Physical principles

A heat pump is essentially a heat engine operating in reverse. Its principle is illustrated below.

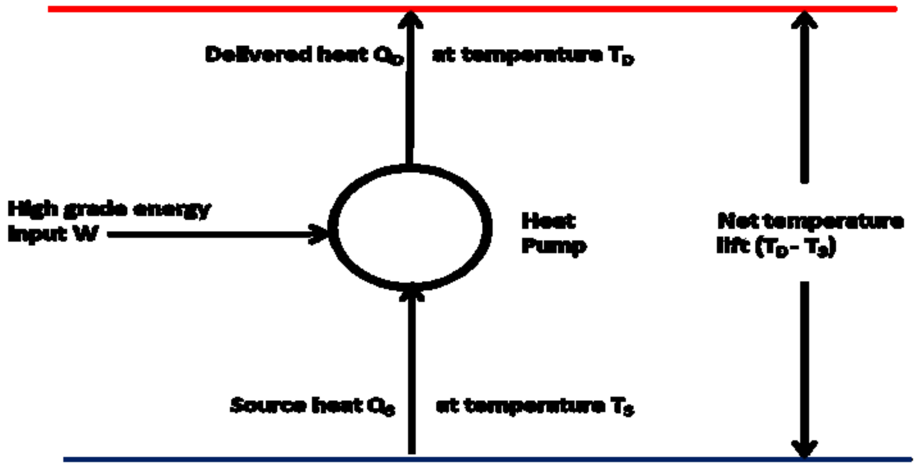

Figure 0-1: Heat pump principle

From the first law of thermodynamics, the amount of heat delivered Q_D at the higher temperature T_D is related to the amount of heat extracted Q_S at the low temperature T_S and the amount of high grade energy input W by the equation

$$Q_D = Q_S + W$$

Compared to heat pumps for space heating, using heat sources such as ground or water, IHPs often have the following advantages:

- high coefficient of performance due to low temperature lifts and/or high temperature levels;
- long annual operating times;
- relatively low investments cost, due to large units and small distances between heat source and heat sink;
- waste heat production and heat demand occur at the same time.

Despite these advantages, the number of heat pump installations in industry is almost negligible compared to those installed for space heating.

Note:
A coefficient of performance (COP) can be defined as

$$COP = \frac{Q_D}{W}$$

The Carnot coefficient of performance

$$COP_c = \frac{T_D}{T_D - T_S}$$

represents the upper theoretical value obtainable in a heat pump system.

In practice attainable coefficients of performance are significantly less than COP_c. Unfortunately, it is difficult to compare the COPs of different categories of IHP, which differ widely for equivalent economic performance. When comparing heat pump systems driven by different energy sources it is more appropriate to use the primary energy ratio (PER) defined as

$$PER = \frac{usefull\ heat\ delivered}{primary\ energy\ input}$$

The equation can be related to the coefficient of performance by the equation

$$PER = \eta \times COP$$

where η is the efficiency with which the primary energy input is converted into work up to the shaft of the compressor.

Source: IEA HPT Annex 35