ErP READY

The Eco-Design Directive ErP for refrigerator systems and heat pumps.

The EU-Regulation 2281/2016/EU defines the new requirements for refrigerator systems and heat pumps and focuses on the new ratios for the efficiency rating.

ErP READY

APPLIES TO EUROPEAN DIRECTIVE AIR HEATING AND COOLING PRODUCTS

robatherm

the air handling company

The Eco-Design Directive ErP (Energy-related Products) for refrigerator systems and heat pumps

The European Energy-related-Products-Directive 2009/125/EG, aka Ecodesign-Directive, defines the minimum requirements for energy-relevant products. The objective of the ErP-Directive is to reduce of energy consumption and CO2-emission rates as well as to increase the overall share of renewable energies. This directive applies for all products placed on the market within the European Economic Area (EEA). Exports from the European Union (EU) are not affected by the ErP-Directive.

Air handling units (AHUs) are affected by various EU-regulations. The EU-regulation 1253/2014/EG for ventilation units remain unchanged in 2018. However, a new regulation now exists for air heaters and air coolers. The new EU-regulation 2281/2016/EU deals with many different products (refrigerator systems, heat pumps, etc.) and has been in effect within the European economic region since 01.01.2018.

Information compactly summarized

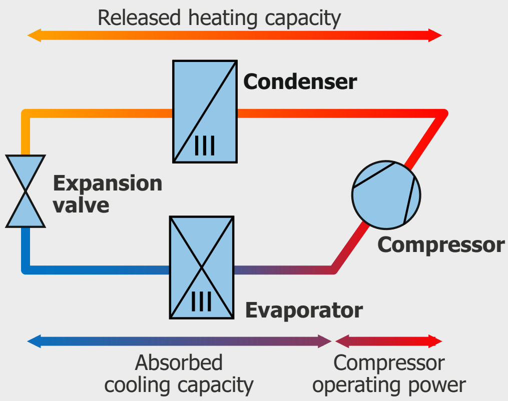
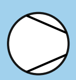
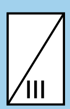
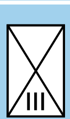
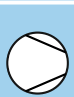
Discussions concerning the new requirements for air heaters and coolers under the ErP-Directive is characterized by uncertainty and contradictions.
robatherm sees itself as a premium manufacturer with the responsibility of dealing intensively with the ErP issue, and counteracts the many questions with compact information.

Answers to the most important questions

What is the scope of the ErP 2281/2016?	This directive applies to air heating and cooling products designed for human applications. They concentrate on the technologies for heating and cooling. The following products are affected: • Combustion chambers • Comfort chillers • Electric air heaters • Gas surface burners • Refrigerator systems • Heat pumps
Which categories of refrigerator systems/heat pumps are to be taken into consideration?	The directive defines the following concepts: • Air/Air heat pumps • Air/Air room air conditioners These 2 concepts are divided into different configurations: • **Heat pump with evaporator in the ambient air** • Heat pump with evaporator in the extract air • **Refrigerator systems with axial condenser** • Refrigerator systems with exhaust air condenser The directive only defines energy requirements for heat pumps with ambient air vaporizers and for refrigerator systems with axial condensers.
Why don't the requirements apply to systems in which the direct vaporizers resp. the condenser is placed in exhaust air?	If the vaporizer resp. the condenser is placed in the exhaust air, the heat pump resp. refrigerator system works like heat recovery. Since they do not generate heat/cooling, but instead recover it, these applications are generally excluded. That's why there is only an information obligation for these applications.
When are refrigerator systems and heat pumps affected by the directive?	Refrigerator systems and heat pumps delivered on and after January 1st 2018 (delivery to the construction site) must comply with the ErP-Directive. As of the 1st of January 2021, a next step will call for a tightening of the requirements. In the year 2022, further tightening is scheduled.
Are there any exceptions in the segment of refrigerator systems and heat pumps?	For example, the following areas are excluded from the scope of the directive: • Devices with Air/Air heat pumps, if the heat pump is used as a HRS • Agricultural applications (greenhouses, stables) • Passenger or freight transport (ships) • Commercial exhaust hoods (grease and steam extraction in commercial kitchens) • Highly thermally polluted rooms (data centers, server rooms, compressor rooms, generator rooms, CHP rooms, foundries) • Machine exhaust air (garage exhaust air) • ATEX (potentially explosive areas) • Exhaust and supply air for fume hoods • Exhaust and supply air for process air technology (not designed to dissipate personal or building emissions) • Recirculating air units with a maximum outside air share smaller than 10% of the nominal air volume

