INTEGRATION OF A CONCENTRATING SOLAR STEAM TOPPING TURBINE TO AN EXISTING GEOTHERMAL BINARY POWER PLANT

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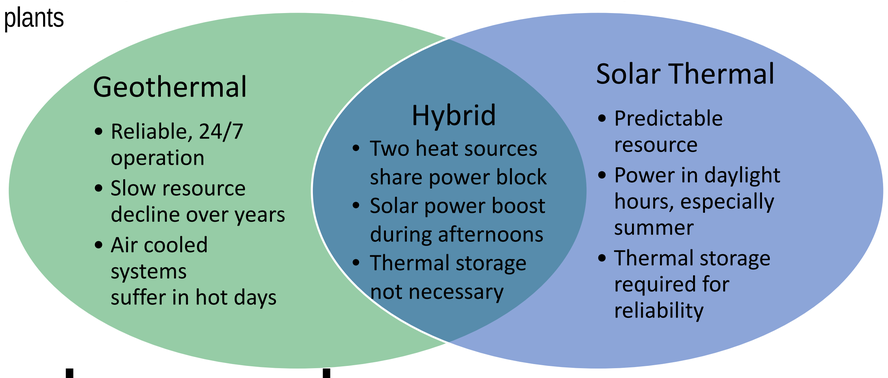
Objective

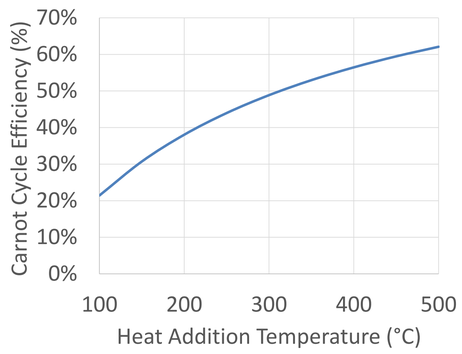
Demonstrate how a Geo-Solar Hybrid can be a cost effective way for any EXISTING underperforming geothermal power plant to achieve full capacity, and how it could help lower the LCOE of NEW geothermal power plants

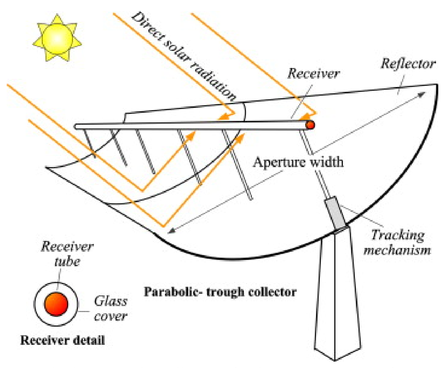


Background

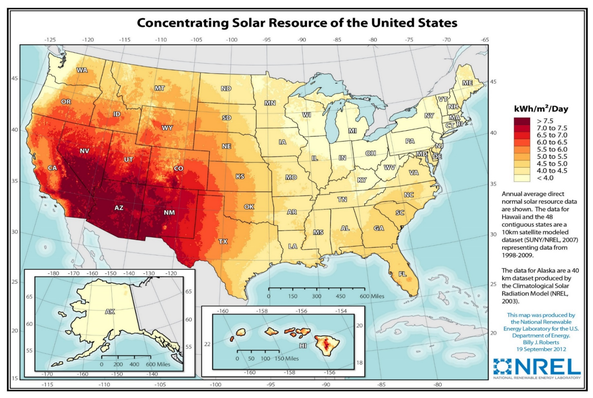
High capital costs produce a higher-than-market levelized cost of energy (LCOE), and so hinder greater deployment of both moderate temperature geothermal binary power as well as concentrating solar power (CSP).

One of the key factors preventing reductions in geothermal binary power plant LCOE is the low efficiency of power generation using low temperature heat. Where typical geothermal binary power plants operate with 12% to 15% efficiency, the high temperature heat from concentrating solar thermal may be converted to electricity with an efficiency nearer to 30%



