CONCENTRATED SOLAR AND GEOTHERMAL HYBRID POWER PROJECT

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ABSTRACT

There is an opportunity to add a concentrated solar power (CSP) system to an existing geothermal power plant. The addition of the CSP system would create a hybrid project that maintains or improves the power output of the geothermal power plant facility.

If viable, this opportunity is important because the marriage of two or more renewable energy technologies can optimize resources and support the following concepts:

- promote the energy park concept,
- increase the cost-effectiveness of developing utility scale renewable technologies,
- support the goals and objectives of the Western Governors' Association - Renewable Energy Zone (REZ), and
- encourage geothermal and solar stakeholder collaboration.

CSP systems use mirrors or lenses to concentrate a large area of sunlight onto a small area. In CSP stand alone projects, electrical power is produced when the concentrated light is converted to heat, which drives a heat engine (usually a steam turbine) connected to an electrical power generator. In a CSP/Geothermal hybrid project the heat would be used to heat the spent brine or another working fluid.

This paper describes a variety of potential hybrid projects and includes discussions on (1) CSP technologies, (2) hybrid project scenarios, (3) hybrid project cost and benefits, and (4) next steps. Although the paper focuses on hybrid project application to existing and future hydrothermal power plants, hybrid projects could have potential in enhanced geothermal systems.

CSP TECHNOLOGIES

According to the Interstate Renewable Energy Council (IREC), CSP is being widely commercialized and the CSP market has seen about 740 MW of generating capacity added between 2007 and the end of 2010. More than half of this (about 478 MW) was installed during 2010, bringing the global total to 1,095 MW. The US ended the year with 509 MW after adding 78 MW, including two fossil–CSP hybrid plants (Sherwood, 2010).

CSP technologies exist in four common forms, namely parabolic trough, dish Stirling, concentrating linear Fresnel reflector, and solar power tower. CSP is used to produce electricity, sometimes called solar thermoelectricity, usually generated through steam. Concentrated-solar technology systems use mirrors or lenses with tracking systems to focus a large area of sunlight onto a small area. The concentrated light is then used as heat or as a heat source for a conventional power plant. The solar concentrators used in CSP systems can often also be used to provide industrial process heating or cooling, such as in solar air-conditioning.

A parabolic trough consists of a linear parabolic reflector that concentrates light onto a receiver positioned along the reflector's focal line. The receiver is a tube positioned directly above the middle of the parabolic mirror and filled with a working fluid. The reflector follows the sun during the daylight hours by tracking along a single axis. A working fluid such as molten salt is heated to 150–350°C as it flows through the receiver and is then used as a heat source for a power generation system.

Fresnel reflectors are made of many thin, flat mirror strips to concentrate sunlight onto tubes through which working fluid is pumped. Flat mirrors allow more reflective surface in the same amount of space as a parabolic reflector, thus capturing more of the available sunlight, and they are much cheaper than parabolic reflectors. Fresnel reflectors can be used in various size CSPs.

A dish Stirling or dish engine system consists of a stand-alone parabolic reflector that concentrates light onto a receiver positioned at the reflector's focal point. The reflector tracks the Sun along two axes. The working fluid in the receiver is heated to 250–700°C and then used by a Stirling engine to generate power. Parabolic-dish systems provide the highest solar-to-electric efficiency among CSP technologies, and their modular nature provides scalability.

A solar power tower consists of an array of dual-axis tracking reflectors that concentrate light on a central receiver atop a tower; the receiver contains a fluid deposit, which can consist of sea water. The working fluid in the receiver is heated to 500–1000°C and then used as a heat source for a power generation or energy storage system.

HYBRID PROJECT SCENARIOS

CSP/Geothermal hybrid projects could be a number of scenarios, all of which use the heat generated by the CSP system to enhance the geothermal project.

1. In steam or flash geothermal power plants, the CSP system could reheat the spent brine, either directly or through a working fluid tied to a heat exchanger, and allow all or a portion of the brine to be recycled back into the geothermal plant to pass through another flash tank and reintroduced to the steam turbine and/or re-injected into the reservoir at a higher temperature.
2. In binary power plants, the CSP system could reheat the spent brine (again, either directly or via a working fluid) and allow all or a portion of the brine to be recycled back into the power plant and/or re-injected into the reservoir at a higher temperature. Reinjection at higher temperatures could off-set the need for the

expense and risk exposure experienced when using acid for brine pH modification. Potentially, the higher reinjection temperature will retard the rate of silica polymerization.

