



Geothermal Opportunity Zone Proposal

Sonoma Clean Power (SCP) is extending invitations to the Counties of Mendocino, Lake and Sonoma to explore the future of geothermal power in our region, and to work collaboratively to identify where and how new geothermal resources should be developed. A Geothermal Opportunity Zone (GeoZone) is the proposed name for this collaboration, and the intent is to identify advances in water-efficient power production, environmentally preferable technologies, ways to ensure local communities benefit from new facilities, and solutions to aid the participating counties in achieving their climate goals as well as California's goals of Senate Bill 100. New technologies have the long-term potential to lower costs, but may have higher initial costs until greater scale is achieved, so another goal of the GeoZone is to find federal or state funding to cover any initial above-market costs.

Background

The success of solar power has led to a new challenge: California now needs a lot of renewable energy that runs when the sun isn't shining to meet its climate goals. With the technology we have today, only offshore wind and geothermal have the potential to meet the scale of this challenge. Locally, we have world-class geothermal potential that can directly address this need.

The SCP Board of Directors passed a resolution on October 7, 2021 creating the initial GeoZone concept and inviting the counties of Sonoma, Mendocino, and Lake to participate.

How does geothermal energy work?

The earth has a constantly-regenerating source of heat that is transferred from the core to areas near the surface by conduction and the flow of magma underground. There are areas in the world where magma exists particularly close to the surface and significantly elevates

subsurface temperatures. This condition is particularly pronounced in this region, where a thermal anomaly exists that is associated with the Clear Lake Volcanic Field.

Power is produced by using geothermally heated rock to transfer heat to water that expands as it converts to steam. That expanding steam is used to spin a turbine and generate electricity. At the existing facilities in the Geysers, fully-treated wastewater is pumped from both Sonoma and Lake Counties to replace the steam that is lost to evaporation. New technologies discussed below have the potential to recapture some of the steam and reduce the amount of water required to generate geothermal power.

What is the need for geothermal?

The Preferred System Plan (PSP) portfolio released by the California Public Utilities Commission (CPUC) estimates 1,200 megawatts of new geothermal resources will be required by 2030 to achieve emissions and reliability targets and 2,300 megawatts by 2045. This is on top of retaining and sustaining the output of 1,600 megawatts of existing geothermal capacity. Northern California is anticipated to contribute a quarter of the required new capacity (over 600 MW by 2045). The CPUC has also ordered load serving entities to procure 1,000 megawatts of firm zero-emitting resources by 2026 to accelerate development of geothermal resources. Given the complexity of permitting and development, this timeline requires rapid action.

Opportunities to expand capacity at the existing Geysers geothermal field with conventional steam plants are limited by the availability of water to inject for pressure maintenance and the extent of reservoir permeability, and such water constraints are not expected to improve over time as forecasts predict more frequent droughts. However, recent technological advances in the geothermal industry could enable widespread development with reduced water use constraints while also minimizing resource assessment risk. To get started, however, these new technologies need a proving ground.

Why create an opportunity zone?

The Counties of Sonoma, Lake and Mendocino contain the largest operational geothermal resource in the world. This provides us with an opportunity to forge a partnership to actively support the development of geothermal power. With SCP staffing and financing, we can

begin to identify and mitigate barriers to development while advocating for federal and state funding.

A GeoZone would create a lower-risk opportunity for geothermal development by having SCP and member counties act as public advocates for grants to cover some or all the above-market costs for new technologies. SCP could also potentially be a purchaser of the energy generated, and customers in Sonoma, Mendocino and potentially also in Lake Counties could be served by the energy. The GeoZone would create a clear opportunity to advocate for federal tax credits and priority for critical grid infrastructure.

SCP would seek to create opportunities for the three counties to lease publicly owned land, increase employment opportunities for the local workforce, and increase the local tax base. Success in the GeoZone will provide the state with a clean energy resource that is reliable, local, affordable, and sustainable. Proactively identifying development barriers, establishing relationships with developers, and advocating for public funding and infrastructure will drive down the cost of geothermal energy, which currently commands a premium.

