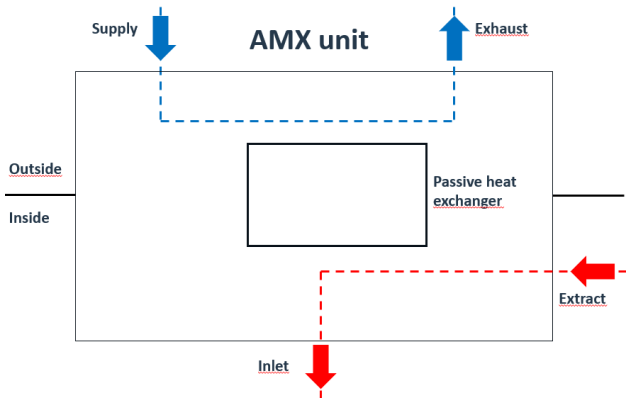
Appendix A - AMX 4, heatpump energy efficiency

AMX 4 control modes

The AMX 4 is a smart ventilation unit with an integrated heatpump. The product utilizes proven ventilation technology from the AM product line in conjunction with state-of-the-art heatpump technology. The innovative hybrid unit provides control of the indoor climate delivering both fresh air and thermal comfort.

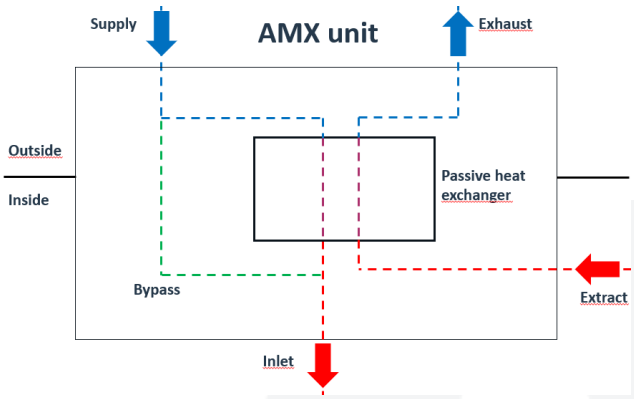
The unit can operate in two modes - recirculation or ventilation. What makes the AMX 4 uniquely efficient is the ability to switch seamlessly between these operating modes whenever it is most beneficial still fulfilling the indoor climate settings.

Recirculation mode

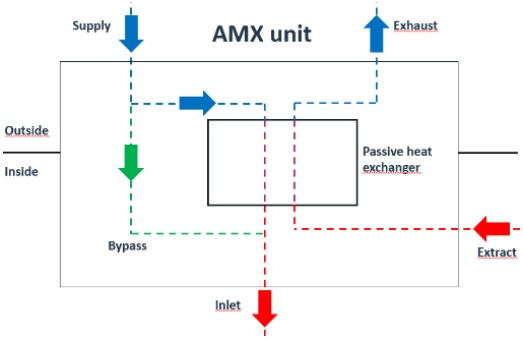


In recirculation mode, the unit recirculates the room air solely for the purpose of regulating the temperature of the room. This mode will be utilized when the indoor air quality is acceptable meaning no fresh air is needed.

Ventilation mode

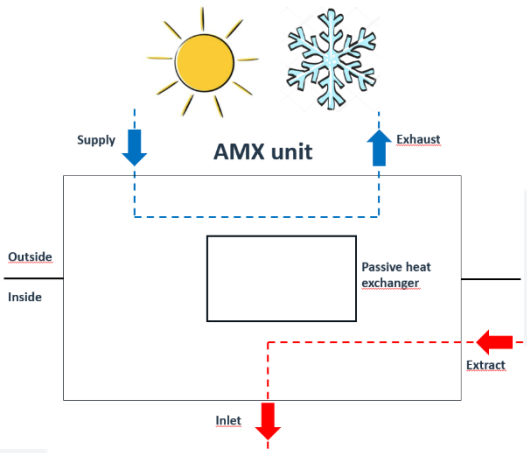


In ventilation mode, the room air is replaced by fresh outside air. Both heating and cooling recovery is available with the AMX 4. This drastically reduces the power consumption for heating and cooling the inlet air.



