MITSUBISHI ELECTRIC

Sustainability & Construction Team

Efficiency Test Standards Overview

Understanding heating efficiency of air and water source heat pump systems

Contents

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Document Outline

This is one of a series of documents produced by Mitsubishi Electric UK to assist with understanding a specific application or design of HVAC systems.

This document aims to highlight the legislation which dictates the minimum efficiency level that a heat pump must reach and how that efficiency is measured, calculated and reported by manufacturers. It also aims to provide insight into why certain data is available/not available for different products and why all data is shown in a particular format with specific references & caveats

Calculating heat pump efficiency is complex as there are many variables which impact the performance. Detailed testing standards set out which tests must be carried out and at what operating conditions. These standards also specify the calculation methodology to derive performance across an entire heating season and provide a platform to compare different products against each other.

Understanding exactly how these tests & calculations are carried out will allow heat pump system designers and other built environment professionals to better use manufacturer published performance data and relate it to individual projects.

Energy Related Products Directive

Overview

The Ecodesign Directive for Energy Related Products (ErP) is European legislation adopted in 2009 to improve the environmental performance of any products that use energy or that are related to energy consumption.

As the ErP covers such a broad range of products, they have been divided into LOTS - this guide concentrates upon LOT 1 (sub regulation No 813/2013) and the methodologies used to determine product performance, efficiency and energy usage of those products.

Example Mitsubishi Electric products which fall under this LOT:

LOT 1

Space heaters <400kW

Commission Regulation (EU) No. 813/2013

MEHP-iS-G07

CAHV-R

EW-HT-G05

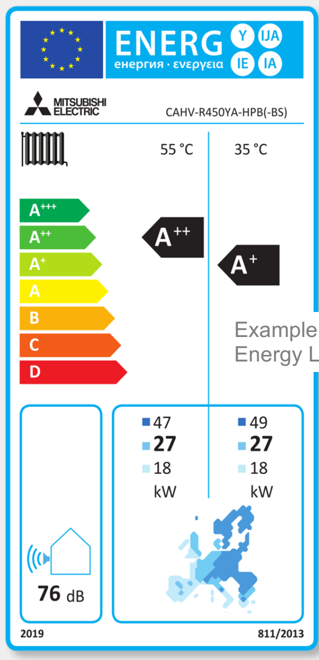
EAHV-M

The Ecodesign directive currently covers space and combination heaters with a rated heat output of up to 400kW, however, manufacturers are only required to provide Energy performance labeling on products up to 70kW capacity - therefore;

- **Energy labels are not required on products with rated heating capacity of >70kW**
- **Products >400kW capacity are likely not to have ErP product heating performance data available as they are not covered by regulation 813/2013 (LOT 1)**

The capacity rating of a heat pump is defined within the ErP and is shown on the standard product data fiche which is provided for all equipment available in the EU and UK markets - product fiches are covered in more detail on page 15 of this guide.

More detailed information on the Energy Related Products Directive can be found in our dedicated CPD guide (link provided in the links section).



Example of Energy Label

Heat pumps are categorised within LOT 1 as **'Heat pump space heaters'** or **'Low temperature heat pumps'**. The low temperature category is applicable for heat pump space heaters that are specifically designed for low temperature application and therefore cannot deliver a flow temperature of 52ºC at an ambient condition of -7ºC.

This distinction is important as the minimum allowable product efficiencies differ for the two product categories. In addition, manufacturer published data for the different product categories is also likely to be different by showing product performance at different operating conditions - see below table showing an example of the standard rating conditions for the different product categories.

Example of Mitsubishi Electric products classed as Low Temperature Heat Pumps

NX-N-G06

NX2-N-G06

i-FX-N-G05

Standard rating conditions for heat pump space heaters and heat pump combination heaters

	Outdoor heat exchanger	Indoor heat exchanger			
Heat Source	Inlet dry bulb (wet Bulb) temperature	Heat pump space heaters and heat pump combination heaters, except low-temperature heat pumps		Low-temperature heat pumps	
		Inlet temperature	Outlet temperature	Inlet temperature	Outlet temperature
Outdoor air	+7ºC (+6ºC)	**+47ºC**	**+55ºC**	**+30ºC**	**+35ºC**
Exhaust air	+20ºC (+12ºC)				
	Inlet / outlet temperature				
Water	+10ºC / +7ºC				
Brine	0ºC / -3ºC				