Should the Counties of Sonoma, Lake and Mendocino agree, the GeoZone will encompass the land they choose to explore, but could initially encompass all of the three counties during preliminary resource studies. Available data from the National Renewable Energy Laboratory (NREL) indicates that the thermal anomaly underlying the Geysers is regionally extensive through much of Lake County and adjacent sections of Mendocino and Sonoma counties. SCP has completed preliminary technical resource evaluation using temperature data from wells drilled in the region to confirm NREL's characterization. The area also hosts a dense network of high voltage transmission capacity. There are potential applications for small-scale low-temperature geothermal projects outside the core of the thermal anomaly that exist throughout a much larger portion of the three counties.

What is the status of the existing geothermal resource?

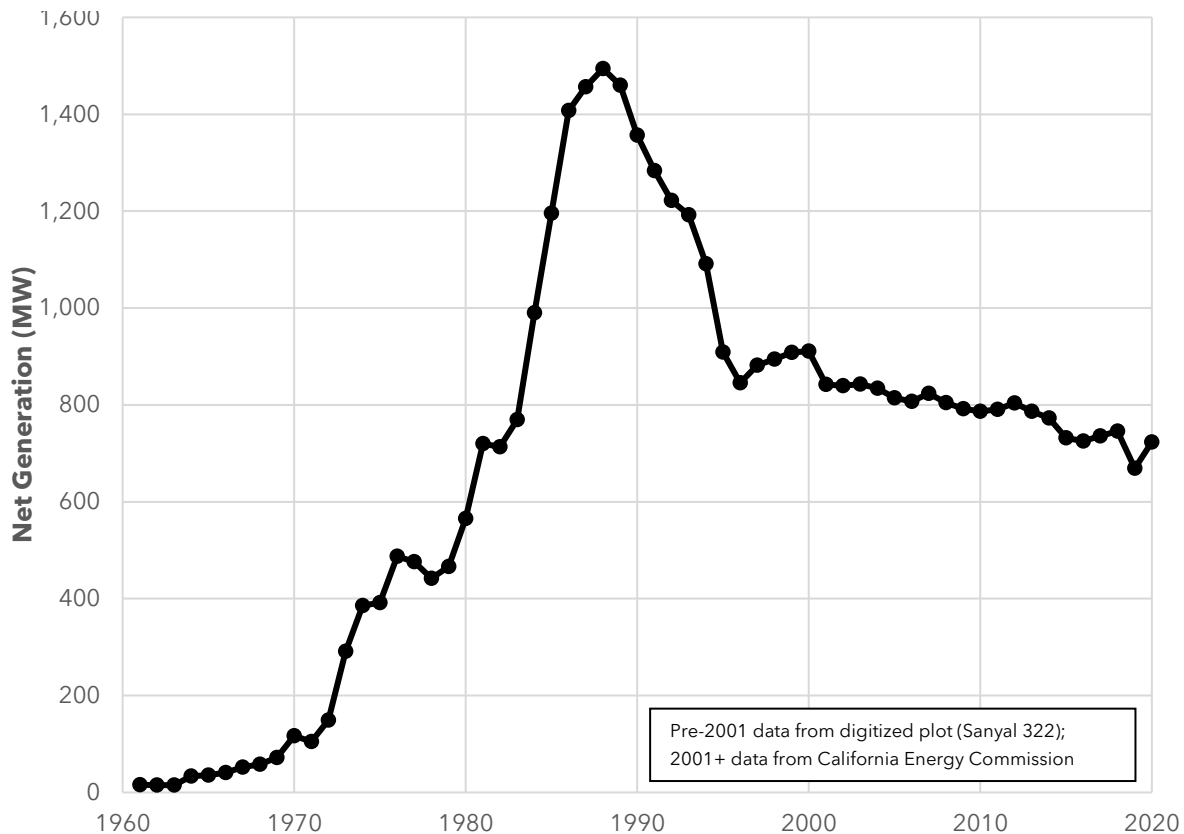
Existing geothermal facilities at the Geysers employ conventional hydrothermal technology that requires a geologic heat source, subsurface permeability, and water to generate power. The geographic area with proven characteristics for conventional development is probably limited to the area in and around the existing Geysers field on the border between Sonoma and Lake counties.