Refrigerator systems and heat pumps

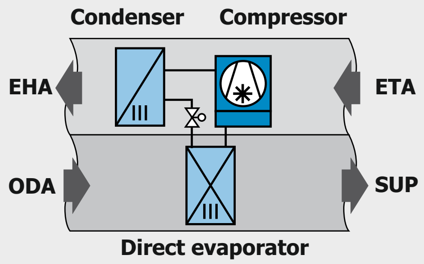
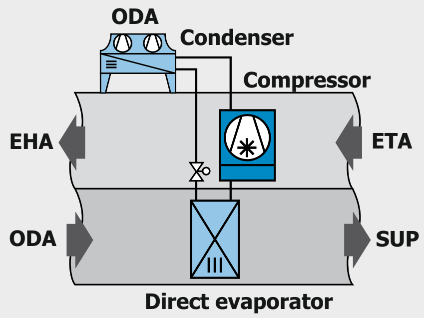
From a thermodynamic point of view, compression refrigerator systems belong to the group of heat engines. A heat flow is created by using electrical or mechanical energy. This is known as a counterclockwise process. However, in heat engines, such as steam turbines or internal combustion engines, one uses heat flow to generate mechanical or electrical energy. Heat engines belong to the clockwise processes. Depending on whether one uses the cooling or heating side, it is called a refrigerator system or heat pump.

Scheme of the cooling cycle		
Description		A **refrigerant** circulates throughout the cooling cycle. The purpose of the refrigerant is to absorb the heat at one point (source) and to release it at another point (sink). In the interaction between pressure and temperature, the state of aggregation in the cycle changes from gaseous to liquid and vice versa. Refrigerants are mostly made of fluorinated hydrocarbons; however, natural refrigerants such as ammonia, propane and carbon dioxide are also used.
		The **compressor** drives the cooling cycle. The compressor's task is to compress the gaseous refrigerant, at low temperature, by means of electrical energy. During the compression process, in addition to the pressure, the refrigerant's temperature also increases.
		The process heat is released from the **condenser**. This is the sum of absorbed heat at the vaporizer and the compressor's electrical operating power. In this connection, the overheated refrigerant is first cooled to condensation temperature and then completely liquefied. The high pressure remains unchanged.
		The liquefied refrigerant flows towards the **expansion valve**. Its job is to regulate any overheating of the steam. The pressure reduction is achieved thru a cross-sectional constriction. During pressure reduction, a part of the refrigerant already begins to evaporate. In addition, the temperature drops and a wet steam mixture is built up.
		In the **evaporator**, the refrigerant's state of aggregation changes to gaseous. Evaporation is achieved through heat absorption. The required heat is removed from the environment or in AHUs is removed from the airflow.
		The **compressor** can now draw in and compress the gaseous refrigerant anew. Thus, the cooling cycle comes full circle.

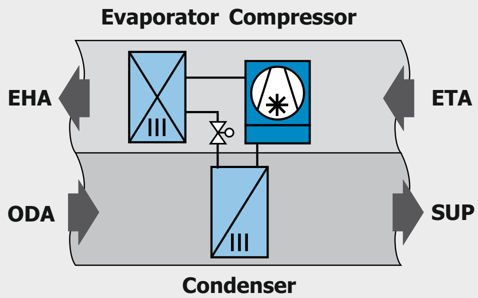
Application Concepts in Air Handling Unit Systems

robatherm integrates the customized cooling and heating generator in the AHU. Refrigerator units, heat pumps, heat exchangers as well as all other functional components and their operating mode are optimally coordinated. Intelligent control strategies for fans, compressors and damper systems, etc., as well as the needs-based use of existing energy sources (e.g. heat recovery, free cooling, condensation heat) ensure high system efficiency.
In principle, two types of integrated direct refrigeration as well as one type of integrated heat generation are customary.

