Effect of External Temperature on System Performance

External outside temperature has a significant effect on heat pump system performance and its COP. The temperature difference between the outside air and the indoor space influences the heat transfer process. According to the basic heat transfer equation:

$$Q = k\, A\, \Delta T,$$

$$\Delta T = T_{inside} - T_{outside}$$

Where:

Q	heat transfer rate	J
k	overall heat transfer coeffecient (affected by level of insulation)	$J/(K^o\, m^2)$
A	surface area	m^2
ΔT	temperature difference	K^o

As the outside temperature ($T_{outside}$) decreases in heating mode, (ΔT) increases, leading to a higher heat transfer rate (Q) that the heat pump must handle. This creates a larger workload for the compressor, often causing a decline in efficiency.

The COP in heating mode is expressed as:

$$COP_{heating} = \frac{Q_{out}}{W_{input}}$$

Where:

Qout	heat delivered to the indoor space	J
Winput	work input to the compressor	J

When the outside temperature drops, the heat pump requires more work to extract heat, which raises (W_{input}) and reduces the COP. Conversely, at higher outside temperatures, the heat pump operates more efficiently, with less work needed for heat extraction, resulting in a higher COP.

In summary, colder outside temperatures decrease the heat pump's efficiency and COP, while milder outside conditions improve performance, highlighting the dependency of heat pump efficiency on external atmospheric conditions.