00	0,00	33,14	193,03	35,11	5,50	71,70	0,37	3,51	14,34	115,44	34,88	3,31	-1,37	0,00	3,49	0,00	47,49
135,86	104,60	31,26	7,69	1,00	1,00	1,00	0,00	31,26	190,54	35,36	5,39	102,42	0,54	3,54	20,91	117,99	34,63	3,41	-4,12	0,00	3,46	0,00	52,16
126,25	96,88	29,37	7,60	1,00	1,00	1,00	0,00	29,37	188,05	35,62	5,28	127,39	0,68	3,56	26,54	120,55	34,39	3,51	-2,74	0,00	3,44	0,00	55,91
116,65	89,17	27,48	7,49	1,00	1,00	1,00	0,00	27,48	185,57	35,87	5,17	158,11	0,85	3,59	33,62	123,10	34,15	3,60	-5,49	0,00	3,42	0,00	61,10
107	81,45	25,59	7,37	1,00	1,00	1,00	0,00	25,59	183	36,1	5,07	183,08	1,00	0,00	36,13	126	33,9	3,71	-4,12	0,00	3,39	-1,11	60,61

About Eurovent

Eurovent is Europe's Industry Association for Indoor Climate (HVAC), Process Cooling, and Food Cold Chain Technologies. Its members from throughout Europe represent more than 1.000 organisations, the majority small and medium-sized manufacturers. Based on objective and verifiable data, these account for a combined annual turnover of more than 30bn EUR, employing around 150.000 people within the association's geographic area. This makes Eurovent one of the largest cross-regional industry committees of its kind. The organisation's activities are based on highly valued democratic decision-making principles, ensuring a level playing field for the entire industry independent from organisation sizes or membership fees.

Our Member Associations

Our Member Associations are major national sector associations from Europe that represent manufacturers in the area of Indoor Climate (HVAC), Process Cooling, Food Cold Chain, and Industrial Ventilation technologies.

The more than 1.000 manufacturers within our network (Eurovent 'Affiliated Manufacturers' and 'Corresponding Members') are represented in Eurovent activities in a democratic and transparent manner.

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