

Effect of Insulation on System Performance

Insulation significantly impacts the performance of heat pump systems and their coefficient of performance (COP). Better insulation reduces heat transfer through building envelopes, leading to lower heat loss or gain. This can be represented by Fourier's law:

$$Q = k A \Delta T$$

Where:

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

Lower (k) values, achieved through improved insulation, decrease (Q), meaning less heat needs to be transferred by the heat pump.

The COP of a heat pump in heating mode is given by:

$$\text{COP}_{\text{heating}} = \frac{Q_{\text{out}}}{W_{\text{input}}}$$

Where:

Q_{out}	heat delivered to the indoor space	J
W_{input}	work input to the compressor	J

When insulation is effective, (Q_{out}) approaches the minimal necessary heat transfer, reducing (W_{input}) for a given heating load, thus increasing the COP.

In summary, improved insulation minimizes building heat loss, enhances heat transfer efficiency, and increases the COP, making the heat pump operation more energy-efficient.