Table extracted from EU Commission regulation 813/2013
https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:239:0136:0161:en:PDF

Minimum Efficiencies

In order for a product to be placed upon the market, it must meet minimum efficiency criteria, which for LOT 1 products is based upon its seasonal space heating energy efficiency - defined in the ErP legislation as; **The ratio between the space heating demand for a designated heating season supplied by a heater and the annual energy input required to meet this demand, expressed as η_s %.**

Seasonal space heating efficiency classes of low temperature heat pumps

Seasonal space heating energy efficiency class	Seasonal space heating energy efficiency η_s in %	
A+++	$\eta_s \geq 175$	
A++	$150 \leq \eta_s < 175$	
A+	$123 \leq \eta_s < 150$	125η_s
A	$115 \leq \eta_s < 123$	
B	$107 \leq \eta_s < 115$	Minimum
C	$100 \leq \eta_s < 107$	
D	$61 \leq \eta_s < 100$	
E	$59 \leq \eta_s < 61$	
F	$55 \leq \eta_s < 59$	
G	$\eta_s < 55$	

Seasonal space heating efficiency classes of heat pump space heaters

Seasonal space heating energy efficiency class	Seasonal space heating energy efficiency η_s in %	
A+++	$\eta_s \geq 150$	
A++	$125 \leq \eta_s < 150$	
A+	$98 \leq \eta_s < 125$	110η_s
A	$90 \leq \eta_s < 98$	
B	$82 \leq \eta_s < 90$	Minimum
C	$75 \leq \eta_s < 82$	
D	$36 \leq \eta_s < 75$	
E	$34 \leq \eta_s < 36$	
F	$30 \leq \eta_s < 34$	
G	$\eta_s < 30$	

Tables extracted from UK Governement document 811/2013.
https://www.legislation.gov.uk/eur/2013/811/annex/II/division/1
https://www.legislation.gov.uk/eur/2013/813/annex/II/division/1#text%3D813%2F2013

The ηs rating and associated energy efficiency class (A+++ to G) allows comparison between heating products with different fuel sources by considering the total heating energy delivered in comparison to the total primary energy input.

In the context of the Ecodesign Directive, primary energy input refers to the total energy input required to deliver usable energy to the end user, including all losses from extraction, conversion, and distribution processes.

Consumed energy, on the other hand, is the energy actually used by an appliance or system during its operation.

Primary Energy: Encompasses the initial energy from natural resources (like coal, oil, wind, solar) and includes losses from generation, transmission, and distribution.

Consumed Energy: The amount of energy directly used by the appliance, excluding upstream losses.

The distinction is crucial for assessing the overall environmental impact and efficiency of different energy-related products as some have more upstream losses than others.

Energy Efficiency (ηs%)

Primary Energy Input	Transmission / Distribution Losses	Consumed Energy	Appliance Efficiency	Delivered Heat	ηs%
1kW	-0.1kW	0.9kW	X 93%	~0.83kW	= 83 ηs%
1kW	-0.6kW	0.4kW	(SCOP) X ~430%	~1.72kW	= 172 ηs%

The assumed average electrical grid efficiency in the ErP is **40%** i.e. for every 1kW of primary energy input only 0.4kW of usable electricity is delivered to the electrical appliance.

Therefore, the overall efficiency of a product covered by ErP regulation 813/2013 can be represented by the simplified formula below;

$$\eta s = 0.4 \times SCOP - 3\%$$

(3% is an assumed fixed figure to account for the negative contribution of temperature adjustment and controls).