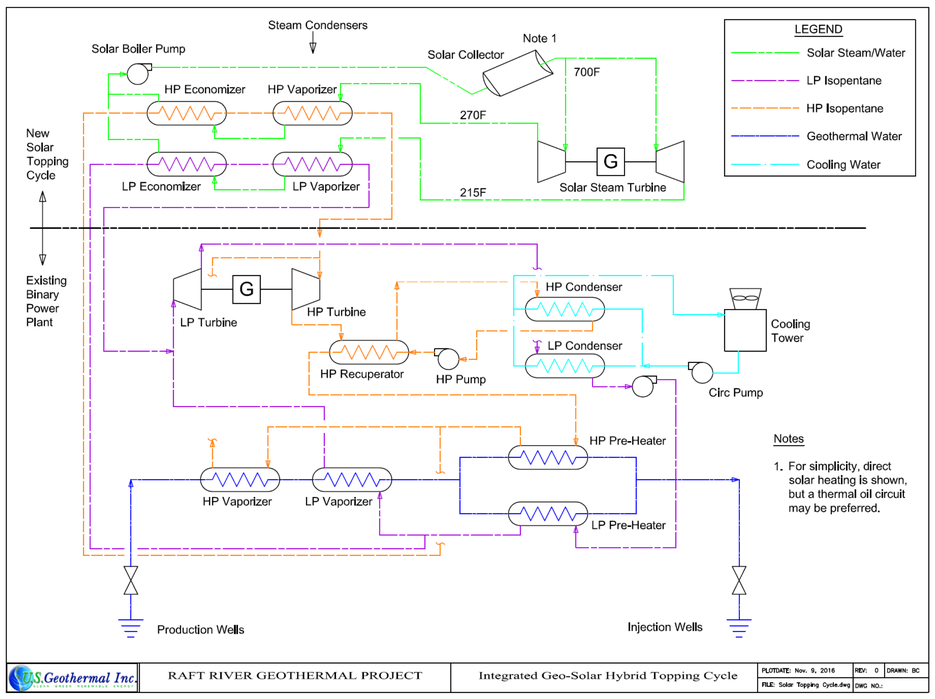


Parabolic Trough Collector (Cabrera et al, 2013)



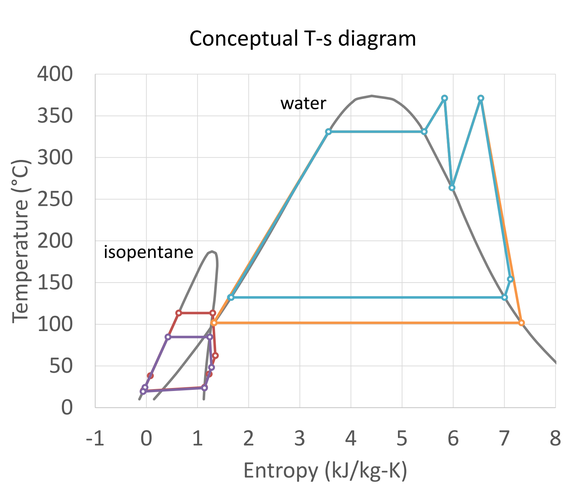
A new thermodynamically efficient approach to integrate CSP and binary geothermal is proposed for DOE lab evaluation which would marry the best aspects of both CSP and geothermal to provide a lower LCOE than either technology could alone, thus improving market penetration for both technologies. The study is for the Raft River plant, specifically, but the technology would be applicable to retrofit of the many existing under-performing geothermal binary power plants.

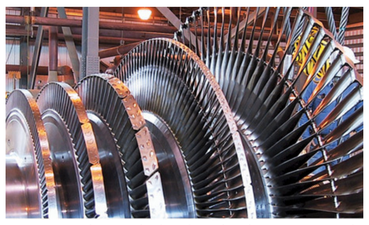
Geothermal binary plant with solar steam Rankine topping cycle



Advantages of Proposed Cycle

- CSP steam turbine operating at high pressure and temperature (high thermodynamic efficiency)
  - Use of a backpressure steam turbine will eliminate the large diameter low pressure stages (lower turbine $/kW)
  - Exhausting and condensing between 16 – 25 psia (lower condenser $/kW)
- The exhausted steam is condensed by boiling isopentane
  - Boiled isopentane is delivered to the binary turbine, making use of the existing turbine, condenser, and heat rejection capacity
  - Increased isopentane mass flow rate will increase binary cycle power generation $\dot{W}_{turbine} = \dot{m}\Delta h$
  - No additional heat rejection infrastructure required (existing cooling towers will be utilized)
- Proposed cycle uses part of the geothermal flow to pre-heat the CSP boiler water
  - Increase heat extraction from the geothermal fluid (greater resource efficiency)
  - Reduce the size of the solar array (lower array $/kW)





Steam Turbine Blades (Bechtel Power Corp)

Raft River Cooling Tower (Power Magazine)

Expected Outcomes

- USGeo to have a validated process flow diagram, and performance parameters for the major equipment. USGeo could then use this information to go to a private sector detailed engineering firm to design the plant, bid and purchase equipment, and install the topping cycle.
- The developed solution to be published by DOE for use by other geothermal developers both to retrofit underperforming plants and to lower the LCOE of new developments.

Raft River Geothermal Power Plant (DOE EE&RE)

Bokpoort South Africa CSP plant (evwind.es)

Anticipated Impacts of Successful Design

- Cost savings: The proposed cycle could reduce the cost per MW and MWh of the CSP plant and the geothermal power plant. For the CSP plant, capital savings could be on the order of 40% per MW through a combination of smaller collector field, smaller backpressure turbine, and no heat rejection system.
- Increased performance: As a retrofit to Raft River, the solar addition could be sized to bring the plant to full output during daylight hours by vaporizing enough pentane for 2 additional MW during the day. The solar steam turbine is estimated to produce an additional 4MW of solar power.
- New products or markets: The net output from a geo-solar hybrid should be very attractive to utilities because it would not have the minute-to-minute fluctuation of PV. The CSP would counter the mid-day sag in output at most geothermal plants. The plants generation profile would be higher during the day, but still maintain steady reduced baseload generation at night, thereby better matching actual utility load curves.
- Reduced greenhouse gas emissions: More generation from existing and new geo/solar hybrid plants reduces CO_2 emissions compared to fossil-fired generation.
- Regulatory acceptance: The smaller solar collector area per MW will reduce the land impact of CSP and so should increase regulatory and community acceptance.

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