Integrated direct cooling technology

	Exhaust-air condenser	Outdoor-air condenser
System schematic ODA = Outdoor Air SUP = Supply Air ETA = Extract Air EHA = Exhaust Air		
Concept's Benefits	• Direct heat transfer, high overall efficiency • Minor pipeline cross-sections • Minor on-site effort • No cold water distribution grid necessary • No antifreeze necessary	

Heat pump / reversible heat pump

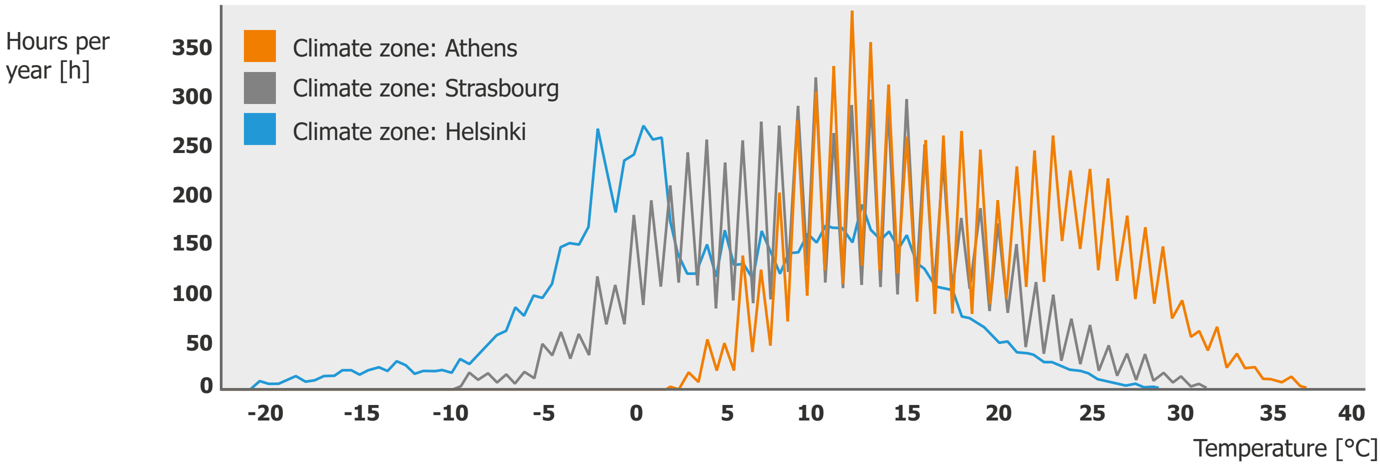
System schematic ODA = Outdoor Air SUP = Supply Air ETA = Extract Air EHA = Exhaust Air	
Concept's Benefits	• Functions like a heat recovery system • Optimal energy supply • Minor space required • No external piping work • Process reversal is possible • Minor pipeline cross-sections

New Calculation for Efficiency according to the ERP-Directive

Considering the course of the year

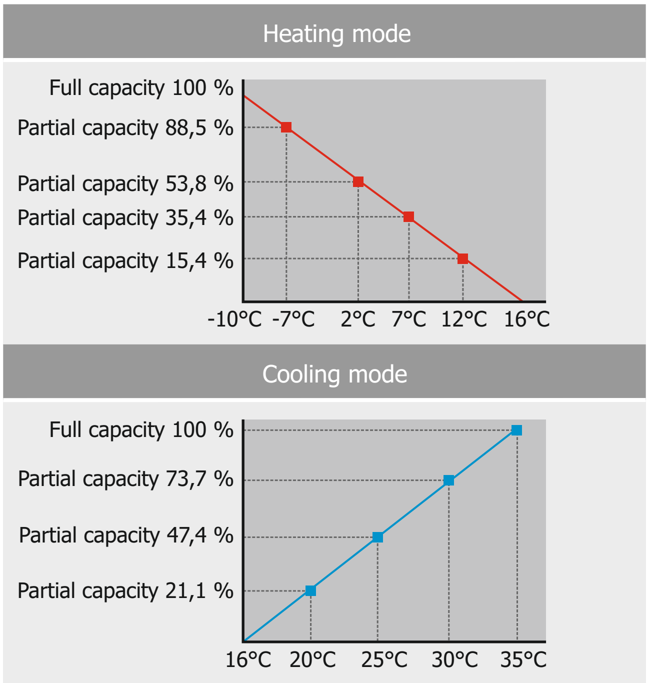
	Selective consideration	Seasonal consideration
Approach	The design of a heat pump and/or a refrigerator system always takes the worst case into account. For this purpose, the coldest outside air temperature is used as the basis for the heat pump and the highest temperature for a refrigerator system.	Weather data is included in the seasonal consideration. Changing outside air conditions influence the efficiency of a heat pump and/or refrigerator system. The COP resp. EER is therefore better than declared.
Performance indicators for the heating mode	**C**oefficient **O**f **P**erformance **COP** = $\frac{\text{Released heating capacity}}{\text{Compressor operating power}}$	**S**easonal **C**oefficient **O**f **P**erformance **SCOP** = $\frac{\text{Annual heating demand}}{\text{Annual power consumption in heating mode}}$
Performance indicators for the cooling mode	**E**nergy **E**fficiency **R**atio **EER** = $\frac{\text{Released cooling capacity}}{\text{Compressor operating power}}$	**S**easonal **E**nergy **E**fficiency **R**atio **SEER** = $\frac{\text{Annual cooling demand}}{\text{Annual power consumption in cooling mode}}$

