DTU

Problem 1: Heat Pump, Carnot Machine

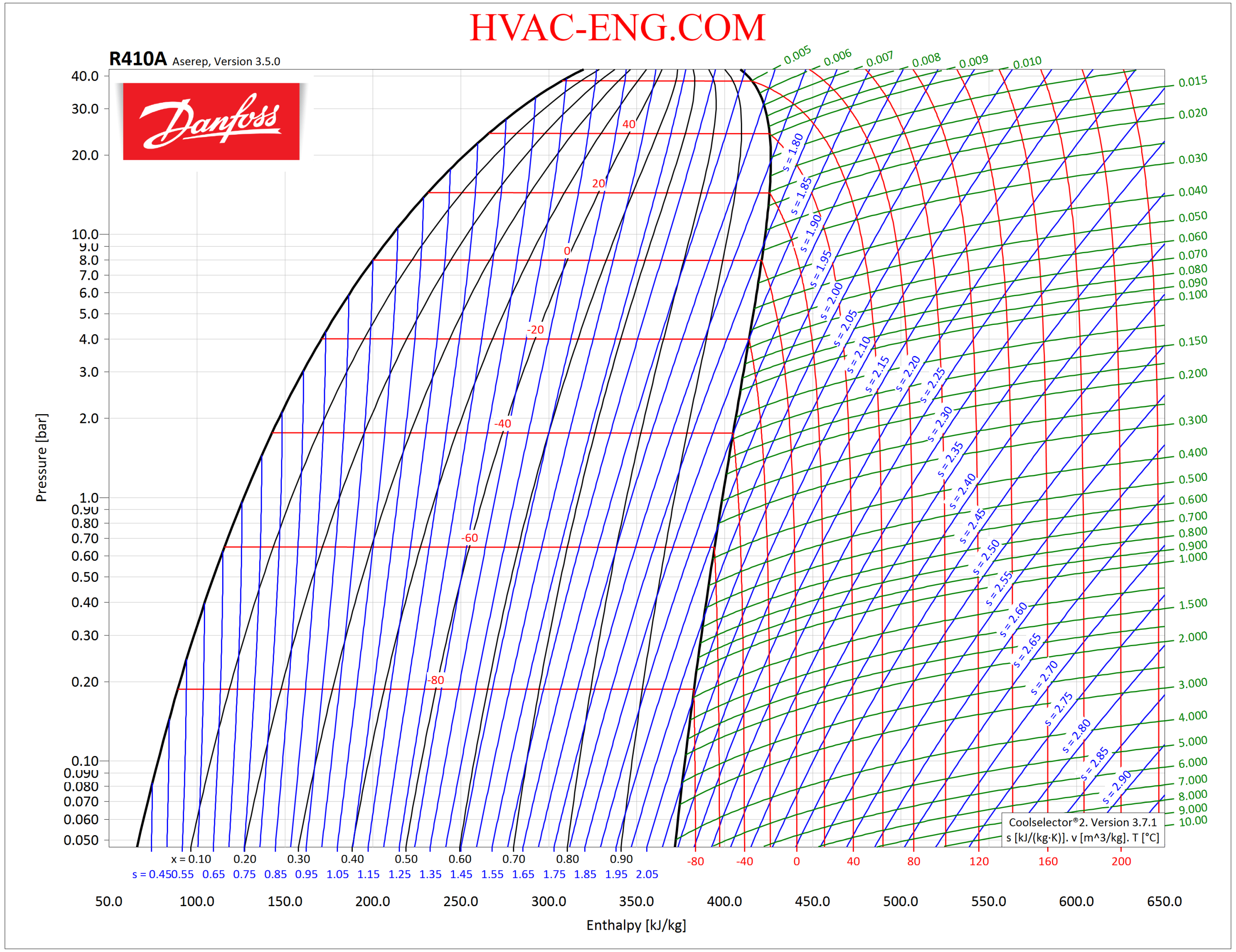
An ideal Carnot machine pumps heat from $T_c = 263$ K to $T_h = 308$ K.

1) What is the COP of the heat pump?

2) How much work (i.e. electrical input power) would be needed for such an ideal (Carnot) heat pump to deliver 10 kW of heat to the hot reservoir?

3) When delivering 10 kW of heat, how much heat would be extracted from the cold reservoir?