There are currently fifteen active plants in the Geysers field generating around 700 MW of net power. Figure 1 on the following page charts the historic generation of the Geysers starting with PG&E's first 11 MW plant in 1960 and peaking near 1,500 MW just before the newest

geothermal plant (Aidlin) was commissioned in 1989. All existing plants at the Geysers utilize dry steam generation technology.

After precipitously declining due to reservoir depletion, generation stabilized in 1997 after startup of an injection project fed from a Lake County wastewater pipeline. In 2003, a second pipeline from Santa Rosa provided additional injection capacity allowing 80% to 90% of produced fluids to be replaced (Khan 2). By 2010, these two projects were estimated to be avoiding 155 MW of projected capacity decline at the Geysers (Khan 2). In total, 15 million gallons per day or 16,000 acre-feet per year of treated wastewater are injected into the reservoir (Calpine). Although the energy requirements for delivering the injection water are significant (9 MW for the Santa Rosa system), they are small compared to the net generation impact. It appears current injection volumes are sufficient to roughly sustain Geysers generation, but any additional capacity will require increased injection volumes or new generation technology that reduces the amount of water needed per MW generated.

Figure 1. Historic generation of Geysers



What new technologies may enable additional resource development?

New geothermal technologies offer the opportunity to reduce water usage, shrink the surface footprint, and expand the geographic range of geothermal power production. SCP proposes to explore the use of these technologies.

Figure 2 illustrates the current technology in use at the Geysers. Wastewater is injected from the Santa Rosa Subregional System and from Lake County to maintain mass balance of water in the reservoir. That water is heated to steam by hot rock in the reservoir, produced, and run through a turbine. Today, most of the water is allowed to evaporate up at the surface, along with geologic emissions (including hydrogen sulfide and carbon dioxide). Most existing wells are vertical, requiring extensive flowlines at the surface to connect wells to surface facilities.

Figure 2. Existing hydrothermal / dry steam

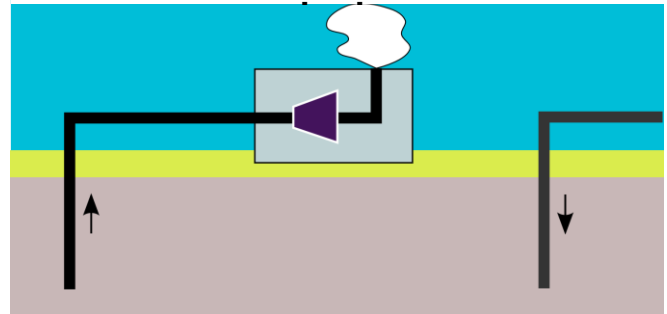


Figure 3. New binary technology



Figure 3 demonstrates the advantages of new technologies available for geothermal development. Instead of evaporating, the steam is run through a heat exchanger that transfers heat to a separate closed-loop system powering the turbine (binary system). Most of the water is then returned to the reservoir through injection wells and there are little to no geologic emissions during operation. Geologic emissions during initial drilling and construction would still need to be studied and minimized to protect workers and local communities. Directional drilling allows wellheads to be located next to surface facilities, minimizing the length of pipes at the surface and associated surface footprint of development. New subsurface technologies, including closed-loop wells and engineered geothermal systems, provide the capability to transfer heat without requiring reservoir permeability. This has good potential to expand the region for development far beyond the footprint of the current Geysers field.

