Question 1: Heat Pump

1. Discuss the differences and the similarities of a compressor heat pump and an absorbtion heat pump, using a schematic.
2. Explain why the full fuel chain is decisive for the ecological usefulness of a heat pump.
3. Someone leaves the door of the fridge open. How does that influence the temperature in the room, in which the fridge is situated? Justify your answer using the first law of thermodynamics. Is there a time dependency to your answer?

Question 2: Geothermal

A double flash geothermal power plant is build to provide electricity and district heating. A schematic of the plant is shown in Figure 1. During summer the plant is operated to maximize the electric power output ($\dot{m}_\mathrm{i} = 0$). In winter however the main purpose is to provide enough heat to the district heating grid.
The plant is run under the following conditions: Water is extracted at the well with a temperature of $T_1 = 195\,°\mathrm{C}$ at a massflow rate of $\dot{m}_\mathrm{well} = 130\,\mathrm{kg/s}$. The two separators are run at $T_\mathrm{sA} = 150\,°\mathrm{C}$ and $T_\mathrm{sB} = 105\,°\mathrm{C}$. The water is reinjected with a temperature of $T_{10} = 60\,°\mathrm{C}$. The efficiencies of the generators can be assumed to be 98 %. The low pressure turbine has an efficiency of 68 %. The properties of water at the different temperatures are listed in Table 1. Furthermore it is assumed that the two expansion ($1 \rightarrow 2$, $3 \rightarrow 5$) are isenthalpic.

Table 1: Properties of water at different temperatures

Temperature [°C]	Pressure [bar]	Enthalpy [kJ/kg] sat. Liquid h_liquid	Enthalpy [kJ/kg] sat. Vapor h_vapor
40	0.074	167.57	2406.7
60	0.199	251.13	2609.6
105	1.224	440.17	2683.8
150	4.758	632.20	2746.5
195	14.04	830.04	2789.8

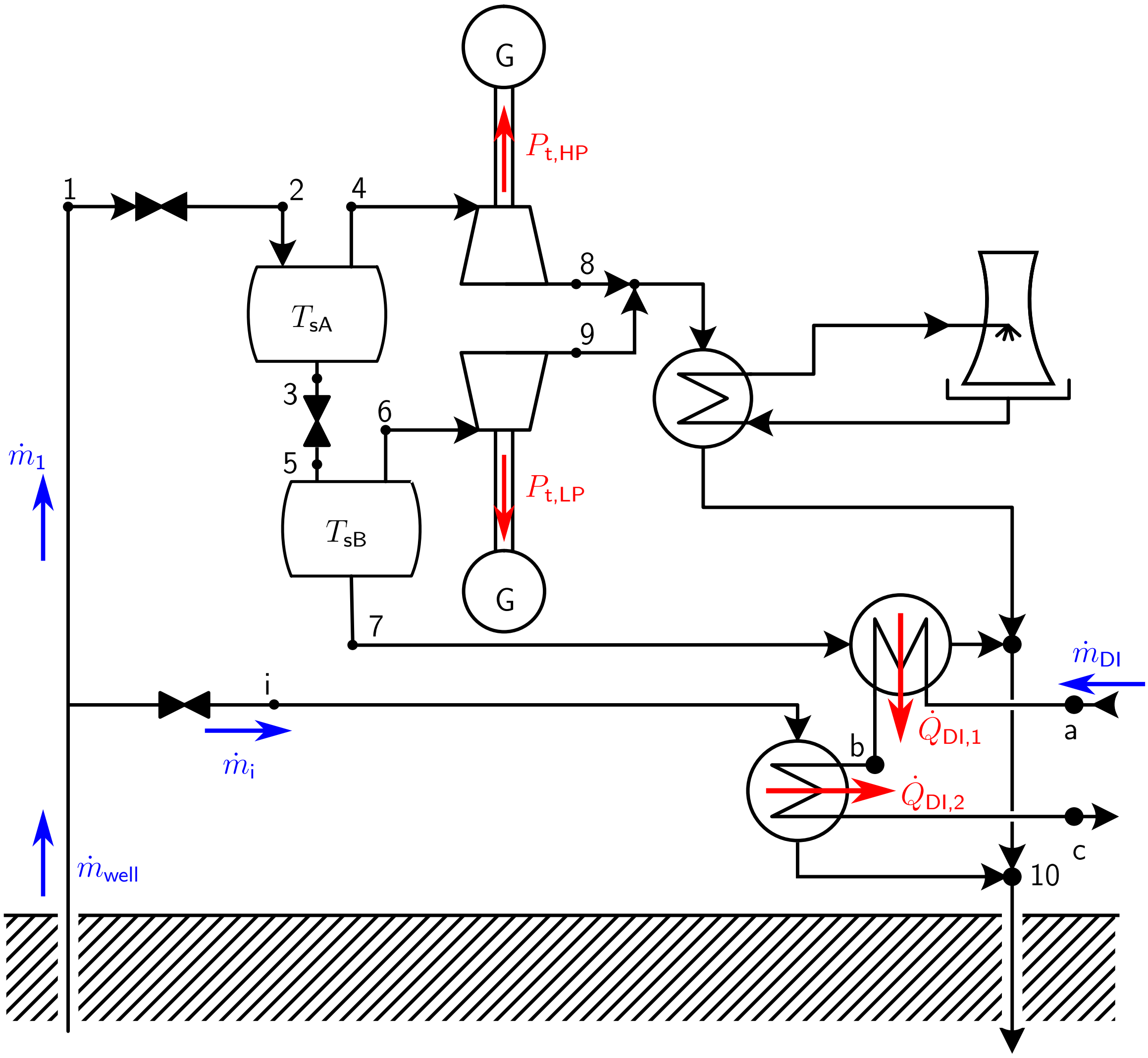

Figure 1: Flow sheet of a double flash power plant.

Summer operation:

1. Calculate the steam qualities (x_{sA}, x_{sB}) in the two separators.
2. Calculate the liquid ($\dot{m}_7$) and vapor massflow ($\dot{m}_6$) out of the second separator and the vapor massflow ($\dot{m}_4$) out of the first separator.
3. Assuming an enthalpy of 2503.2 kJ/kg at point 8 and 2508.8 kJ/kg at point 9, calculate the total electric power output of the two turbines.
4. Calculate the heat input ($\dot{Q}_{\text{DI},1}$) to the district heating grid. How big is the massflow $\dot{m}_{\text{DI}}$ (Assume $T_{\text{a}} = 40\,°\text{C}$ and $T_{\text{c}} = 60\,°\text{C}$).
5. Draw the process in a T-s diagram. Take care to label all points present in Figure 1.
6. Calculate the electric and thermal efficiency of the power plant.

Winter operation: During winter a minimum heat input to the district heating grid of 40 MW is required.

1. Calculate the maximum possible heat input to the district heating grid. Is it possible to satisfy the requirements for winter operation?
2. What is the required bypass massflow ($\dot{m}_{\text{i}}$) to meet the requirement of 40 MW heat input?
3. How do the efficiencies change compared to summer operation?