In modern well insulated buildings, cooling is often needed to maintain a comfortable room temperature, even when the outside temperature is lower than the room temperature. In those cases the AMX 4 can very efficiently cool the building with cold outside air using ventilation mode instead of using the heatpump in recirculation mode.

During extreme temperature conditions the AMX 4 benefits from switching to recirculation mode. Reusing the already conditioned air which makes controlling the room temperature more efficient. The control system monitors the indoor air quality using the integrated CO2 sensor and will switch between recirculation and ventilation to be as efficient as possible while maintaining good indoor air quality.



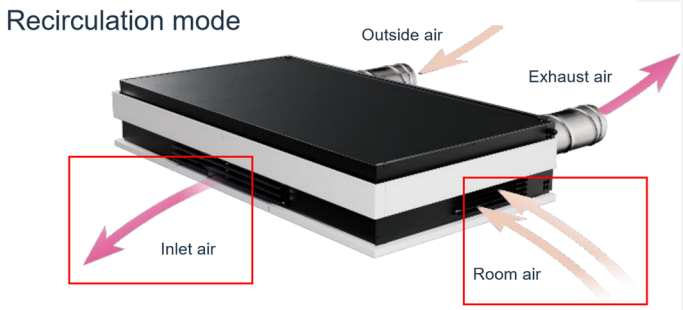
In rooms that see intermittent use, such as meeting rooms, the AMX 4 benefits from being able to switch to recirculation mode whenever the room is not in use thus maintaining the thermal conditions without adding fresh air, which will save energy. The control system monitors the CO2 level in the room and will switch to ventilation, when fresh air again is needed to retain the good indoor air quality.

The control system in AMX 4 is programmed to prioritize using the most efficient operating mode while also keeping the indoor air quality and thermal comfort at the set conditions.

AMX 4 energy efficiency

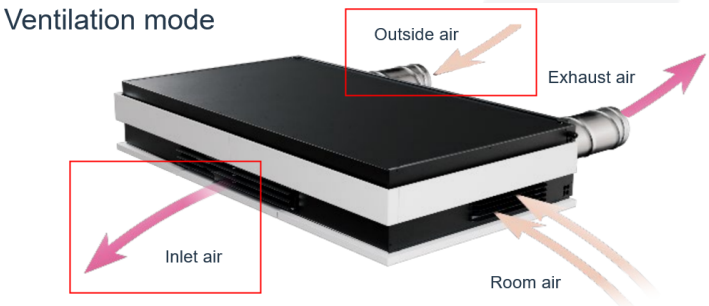
The performance of the unit has been tested according to EN 14511 and EN 14825 by an independent third-party laboratory. The tests have been used to calculate the energy efficiency factors (COP, EER, SCOP and SEER) of the unit. The standards describe the test conditions and calculation methods used to calculate these values. The standards are not written with a combined ventilation and heatpump system in mind. The standards only describe the conditions and calculation methods for a traditional heatpump. The closest we get to a traditional heatpump with the AMX 4 is when it is operating in recirculation mode (no fresk air is added). The unit however will in practice operate in both recirculation mode and ventilation mode – shifting between the two depending on weather fresh air, heating or cooling is needed.

To justify, that the AMX 4 is a ventilation unit with the advantages of being able to operate in different modes as mentioned above, the laboratory has also tested the performance of the unit in ventilation mode under the temperature conditions described in the standards to see the effect on the result. To get the full understanding of the differences in the results, when the unit is in recirculation mode and ventilation mode, we have to look at the different temperatures in the calculations. In recirculation mode the air is extracted from the room, heated or cooled in the unit and then blown into the room again through the inlet opening, se below.