3. In binary power plants, the CSP system could heat the working fluid to a higher temperature to produce more power.
4. In binary and flash units, CSP systems could be utilized to off-set parasitic load. The use of CSP would not require additional inter-connection costs as it would be used for plant consumption thus allowing the geothermal net electrical production to increase by the CSP off-set.

In all of the above scenarios, the hybrid project reduces the stress on the reservoir by either producing more power and/or increasing the temperature of the re-injected brine. Increasing the temperature of the re-injected brine increases the temperature/pressure thermodynamics of the reservoir. The hybrid technology can also apply to future enhanced geothermal systems. A simplified CSP flow diagram is shown in Figure 1.

COSTS AND BENEFITS

As of September 2009, the cost of building a stand-alone CSP station was typically about $2.50 to $4.00 per watt. Given that cost, the energy cost from a 250 MW CSP station would be $0.12 to $0.18/kWh. The cost range is based on information in a November 2008 Congressional Research Service report to Congress (Kaplan, 2008). The report analyzed four major factors that determine the cost of electricity from new power plants:

1. construction costs,
2. fuel expense,
3. environmental regulations, and
4. financing costs.

Although the report is four years old, there may not be a better document that provides projections of the possible cost of power from new fossil, nuclear, and renewable plants or that describes how different assumptions, such as for the availability of federal incentives, change the cost rankings of the technologies.

There is evidence that the costs will drop in the future. For example, in 2009, National Renewable Energy Laboratory (NREL) and SkyFuel staff teamed to develop large curved sheets of metal that have the potential to be 30% less expensive than today's best collectors of concentrated solar power by replacing glass-based models with a silver polymer sheet that has the same performance as the heavy glass mirrors, but at much lower cost and weight. It also is much easier to deploy and install. The glossy film uses several layers of polymers, with an inner layer of pure silver.

