Direct Use Geothermal Problem Set

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1 Greenhouse Design

Your task is to design a geothermal heating system for a single greenhouse. You will need to first compute the peak heating load, then the annual heating load, and then determine how much geothermal water will be needed for a couple types of heating systems: finned radiators and standard unit heaters.

1.1 Greenhouse Size

The greenhouse is a high-sided, angled roof structure 50 m long, 20 m wide, with 3 m walls and a 2 m peak height. The walls are fiberglass, and the angled roof is single-paned glass; these materials will set your U-Factors for heat transfer.

Assume the greenhouse needs to be kept at 20°C, the minimum temperature is -5°C, and the design wind speed is 32 km/hr.

1.2 Questions

Given the design criteria above, find:

1. Total peak heat loss of the greenhouse
2. Annual heat loss, assuming a capacity factor of 0.48 (WGC 2010 global average)

3. Cost per year of heating with 90% efficient natural gas furnace, assuming $1.20/therm; recall that a therm is 10^5 BTU.

4. Peak flow for a 70°C geothermal resource, assuming 20°C drop in the heat exchanger (50°C return to reservoir). Assume working fluid is 5°C cooler than resource (65°C into greenhouse, 45°C return to heat exchanger).

5. Heating tube length and placement, assuming finned tube radiators, for peak heating load.

6. Number and placement of standard unit heaters for peak heating load.

2 Aquaculture Design

Your task is to design a geothermal heating system for an aquaculture pond to raise fish. As with a greenhouse, you will need to find the peak heating load, annual heating load, cost savings, and geothermal resource necessary for maintaining the pond at the optimal temperature.

2.1 Pond Size

Your pond is 15 m long, 7 m wide, and 1.5 m deep. Assume vertical sides - you have excavated and lined a vertical pool. Wind direction is across the width (perpendicular to length) to minimize waves, and you can assume a design wind speed of 3.0 m/s.

Design for a minimum temperature of -5°C, and the pond must be maintained at 27°C. Your available geothermal resource has a production temperature of 55°C.

2.2 Questions

Using the information above, find:

1. Peak heating load.

2. Annual heating load, assuming capacity factor of 0.56 (WGC 2010 global average).

3. Estimated cost per year to heat the pond with natural gas, using a 90% efficient furnace. Natural gas is assumed to cost $1.20/therm.

4. Peak flow of geothermal water needed to heat the pond.

5. If the available geothermal resource was 90°C, what flow(s) would be needed to heat the pond.