This means that the capacity is calculated using the temperature difference between the room air and the inlet air.

In ventilation mode the air is taken from the outside instead of the room making the temperature difference different compared to recirculation mode, see below.



In this case the capacity is calculated using the temperature difference between the outside air and the inlet air. This means that we can take the advantages of the passive heat exchanger (the traditional counterflow heat exchanger) into the calculations in this situation.

COP- and EER-values

When describing a heatpumps energy performance the values often referred to are the Coefficient of Performance (COP) and the Energy Efficiency Ratio (EER). The COP-value describes the energy efficiency when the heatpump is heating the air and is calculated as the ratio between heat added to the room and the power consumed. The EER-value describes the energy efficiency when the heatpump is cooling the air and is calculated as the ratio between cooling added to the room and the power consumed, se below:

$$\text{COP} = \frac{Heat\ supplied\ to\ the\ room}{Power\ consumption}$$

$$\text{EER} = \frac{Heat\ removed\ from\ the\ room}{Power\ consumption}$$

These parameters show you how much energy is used for delivering/removing a certain amount of energy to/from the room. The calculation conditions when calculating the COP and EER values for the AMX 4 are shown below:

	Outside temperature	Room temperature
COP (heating)	7	20
EER (cooling)	35	27

The COP- and EER- values for the AMX 4 are seen below:

	Recirculation mode
COP (heating)	3,7
EER (cooling)	3,0

However using these data to compare different heatpumps is not recommended. This is due to the fact, that the values according to the standards are calculated from one specific temperature set only. For other temperature sets the values will be different. This is why we recommend using SCOP- and SEER values instead when comparing units.

SCOP- and SEER-values

The primary purpose of the SCOP and SEER measurements is to approximate the average efficiency of a heatpump.

A heatpump can be constructed to be very efficient at the specific temperature set used when calculating the COP and EER-values, but a heatpump operates in all seasons and weather conditions. This is why a better tool for comparing energy efficiency of heatpumps is the SCOP- and SEER-values. The “S” in these parameters stands for “Seasonal”, which means, that they are calculated as an average value for a full season including both summer and winter. As the different seasons have different outside temperature the calculations are made for more than just one temperature set, se below:

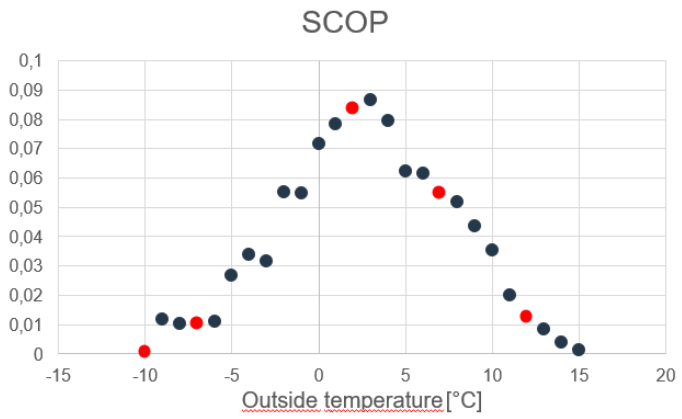
SCOP (heating)

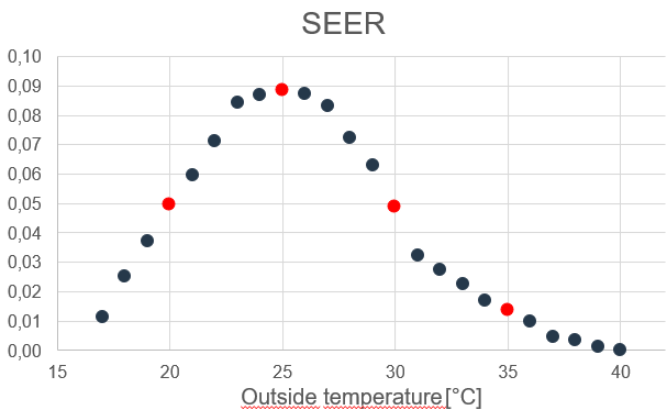
Outside temperature	Room temperature
-10	20
-7	
2	
7	
12	