Meanwhile, greatly enhanced resource assessment capabilities increase the resolution of characterizing reservoir properties and reduce the risk in identifying suitable drilling targets. New monitoring techniques improve reservoir management and the longevity of geothermal

resources. Advances in energy storage can be used to add valuable flexibility to geothermal generation.

How could our local communities benefit from the GeoZone?

While it is too early to know exactly how our local communities could benefit from the activities of the GeoZone, it is certainly possible that development of geothermal resources in the GeoZone will create high-paying jobs to support drilling, facility construction, operation, and maintenance. Increased development activity is expected to increase the security of current industry jobs and provides the opportunity for workers in the oil and gas industry in the Central Valley to relocate to the region as California hydrocarbon extraction winds down. These benefits no doubt have multiplicative effects in creating jobs and economic activity across sectors. Meanwhile, revenue from property taxes and leases on public land could provide a sustainable source of income for the community.

Pursuing geothermal technological development, seeking grant funding, and leveraging economics of scale give the community a leading role in reducing energy costs. Alternatives to geothermal power will require assets with very low utilization (natural gas plants or long-duration storage) and resultantly high costs for ratepayers. Local resources could also provide opportunities for communities and businesses to directly procure low-cost power or waste heat.

SCP is also focused on aligning any new geothermal development with the desires of the community. As a member of the GeoZone, counties would partner in proactively deciding the locations and serve as the deciding body in approving acceptable environmental impacts of development. Development of new technologies may also translate to improvements to the existing Geysers operation: reduced water requirements, smaller land footprint, minimized emissions, and extended project life.

The use of the geothermal energy in Sonoma and Mendocino Counties is easily facilitated through purchase agreements by SCP. However, SCP is interested in exploring the options for ensuring the Lake County electric customers also receive the benefits of using the geothermal energy. The most straightforward option for this is to plan an eventual expansion of SCP's service territory to include Lake County, but other options may exist – such as Lake County forming and operating its own community choice power provider or joining another CCA.

What are the potential environmental and community impacts of development in the GeoZone?

With any major power production, the environmental impacts need to be carefully studied and mitigated, and geothermal is no exception. Although operational air emissions and solid waste may be nearly eliminated with binary plant technology, there will still likely be emissions and waste associated with drilling and well testing, and these could be significant in some regions. Directional drilling and modular facilities can greatly shrink the visible footprint of new development, but there will still be land disturbance from roads and transmission lines.

Proactive identification and mitigation of adverse impacts will be an early objective of the GeoZone. Technologies and development concepts that minimize impacts will be a key criteria in selecting private development partners.

At a minimum, SCP considers the following impacts to be of a very high priority to study and mitigate:

- Transmission line construction and land use
- Geothermal facility footprints and visual impacts
- Initial and operating water use
- Construction & drilling air emissions (and possibly operating air emissions)
- Construction & drilling solid waste generation and impacts on waterways
- Risk of groundwater contamination
- Seismicity from the injection of water into hot rock.

No doubt that during the initial feasibility studies, many more impacts will also be identified and studied.

What work has SCP started in forming an opportunity zone?

SCP started preliminarily investigating the opportunity to promote local geothermal resource development earlier this year. As part of that effort, work has started in the following focus areas:

1. **Initial resource evaluation:** After using available public datasets on the extent of the local geothermal resource to define the GeoZone, SCP entered into an initial pre-feasibility contract with Dr. William Glassley to perform a characterization of geothermal potential within the potential GeoZone area. The results of this study

could be used by the participating GeoZone counties and SCP in refining the scope of the GeoZone.