Problem 2: R410a-based machine



A R410a-based heat pump pumps heat from Tc = 253 K to Th = 313 K.

Assume that the machine operates with 1 kg of R410a as the operating medium.

1) Based on the figure, estimate the COP of the heat pump. Assume that the compression and expansion are isentropic and that evaporation and condensation are isothermic.

2) How much heat is pumped per cycle (i.e. calculate Qc and Qh).

3) Calculate how many grams of R410a which must complete a cycle every second to deliver 10 kW of heat.

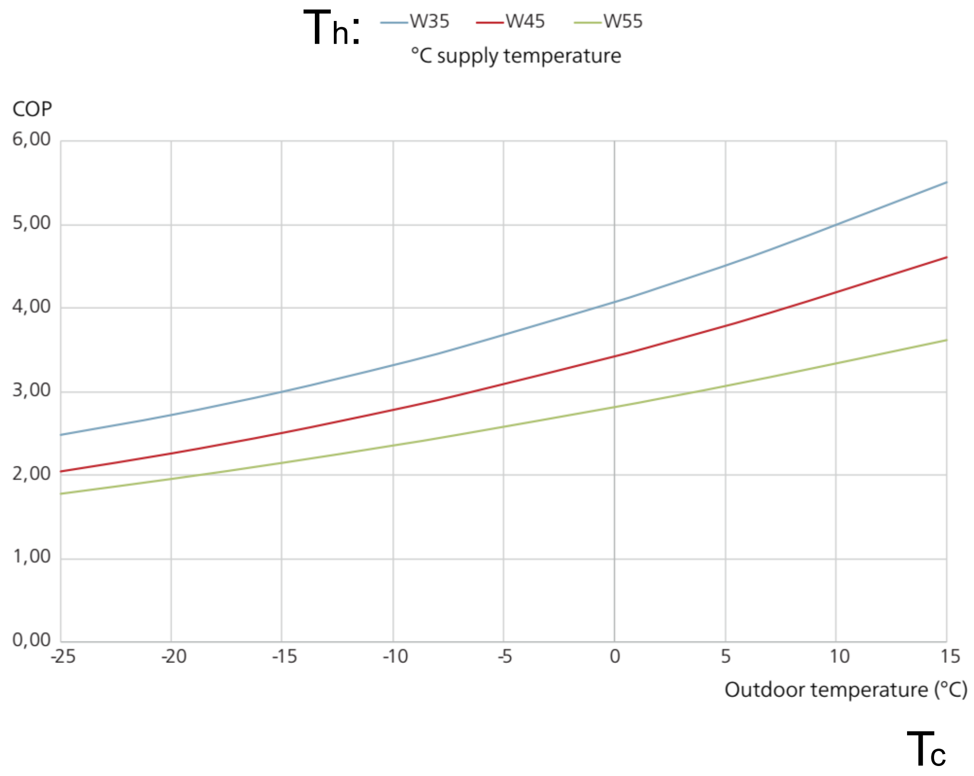
Problem 3: SCOP

SCOP is the **Seasonal coefficient of performance**. This is what the end user really cares about:

SCOP = total annual heat output/total annual electricity need.

The colder it is outside, the more heating power is needed, and delivered to the radiators at a higher temperature

Fill out the table (use the graph below to find COP values).
Sum the heat and electricity columns and use that to calculate SCOP



Outside temp/°C	Th/°C	Tc/°C	Pheat / kW	Hours / year	Total heat/ kWh	COP	Total electricity /kWh
T< 0	55	-3	6	1000			
5<T<0	45	2	4	2000			
10<T<5	35	7	2	3000			
-	-	-	-	-	(total)	-	(total)

Problem 4: Heat Pump vs Gas Stove

Which is better – a gas stove or a heat pump (powered by natural gas via electricity)?

Assume that a heat pump system delivers a real-world SCOP of 3.5

Assume also, that the losses in the electricity grid are 10% (i.e. 90% of the electricity delivered from the power plant arrives at the consumer) and that the gas stove is 100% efficient.

1) Calculate the power plant efficiency, η, for which a grid powered heat pump use as much gas as a 100% efficient gas powered stove.

2) What is the typical efficiency of a natural gas powered plant (look it up)?

3) Explain why no thermal power plan comes close to 100% efficiency.