SEER (cooling)

Outside temperature	Room temperature
20	27
25	
30	
35	

The above temperatures are according to the standards (EN 14511 and EN 14825). Beside the increased number of temperatures, each temperature is weighted differently, which means, that the most common outside temperatures count more than the less common temperatures in the calculations, se below:



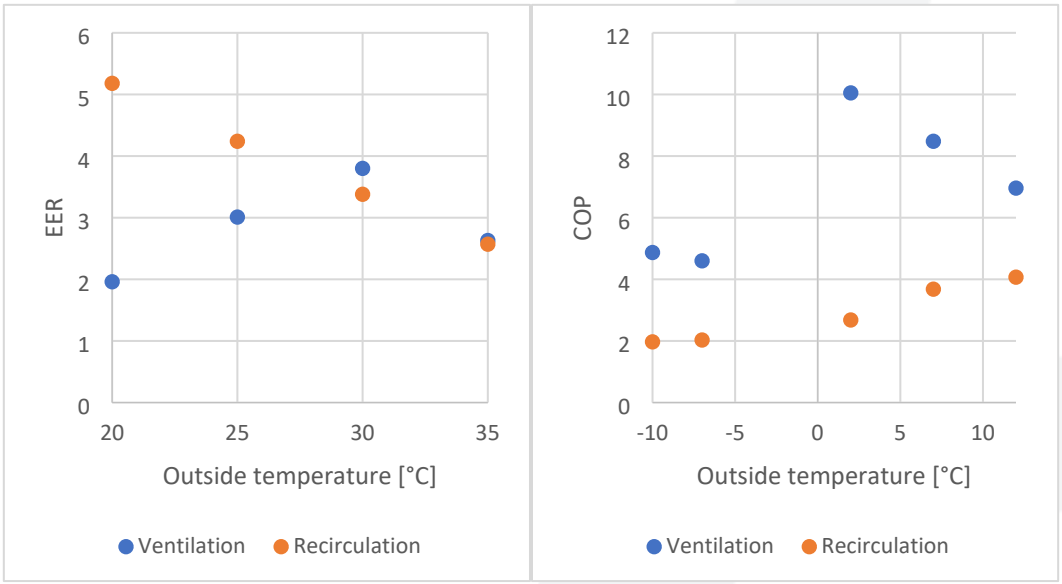


The red points are the measurement points from the table above, and the dark points are points used in the calculations. These are interpolated between the measurement points. The results of the third-party measurements and calculations in recirculation mode and ventilation mode are seen below:

	Recirculation mode	Ventilation mode
SCOP (heating)	2,8	7,8
SEER (cooling)	3,2	2,4

As seen in the table above the SCOP-value in ventilation mode is much larger than the SCOP-value in recirculation mode. This is primarily because of the effect of the passive heat exchanger.

The SEER-value in ventilation mode however is lower than the value in recirculation mode even though the passive heat exchanger is contributing positively to this value. In general, the performance of a traditional heatpump will decrease as the temperature difference between the room and outside rises, but also the weight of the measurement points as mentioned above play a role in the calculations. Below the individual measurements points for calculating the SCOP and SEER are shown:



It is seen, that there are not a simple relation between the measurement points, when calculating the SCOP- and SEER-values.

When calculating the energy efficiency values above you should be aware, that outside temperature often is below 20°C, while the building/room needs cooling. In these cases, you can to some extend cool the building without using the heatpump by opening the bypass damper in the unit and thus using the cooling effects of the outside air. This operating mode is not depicted in the results when calculating according to the standards as there are no measurements with an outside temperature below 20°C. Such situations occur in a lot of modern buildings, that are airtight and with lots of people, computers, screens, large windows, etc.