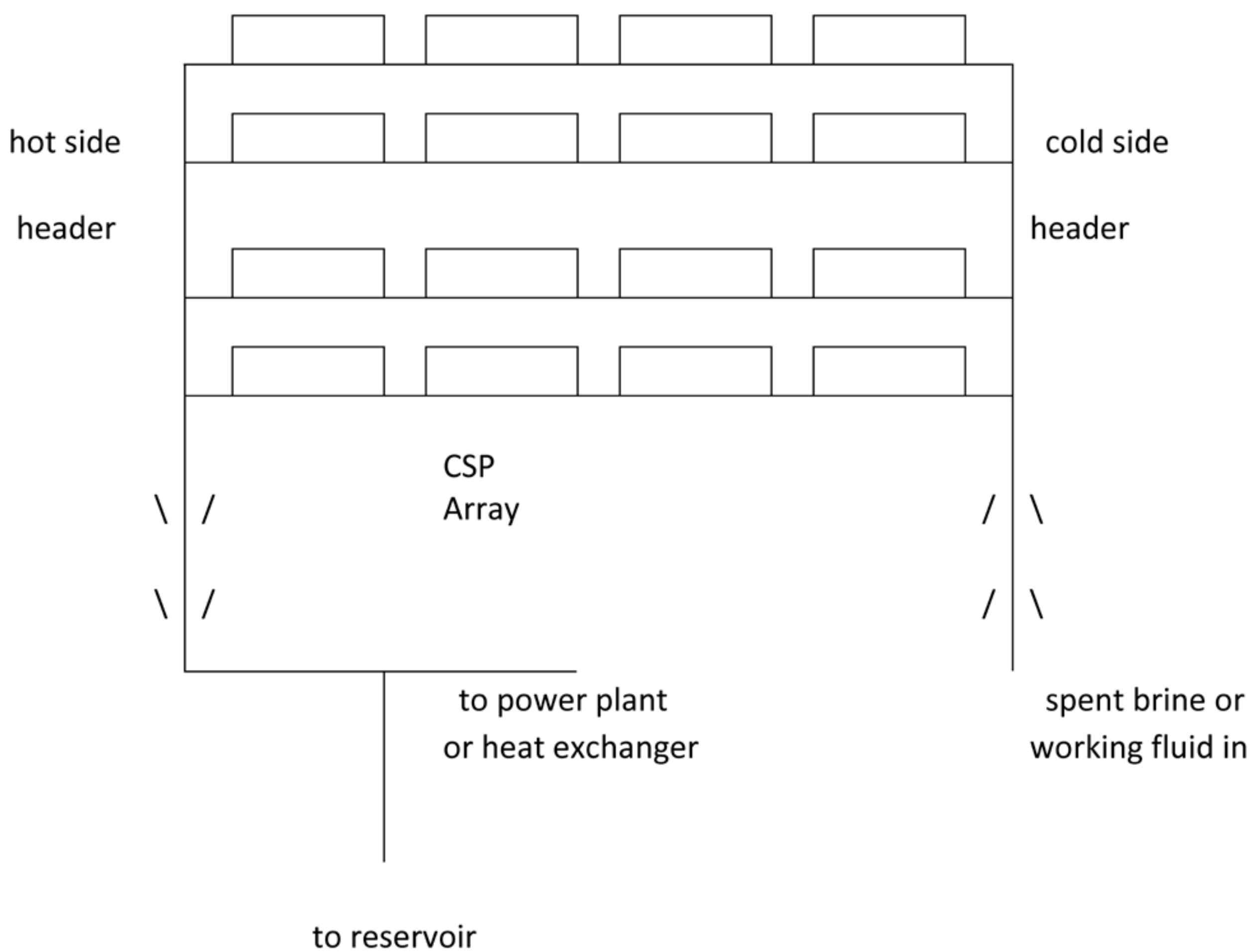

Figure 1. Simplified CSP Flow Diagram.

The economics of a hybrid CSP/Geothermal project will likely be more attractive than the CSP stand-alone project, because of less storage requirements. Also, the integration into the existing geothermal power plant infrastructure can lower CSP costs. Furthermore, CSP works best with areas of high solar radiation, such as the southwest United States. This area is also where there are existing geothermal power plants and where there is significant geothermal potential.

CSP can contribute to the long-term success and profitability of a geothermal project by extending the life of the geothermal reservoir and reducing the need to drill additional production wells or relocating injection wells. Drilling costs for new wells can be $5 million or higher, depending on geologic conditions and depth requirements. CSP can also contribute to the benefit of using dry cooling towers in arid climates. CSP can offset parasitic load, thus making more megawatts available to the market and mitigating the negative impact of reduced output during summer peak due to high ambient temperatures. This can especially be applied in dry climates where water is scarce and the need to conserve water is significant. Thus, supplementing the parasitic load with CSP can reduce costs of buying and treating water and can also significantly reduce the rate of reservoir depletion due to evaporative loss. Augmenting parasitic load with CSP can effectively extend the life of the geothermal reservoir and improve the long-term economics of the geothermal project.

Like oil and gas reservoirs, geothermal reservoirs can reduce output if not properly managed. For example, overproduction of a reservoir, such as was historically practiced in the Geysers geothermal field in northern California, leads to a significant shortening of its productive lifetime and a loss of income. Even a properly managed reservoir often requires relocation of production and reinjection wells to maintain an acceptable output. A hybrid project can delay or eliminate the need to drill new wells or redesign the reservoir gathering and re-injection system.

The hybrid application can also help get more CSP equipment installed in the U.S. According to an Emerging Energy Report, Spain has eclipsed the U.S. in CSP potential and U.S. applications must compete with lowering power demand, energy prices, and PV module costs (Emerging Energy Research, 2010).

NEXT STEPS

The CSP/Geothermal hybrid project is only a concept at this time. The next steps to move the project from conception to implementation include

1. Identify potential hybrid project sites (month one).
2. Assess industry support (month two through three).
3. Refine cost and benefits (month two through four).
4. Determine Go/No Go Decision on developing a project. Several factors go into determining the Go/No Go Decision (Step 5), including confidence in the cost and benefits of the project and budget to fund one or more projects through project partnership funds, including potential grant awards

EDITOR'S NOTE

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