Test Standard EN14511

Performance Testing

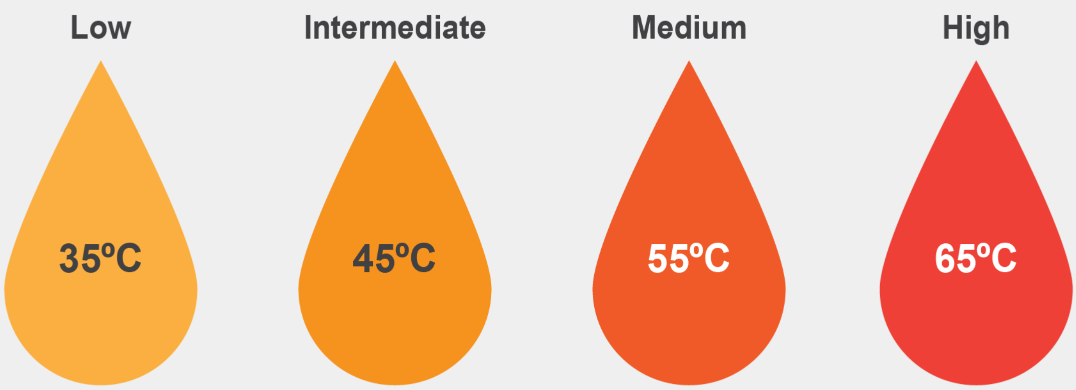
The terms, definitions, test standards, methodologies and requirements for calculating and demonstrating product performance are set out across the 4 parts of:

- **EN14511** - Air conditioners, liquid chilling packages and heat pumps for space heating and cooling with electrically driven compressors
- **EN14511 - 1** = Terms & Definitions
- **EN14511 - 2** = Test Conditions
- **EN14511 - 3** = Test Methods
- **EN14511 - 4** = Requirements

These separate documents focus upon demonstrating product performance at specified conditions using transparent and standardised testing methods to provide consistent criteria for assessing energy efficiency, heating and cooling capacity, and operational characteristics.

These standards ensure reliable and comparable data, helping manufacturers meet regulatory requirements and aiding consumers in making informed decisions about energy-efficient products.

Standard rating conditions are provided for heat pumps at different water flow temperatures of:



Performance at these different water flow temperatures is measured against defined air/water source temperatures and are typically shown by manufacturers in their product catalogue, in technical documentation or printed on equipment model/data plates.

Extract of standard rating conditions at intermediate water flow temperature for air to water heat pump from EN14511-2

Air-to-water (brine) units - Heating mode **(Intermediate temperature)**

		Outdoor heat exchanger		Indoor heat exchanger intermediate temperature application	
		Inlet dry bulb temperature °C	Inlet wet bulb temperature °C	Inlet temperature °C	Outlet temperature °C
Standard rating conditions	Outdoor air	7	6	40	45
	Exhaust air	20	12	40	45
Application rating conditions	Outdoor air	2	1	a	45
	Outdoor air	-7	-8	a	45
	Outdoor air	-15	-	a	45
	Outdoor air	12	11	a	45

a The test is performed with the fixed flow rate or with the ΔT obtained during the test at the corresponding standard rating conditions for units with variable flow rate. If the resulting flow rate is below the minimum flow rate then this minimum is used with the outlet temperature.

Extract of standard rating conditions at medium water flow temperature for water to water heat pump from EN14511-2

Water (brine)-to-water (brine) units - Heating mode **(Medium temperature)**

		Outdoor heat exchanger		Indoor heat exchanger medium temperature application	
		Inlet temperature °C	Outlet temperature °C	Inlet temperature °C	Outlet temperature °C
Standard rating conditions	Water [a]	10	7	47	55
	Brine	0	-3	47	55
Application rating conditions	Water (brine)	15	b	c	55
	Brine	10	b	c	55
	Water (brine)	5	b	c	55
	Brine	-5	b	c	55

a The term ‘water’ includes indifferently water from a river or lake, ground water or water in a close water loop.
b The test is performed with the fixed flow rate or with the ΔT obtained during the test at the corresponding standard rating conditions for units with variable flow rate. If the resulting flow rate is below the minimum flow rate then this minimum is used with the inlet temperature.
c The test is performed with the fixed flow rate or with the ΔT obtained during the test at the corresponding standard rating conditions for units with variable flow rate. If the resulting flow rate is below the minimum flow rate then this minimum is used with the outlet temperature.