Since outside air temperatures change constantly, any selective consideration, for example, the efficiency calculation based on a defined temperature, doesn't reflect reality. For example, should the efficiency of a refrigerator system be solely determined at full load at an outside temperature of 35° C, the illustration above shows that, even in Athen's climate zone, this only applies for a few hours a year.



Saisonal considering the cooling and heating mode

From a seasonal analysis, the year's course is now used, and taken into consideration based on four strongly differently weighted operating points.



Standby-Mode

Even in a standby-mode, a refrigerator system and/or heat pump consume electricity. This consumption influences the system's overall efficiency. To achieve a key figure that is as realistic as possible, power consumption in standby mode is also taken into account, and is included in the calculations of the SCOP (seasonal coefficient of performance) and the SEER (seasonal energy efficiency ratio). Four different modes of operation are defined in the ErP-Directive:

- Off Mode:
  The heat pump resp. the refrigerator system is connected to the power grid, yet doesn't fulfill any function.
- Thermostat Off Mode:
  In this operating mode, the heating function of the heat pump and cooling function of the refrigerator system is turned on, but the AHU is not active.
- Crankcase Heater Operating Mode:
  This mode defines the condition in which the unit has activated a heater that prevents the refrigerant from passing into the compressor, limiting a cold concentration in the oil when the compressor is started.
- Standby Mode:
  The heat pump or the refrigeration system is connected to the power grid and indefinitely fulfills only certain functions (reactivation function, information or status display).

Considering the Climate Zones

In addition to the seasonal analysis with different temperatures, the climatic conditions are now taken into consideration when assessing heat pumps.
Three climate zones were defined.

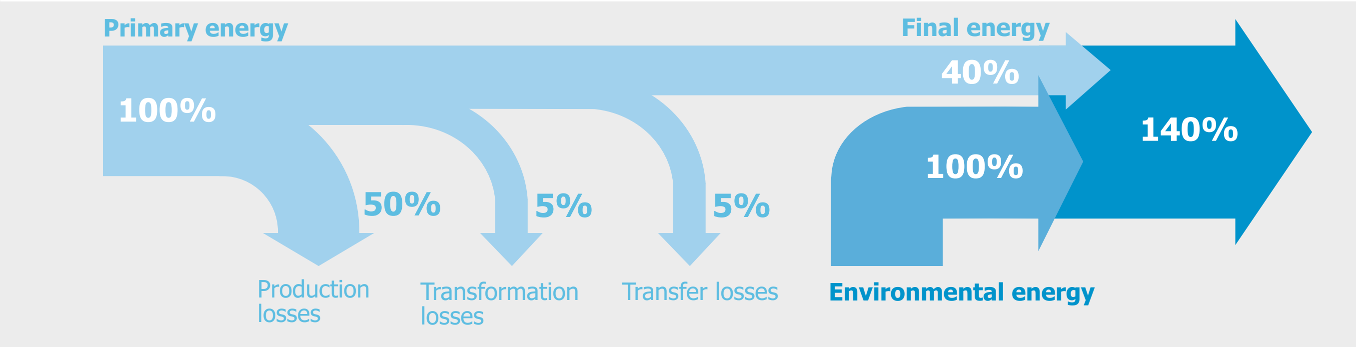
- Helsinki
- Strasbourg
- Athens

Annual Usage Rate

The annual usage rate describes the efficiency of a refrigerator system or heat pump based on an entire year. The complete energy cycle, from primary up to useful energy is taken into consideration in this rate. The CC-rate in the aforementioned formulae is a conversion coefficient that considers the entire cycle's energy losses. This value is fixed and defined in Regulation 2281/2016/EU. The annual usage rate should always be greater than 100% for refrigerator systems and heat pumps. This results from the adoption of environmental energy. This environmental energy is the heat transfer from the vaporizer to the condenser. If the benefit is set in relation to the effort, values exceeding 100% result.

