SCHOOL OF ENGINEERING
MECHANICAL ENGINEERING
LRESE - Laboratory of Renewable Energy Sciences and Engineering

Renewable Energy: Geothermal Exercise

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1. A central heating system for a small town is deigned based on geothermal heat and a heat pump. The yearly heating demand for the 8000 m^3 building volume is 135'000 kWh.

   (a) What heating capacity needs to be installed in order to ensure that the complete volume can be heated at a maximal rate of 7.3 $\cdot 10^{-3}$ K/s ?

   (b) Calculate the electrical power requirement of the heat pump and the heating power of the probe.

   (c) What is the length of the probe in order to ensure that the required heating demand and power can be met? The maximal extractable energy per year and length of the probe is 110 kWh/m, the specific power density of the probe is 52 W/m.

   (d) How much are the yearly electricity costs?

   (e) Assume the geothermal heat pump is replaced by an oil heating. How much would be the yearly oil demand and the oil cost of this heating alternative?

   (f) How much are the relative reduction in CO_2 emissions between the geothermal heat pump and the oil heating?

   Assume:

   i. air density 1.29 kg/m^3, specific heat capacity of air 1000 J/kg/K
   ii. COP of heat pump 4.2
   iii. Electricity cost 0.13 CHF/kWh, specific CO_2 emissions of electricity 130 g CO2 / kWh
   iv. Oil heating value 42.6 MJ/kg, oil density 0.86 kg/L, specific CO_2 emissions 74 g/MJ, oil costs 0.86 CHF/L

2. A geothermal source has a well head exit temperature of 190°C and is cooled down to 85°C at which temperature the geothermal fluid (water) is reinjected into the soil reservoir. The water mass flow rate is 50 kg/s. A flash system using a cold source at 14°C allows for electricity-only production in summer (3.2 MW electrical), and for combined heat and electricity production in winter (2.4 MW electrical, and 12MW thermal at 60°C delivery temperature and 40°C return temperature for a district heating system).:

   (a) Calculate, for summer and winter, the energy and exergy efficiency of the system

   (b) What is the relative or "marginal" electrical efficiency in winter (i.e. the electricity produced from residual heat)? Hint: Compare the produced electricity in winter (2.4 MW) with the expected electricity production.