Tables Extracted from BS EN14511-2 2022

Example Product Information for Mitsubishi Electric PUZ-WZ80 VAA Air source heat pump

Heating | Product Information

MITSUBISHI ELECTRIC

PUZ-WZ80VAA(-BS)

Ecodan R290

Monobloc Air Source Heat Pump

R290

OUTDOOR UNIT		PUZ-WZ80VAA(-BS)
HEAT PUMP SPACE HEATER - 55˚C	ErP Rating	A++
	η_s	140%
	SCOP (MCS)	3.56
HEAT PUMP SPACE HEATER - 35˚C	ErP Rating	A+++
	η_s	176%
	SCOP (MCS)	4.49
HEAT PUMP COMBINATION HEATER - Large Profile*1	ErP Rating	A+
	η_{wh}	134%
HEATING*2 (A-7/W35)	Capacity (kW)	8.2
	Power Input (kW)	3.51
	COP	2.28
OPERATING AMBIENT TEMPERATURE (°C DB)		-25 ~ +46
MAXIMUM WATER OUTLET TEMPERATURE (°C)		75
SOUND DATA*3	Pressure Level at 1m (dBA)	40
	Power Level (dBA)*4	58
WATER DATA	Pipework Size (mm)	28
	Flow Rate (l/min)	23
	Water Pressure Drop (kPa)	32.22
DIMENSIONS (mm)	Width	1050
	Depth	480
	Height	1020
WEIGHT (kg)		117
ELECTRICAL DATA	Electrical Supply	220-240v 50Hz
	Phase	Single
	Nominal Running Current [MAX] (A)*5	22
	Fuse Rating - MCB Sizes (A)*6	25
REFRIGERANT CHARGE (kg) / CO_2 EQUIVALENT (t)	R290 (GWP 3)	1.0 / 0.009

NOTES:
*1 Combination with EHPT20X-MEHEW Cylinder
*2 Under normal heating conditions at outdoor temp: -7°CDB / -8°CWB, outlet water temp 35°C, inlet water temp 30°C.
*3 Under normal heating conditions at outdoor temp: 7°CDB / 6°CWB, outlet water temp 55°C, inlet water temp 47°C as tested to BS EN14511.
*4 Sound power level tested to BS EN12102.
*5 Under nominal heating conditions at outdoor temp: 7°C, outlet water temp: 35°C.
*6 MCB Sizes BS EN60898-2 & BS EN60947-2.
η_s is the seasonal space heating energy efficiency (SSHEE)
η_{wh} is the water heating energy efficiency

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Example of unit mounted data plate from EAHV-M1500YCL

CE 0035

MITSUBISHI ELECTRIC

AIR-COOLED CHILLING UNIT

MODEL EAHV-M1500YCL <H>

REFRIGERANT
R32 (GWP : 675)
WEIGHT 11.5 kgx4
CO_2 EQUIVALENT 31.1 t

LEGAL REFRIGERATION TON
17.0RT(4.26RT x 4)

ALLOWABLE PRESSURE(Ps)	HP 4.15 MPa(41.5bar) LP 2.26 MPa(22.6bar)
WEIGHT	1280 kg
IP CODE	IPx4
YEAR OF MANUFACTURE	
SERIAL No.	

OPERATION		COOLING			HEATING		
RATED VOLTAGE	3N~ V	380	400	415	380	400	415
FREQUENCY	Hz	50/60			50/60		
CAPACITY	kW	149.8			150.82		
	kcal/h	123295			129705		
	Btu/h	509002			514598		
RATED INPUT	kW	45.55			43.43		
EER/COP		3.28			3.47		
RATED CURRENT	A	76	72	69	72	68	66
MAX CURRENT	A	120			120		
RATED CONDITION							
OUTLET WATER TEMP.	°C	7			45		
INLET WATER TEMP.	°C	12			40		
OUTDOOR DB/WB.	°C	35/24			7/6		

EER / COP and capacity according to EN14511

Contains fluorinated greenhouse gasses.

MANUFACTURER:
MITSUBISHI ELECTRIC CORPORATION
AIR-CONDITIONING & REFRIGERATION SYSTEMS WORKS
5-86, TEBIRA, 6-CHOME, WAKAYAMA CITY, JAPN
MADE IN JAPAN

Tests are carried out for minimum time periods (1 hour in some cases) after a minimum period of steady state conditions (15 mins in some cases) are created within the declared operational window of the unit.

Testing of safety protection devices such as shut off due to lack of water flow are carried out along with removal of power supply during operation and testing of restart procedures are also performed.

Sound levels, starting current, electrical power factor and individual power consumption of fans and pumps are recorded accordingly.

The power consumed by any fans or pumps is considered within the efficiency calculations whether they are integrated within the unit or external.

Testing and reporting of power consumption during periods of "off ", "thermostat off", "Standby" and "active" are all prescribed and used latterly as part of a seasonal efficiency calculation described later in this document (see page 12).