Annual Usage Rate	
Heating Mode	$\eta_{s,h} = \frac{SCOP}{CC}$
Cooling Mode	$\eta_{s,c} = \frac{SEER}{CC}$

Example: Heat Pump



The minimum requirements of the ErP-directive 2281/2016/EU

The ErP-directive 2281/2016/EU defines the minimum requirements for annual use efficiency and und provides for a tightening of the requirements in the year 2021.

The annual usage rate	ErP 2018	ErP 2021
Refrigerator system with axial condenser	≥ 117 %	≥ 138 %
Heat Pump with ambient air evaporator	≥ 115 %	≥ 125 %

ErP-compliant refrigerator systems and heat pumps in practice

Practical Example: Effect of evaporation and condensation temperatures on the energy efficiency

The following examples have been calculated with the same compressor composite and air flow volume. Only the design temperatures have been changed to create a comparison of the two refrigerator systems.

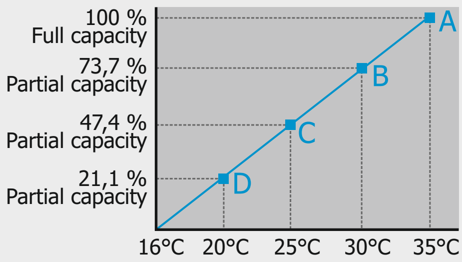
General Conditions for the refrigerator system:

- Axial Condenser
- Refrigerant: R407C
- Climate Zone Strasbourg

	Refrigerator system 1	Refrigerator system 2
Design temperature	Evaporation temperature: 7°C Condensation temperature: 53°C	Evaporation temperature: 10°C Condensation temperature: 48°C

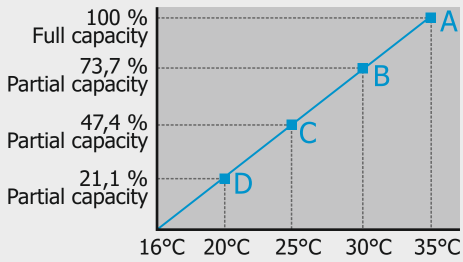
Calculation

Refrigerator system 1



Point	Condensation temperature: [°C]	Cooling capacity [kW]	**EER**
A	53	132	2,68
B	48	143	3,06
C	43	154	3,48
D	38	165	4,18

Refrigerator system 2



Point	Condensation temperature: [°C]	Cooling capacity [kW]	**EER**
A	48	161	3,29
B	43	173	3,75
C	38	186	4,53
D	33	198	5,95

Result	Refrigerator system 1	Refrigerator system 2
Electrical power:	49,2 kW	44,5 kW
SEER:	3,38	4,38
Annual usage rate:	135%	175%
ErP-Level:	**2018**	**2021**

Conclusion:
In a comparison of both refrigerator systems, the refrigerator system 2 reached the ErP-Level 2021 and exhibits a lower wattage. This higher efficiency results from the refrigerator system's thermodynamic capacity. This increases as soon as the difference between condensate and evaporation temperature is reduced.

In practice, larger heat exchanger surfaces are used to achieve a lower temperature difference between the ambient and condensation temperature.
Therefore, in the future, it will be essential to invest in larger heat exchanger surfaces in order to meet the ErP-Directive's efficiency requirements.

With robatherm, you're always on the safe side

The EU regulations 1253/2014 / EC for ventilation units and 2281/2016 / EU for air heaters and air coolers still offer reasons for discussion and often cause uncertainty in the practical implementation.
robatherm is intensively involved with the ErP topic, in order to be able to offer competent, legally secure and compliant solutions.
Our contact persons are happy to advise you about the many possible solutions offered by robatherm.
You're more than welcome to send us your specific questions concerning Eco-Design Directive (ErP) to ErP@robatherm.com. Our ErP-Team will respond to your questions as quickly as possible.

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