2. **Technology:** SCP arranged initial meetings with geothermal development and technology companies to understand the current landscape of the industry, identify potential applicability of new development technologies and processes to the GeoZone, and further understand potential barriers to development. SCP also engaged Redwood Coast Energy Authority (RCEA) on the process they used to partner with private entities to promote development of offshore wind.
3. **Transmission:** SCP is working on developing more in-house expertise on the transmission planning process. SCP held an initial meeting with CAISO's Transmission Planning group to get more familiar with CAISO's processes. Concurrently, SCP is collecting information on the existing transmission infrastructure, and discussing related transmission issues with PG&E, such as large-scale transmission outages for public safety power shutoffs and how solutions to those problems might also benefit GeoZone efforts.
4. **Site control:** SCP has completed a preliminary assessment of some publicly-owned parcels of land to ensure that there is at least some legitimate potential for new geothermal development, and confirmed that it appears worth further exploring that potential. SCP also started a high-level appraisal of mineral ownership rights in the GeoZone area, since title to the heat in the ground can be severed from surface ownership.

What are the next steps?

SCP is reaching out to the County Boards of Supervisors in Sonoma, Mendocino and Lake Counties to introduce the GeoZone concept and seek their participation in exploring geothermal opportunities. By joining the GeoZone, the counties would be asked to enter into discussions to review SCP's technical findings and help narrow the geographic focus areas as well as the technologies to explore. GeoZone counties would also be asked to sign letters in support of federal or state grants and supportive policies, and continue meeting to explore if and how to best develop new local resources.

Early in 2022, SCP will be releasing a Request for Information (RFI) to potential development partners and use the responses to the solicitation to further inform the potential for success of the GeoZone. SCP will include current operators of the Geysers in the solicitation.

While it is still a bit speculative at this early stage, SCP is researching whether a public-private partnership would be prudent to maximize the value of tax credits and take advantage of technical capabilities.

Through the GeoZone, SCP will facilitate networking between administrative and planning staff of member counties to foster collaboration and build organizational capability on geothermal development. Initially, this organization will be focused on evaluating geothermal technologies that are compatible with the local community. However, this partnership can extend beyond geothermal development to include other energy projects and enhancements to regional infrastructure.

SCP staff would consider targeted advocacy at the CPUC and CAISO for plans and rulings that could further enable development of local geothermal resources. This could include engagement in the Integrated Resource Plan proceeding, the Transmission Planning Process, and the interconnection enhancements stakeholder initiative.

SCP, along with its partner counties might eventually consider facilitating a programmatic EIR that defines the GeoZone formally and addresses the potential programmatic environmental impacts of geothermal development within the GeoZone. We could also institute a best practices forum in the GeoZone to allow private and public partners to share lessons learned in permitting, exploration, development, and stakeholder engagement to improve the success of development in the region.

What role will member Counties play in decision-making and project development?

Member counties will govern the approval process for any projects in their jurisdiction. In advance of any project proposal, participating Counties would be expected to provide advance direction on the compatibility of proposed technologies and development concepts with their communities. SCP expects that early involvement in the process would improve the chance of partnering with a private entity that can design projects that can successfully navigate the permitting process and garner local support.

Once a specific project is proposed in the GeoZone, counties will retain their statutory authority to evaluate and approve required permits. If a programmatic EIR is pursued, counties will be integrally involved in the design and approval of the requirements for compliant projects.

In the Lake County Board of Supervisors meeting on November 2, the Board expressed an interest in having strong control over any projects located in Lake County and suggested

gaining a seat on the SCP Board as a means of doing so. In reflecting on this request, both staff and the Board of SCP think that a single seat on the SCP Board would not provide Lake County with much ability to steer SCP decisions (it would be one vote among 12 Directors) and would place Lake County into an unusual situation of making rate decisions for Sonoma and Mendocino Counties, among other votes. An alternate proposal SCP advances here is this:

1. Agree that any projects in Lake County must be specifically reviewed and approved by Lake County.
2. Agree that throughout the entire feasibility process and exploration, Lake County staff and the Board of Directors will be active participants to the extent that the area being explored is located in Lake County.
3. Agree that any negotiations for community benefits actively involve and ultimately require the approval of Lake County for projects within Lake County.

References

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