Strict uncertainties of measurement are specified to ensure accuracy of measurements for example +/- 0.15K for liquid temperature, +/-0.2K for air temperature and +/-1% for both liquid mass flow rates and electrical energy consumption.

Prescriptive measurements are required to be taken around any defrost process with average output calculated over set time periods with specified transient periods between starting and ending of defrost processes stipulated to ensure that stable conditions are created and the equipment performance is accurately captured.

The overall equipment performance must then fall within the below stated verification tolerances.

Verification tolerances

Parameters	Verification tolerances
Seasonal space-heating energy efficiency, η_s	The determined value shall not be lower than the declared value by more than 8%
Water-heating energy efficiency, η_s	The determined value shall not be lower than the declared value by more than 8%
Sound power level, L_{WA}	The determined value shall not exceed the declared value by more than 2 dB(A)

Table extracted from Regulation (EU) 813/2013 Annex 4.

Test Standard EN14825 - Seasonal Efficiency Calculation

Climate Profiles & Heating Load

To ensure that seasonal performance of heating systems reflect real world usage across different climatic conditions in Europe, EN14825 offers 3 different profiles;

Cold - **Cold winters / mild summers** - reference city Helsinki, Finland

Average - **Moderate winters / warm summers** - reference city Strasbourg, France

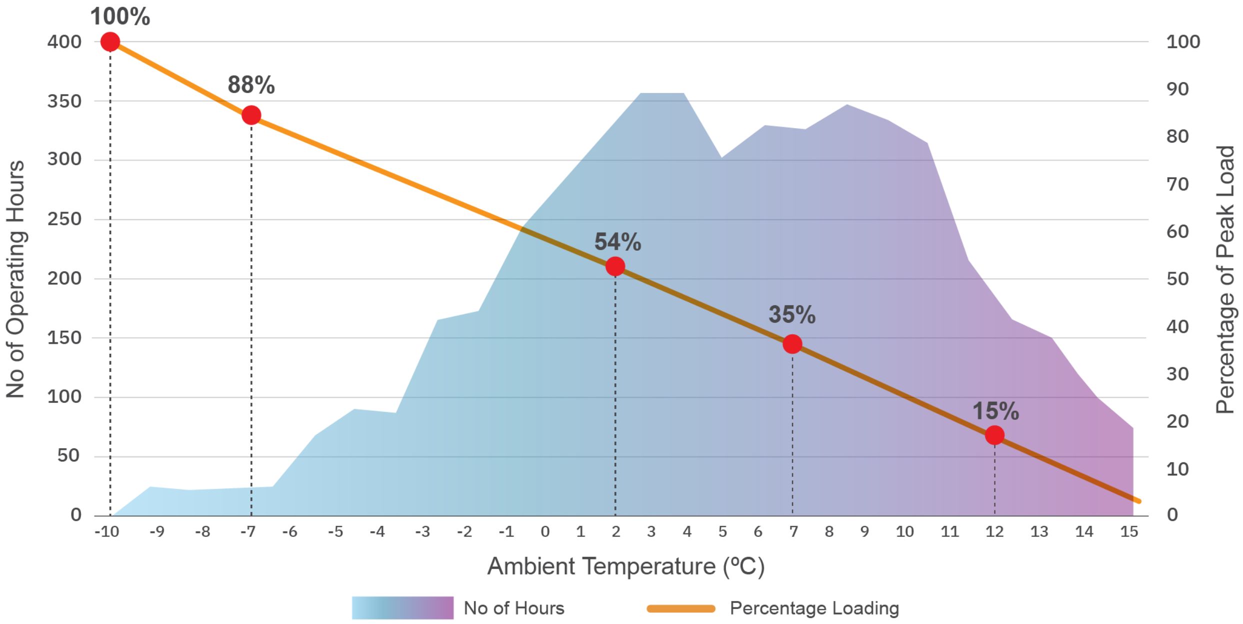
Warm - **Mild winters / hot summers** - reference city Athens, Greece

The purpose of these climate profiles is to ensure that the seasonal performance metrics of heat pumps and air conditioners reflect real-world usage across different climatic conditions in Europe.

The UK broadly falls into the average climate profile which defines the minimum and maximum ambient temperatures of the heating season as -10ºC and +15ºC respectively with a total of 4910 hours spent in heating mode.

The climate profile also defines the specific percentages of peak heating load experienced at each external ambient temperature with manufacturers having to report data at these points as part of a technical product fiche (shown on page 15).

EN14825 Average



EN14825 - Seasonal Efficiency

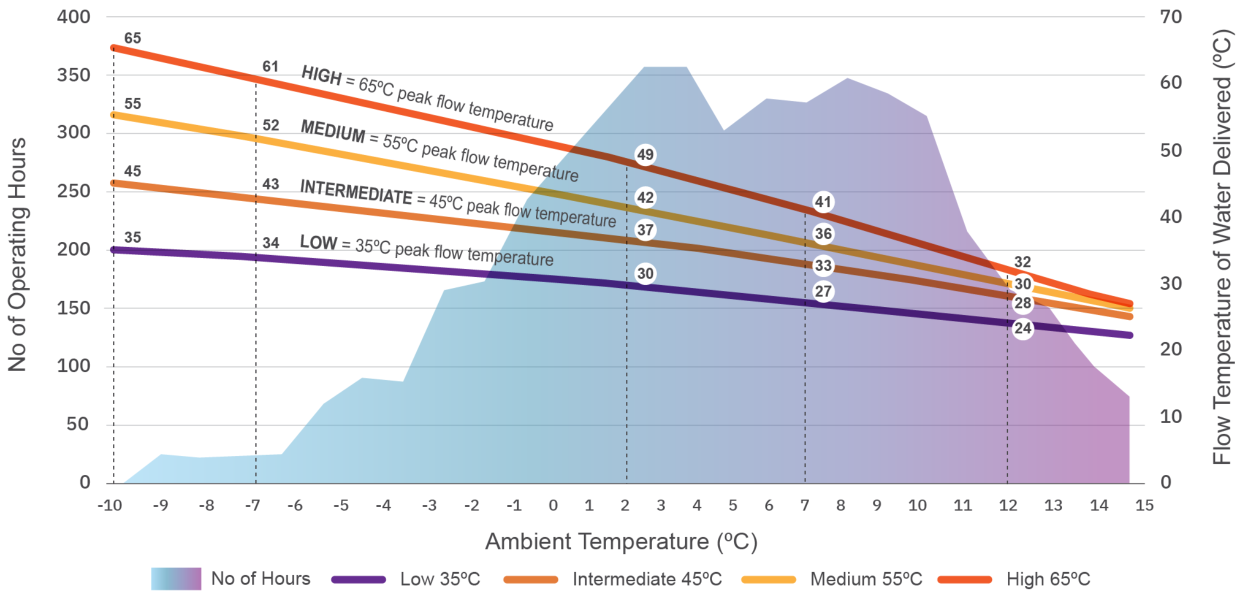
Delivered Water Temperatures

Now that both climate and load profiles have been specified, EN14825 provides the option of 4 different tests to demonstrate product seasonal performance across an annual heating season at different water flow temperatures - these are referred to as;

Low	=	35ºC
Intermediate	=	45ºC
Medium	=	55ºC
High	=	65ºC

Each of these tests allows for either fixed water flow temperature across the year or for a variable (weather compensated) flow temperature to be used.

The below chart shows how the 4 different flow temperatures would be adjusted for weather compensation across the average climate heating season.



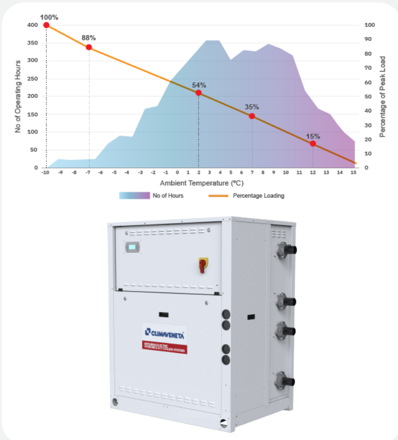
It is worth noting that due to the prescribed number of hours spent at peak load and the impact of weather compensation, a heat pump is assumed to only spend 0.02% of the annual heating season operating at the peak flow temperature - this may not be representative of a project specific design but is part of the standard calculation.

EN14825 - Climate Profile & Heating Load

Although water source heat pumps (WSHP) use the same climate profile as air source heat pumps (ASHP) to determine the required heating load percentages delivered across the heating season, as a WSHP takes its energy from water instead of air, an additional source water temperature must also be specified to calculate efficiency at the various defined points across the heating season.

This source energy is specified as either **"water"** which is assumed to be at +10ºC all year round or as **"brine"** which is assumed to be at 0ºC all year round.

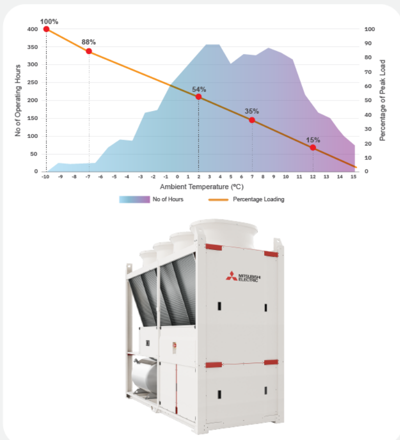
Brine = 0ºC (fixed)
Water = +10ºC (fixed)



Heating energy delivered

Therefore, the only factors which affect WSHP seasonal efficiency within EN14825 are operation at part load conditions and changing water flow temperatures due to weather compensation - ASHP efficiency on the other hand, also considers the changing air temperatures experienced across the heating season hence why calculating ASHP seasonal efficiency is more complicated.

Minimum air temp = -10ºC
Maximum air temp = +15ºC



Heating energy delivered

Displaying Data - Product Fiche

A product fiche is a detailed information sheet that provides key data and specifications about a product, such as a heat pump or air conditioner.

It includes information on the product's brand, model, energy efficiency class, rated capacity, power input, noise levels, and performance in different climate zones. The fiche aims to help consumers make informed decisions by offering clear and comparable details on energy efficiency and operational features, ensuring regulatory compliance and transparency.

See below example for a **Mitsubishi Electric MEHP-iS-G07 modular reversible ASHP** with some of the key data explained;

MEHP-iS-G07 /0051 LOW TEMPERATURE application			
Air-to-water heat pump:	yes / no		yes
Water-to-water heat pump:	yes / no		no
Brine-to-water heat pump:	yes / no		no
Low-temperature heat pump:	yes / no		no
With supplementary heater:	yes / no		no
Mixed unit with heat pump:	yes / no		no
Temperature application (1)	(low 35°C/ medium 55°C)		low 35°C
Water flow rate	fixed / variable		variable
Outlet temperature	fixed / variable		variable
Parameters are declared for average/warmer/colder climate conditions (1)	average / warmer / colder		average
Rated heat output at Tdesignh	**Prated = Pdesignh**	**[kW]**	**40**
Seasonal space heating energy efficiency	**ηs**	**[%]**	**172**
Seasonal space heating energy efficiency class	**-**	**-**	**A++**
Declared capacity for heating for part load at indoor temperature 20 °C and outdoor temperature Tj			
Declared capacity for heating with outdoor temperature Tj = – 7 °C	Pdh	[kW]	35,7
Declared capacity for heating with outdoor temperature Tj = +2 °C	Pdh	[kW]	21,7
Declared capacity for heating with outdoor temperature Tj = +7 °C	Pdh	[kW]	21,3
Declared capacity for heating with outdoor temperature Tj = +12 °C	Pdh	[kW]	25,1
Declared capacity for heating with outdoor temperature Tj = Bivalent temperature	Pdh	[kW]	35,7
Declared capacity for heating with outdoor temperature Tj = Operation limit temperature	Pdh	[kW]	33,4
For air-to-water heat pumps: Tj = – 15 °C (if TOL < – 20 °C)	Pdh	[kW]	-
Bivalent temperature	Tbiv	[°C]	-7
Degradation coefficient	Cdh	-	0,90
Declared coefficient of performance or primary energy ratio for part load at indoor temperature 20 °C and outdoor temperature Tj			
Declared coefficient of performance with outdoor temperature Tj = – 7 °C	COPd	-	2,95
Declared coefficient of performance with outdoor temperature Tj = +2 °C	COPd	-	4,32
Declared coefficient of performance with outdoor temperature Tj = +7 °C	COPd	-	5,68
Declared coefficient of performance with outdoor temperature Tj = +12 °C	COPd	-	7,10
Declared coefficient of performance with outdoor temperature Tj = Bivalent temperature	COPd	-	2,95
Declared coefficient of performance with outdoor temperature Tj = Operation limit temperature	COPd	-	2,74
For air-to-water heat pumps: Tj = – 15 °C (if TOL < – 20 °C)	COPd		-
For air-to-water HP : Operation limit temperature	TOL	[°C]	-20
Heating water operating limit temperature at TOL	WTOL	[°C]	45

The parameters for the test confirm which climate profile and leaving water temperature are being used (see page 12).

The rated heating capacity output of the unit is shown.

The overall efficiency including primary energy conversion is shown as ηs % (see page 7).

The capacity delivered at each of the different ambient temperatures specified is provided (see page 13).

Instantaneous efficiency (co-efficient of performance, COP) of the heat pump is provided at the 5 different part load and ambient temperature conditions (see page 7).

ErP Website: https://erp.mitsubishielectric.eu/home

Mitsubishi Electric Product Fiches: https://ae.climaveneta.com/en/downloads

Summary

Calculating seasonal performance of heat pump systems takes many different factors into consideration - most of these factors can significantly affect the outcome of the calculation.

Project specific design conditions may not be similar to standardised test conditions and therefore reported seasonal efficiency may not be an accurate representation of product performance - it is however, the most accurate way to standardise testing and allow for generic comparisons.

Some of the factors that often differ significantly are;

- **Flow temperature** - only 4 flow temperatures are available which might not match project specific design flow temperature
- **Weather Compensation** - project specific flow temperature adjustment is unlikely to match the assumptions
- **Climate Profile** - the temperatures experienced and for how many hours per annum is not likely to match project specific estimations due to significantly different climate around the UK
- **WSHP Source temperatures** - WSHP source temps are unlikely to match standard test assumptions which will disproportionately affect seasonal efficiency
- **Hydraulic arrangement** - different configurations such as fixed or variable water flow rates, separate primary and secondary circuits, thermal storage etc. will impact overall system efficiency
- **Control logic** - dynamic operation under part load conditions, sequencing of multiple units operating in parallel and control of ΔT will affect overall performance

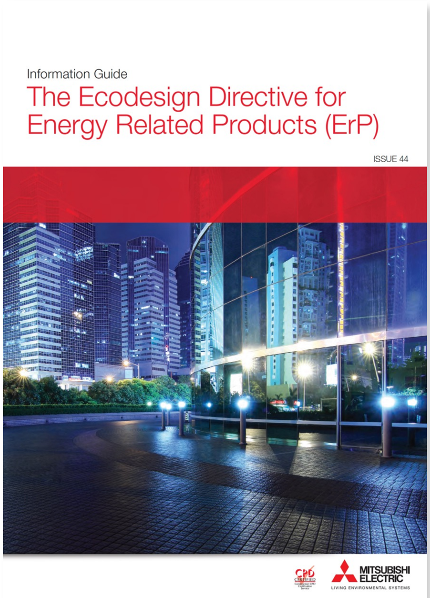
By understanding the differences between test conditions/assumptions and project specific conditions, designers can make more informed decisions on how best to use manufacturer published efficiencies on individual projects to help bridge the performance gap or better represent likely equipment operational energy usage.

Links

Click documents to view

Seasonal Efficiency Explained Guide

ERP Guide



Bivalent Heat Pump Overview

Cascade Heat Pump Overview

Sales Contacts

Corporate Sales: 0870 3000 070
London South: 01737 387170
London North & East Anglia: 01707 282480
Birmingham: 0121 329 1970
Manchester: 0161 866 6060
Bristol: 01454 202050
Scotland: 01506 444960
Wakefield: 01924 241120
Ireland: +353 (0)1 419 8800

Changes for the Better

Telephone: 01707 282880

MELServe Customer Services & Support: 0161 866 6089

Option 1 - Homeowners
Option 2 - Commercial Products
Option 3 - Residential Ecodan Installer or Service Provider

Commercial Product Options (following Option 2)
Option 1 - Technical Support
Option 2 - Spares
Option 3 - Warranty
Option 4 - Site Visits
Option 5 - Training

Middlesex: 020 8783 1008
Scotland: 01786 450 348

email: **livingenvironmentalsystems@meuk.mee.com**
website: **les.mitsubishielectric.co.uk**

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