REPORT ON THE STATE OF GEOTHERMAL ENERGY IN CALIFORNIA

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PREFACE

As California proceeds to implement its Climate Change Action Plan to mitigate and reduce carbon emissions, and coordinate initiatives between the California Air Resources Board, the California Energy Commission, and the California Public Utilities Commission, it should consider geothermal power as a viable, cost effective, and plentiful renewable energy option to meet these goals.

Geothermal power has historically played a large role in California's renewable power mix. However, mistaken perceptions about the geothermal resources in the state and their value for achieving the state's goals have stymied further growth.

To assist California in achieving carbon reductions with the least total cost and highest power system reliability, GEA has prepared this Report on the State of Geothermal Energy in California. It is intended to be a resource document for the Governor and the various state agencies involved in the Climate Change Action Plan. Geothermal power can be a significant part of the California vision that "economic prosperity and environmental sustainability are one and the same."[1]

In brief, this status report shows that:

- geothermal power generated 4.4% of total system power in California in 2012, but could have generated substantially more;
- geothermal power produces some of the lowest life-cycle emissions when compared to almost every other energy technology and even some renewables;
- depending on the resource characteristics and plant design, geothermal power plants can be engineered to provide firm and/or flexible power;
- even with high upfront capital costs, geothermal power is a competitive renewable energy source;
- about half of California's identified geothermal resources are still untapped, and significant resources may remain undiscovered;
- geothermal power is key to achieving an expanded renewable power portfolio at the lowest total cost;
- new technology will reduce geothermal power risks and can expand the supply curve to make more resources commercially available;
- the Salton Sea Known Geothermal Resource Area (SSKGRA) is considered by many to be the best opportunity for growth in California in the near term;
- distributed generation geothermal power and heating projects have potential in a number of areas, but are not eligible for the type of support provided other distributed generation projects;
- challenges to growth of utility scale plants include weak demand, inadequate transmission, permitting delays, and a lack of coordinated policies.

GEOTHERMAL POWER'S ROLE IN REDUCING EMISSIONS IN CALIFORNIA

In 2012, geothermal power generated 4.4% of total system power in California but could have generated substantially more. California's unique geology contains a significant amount of geothermal resources that can provide renewable, firm, and sometimes flexible power to the state's power grid. Not only does geothermal power have one of the smallest land footprints[2] of almost any other energy technology, geothermal power releases very little greenhouse gas emissions. More specifically, binary plants produce near-zero GHG emissions while flash and dry steam plants represent a significant reduction compared to fossil fuel based generation.[3]

NREL found geothermal power produces some of the lowest life-cycle emissions[*] when compared to almost every other energy technology and even some renewables. Binary power plants emit only 5.7 g/kWh of greenhouse gas emissions (GHG), as opposed to 8 g/kWh for Wind, 38 g/kWh for Photovoltaic, and 537 g/kWh for Natural Gas Combined Cycles. Only hydro had a lower rate than geo power at 5.4 g/kWh. In layman's terms, California binary plants average 5.7 grams of greenhouse gasses for every kWh of electricity they generate when factoring all aspects of constructing and running a power plant including fuel production, fuel use, fuel cycle, and plant cycle. Binary power plants are a closed loop system which prevents emissions.[4]

Since Flash and Dry steam plants do not use completely closed loops, GHG calculations for these plants were 126 g/kWh. However, these were still considerably lower than fossil fuels like natural gas or coal. Most of these emissions came from the steam itself. While EGS projects were found to be a considerably emissions-free form of energy emitting only 28 g/kWh.[5]

In addition, geothermal power plants may be engineered to provide both firm and flexible power. Several roles historically performed by emission-heavy fossil fuels, such as baseload, regulation, load-following, and reserve functions typically reserved for coal and/or natural gas plants are easily filled by geothermal power. Like coal or natural gas, geothermal power can provide a range of services including but not limited to baseload, regulation, load following or energy imbalance, spinning reserve, non-spinning reserve, and replacement or supplemental reserve.

The environmental advantages over dirty energy sources and the ability to imitate these energy sources functions in the grid align geothermal power to be the perfect substitute for fossil fuels. The California Air Resource Board (CARB) stated in the October 2013 discussion draft of its, "Climate Change Scoping Plan First Update,"

> "Looking beyond 2020, California will need to continue to transform the energy sector with wholesale changes to its current electricity and natural gas systems. Developing a near zero emission strategy for the energy sector will require efficient next-generation technology; vast new low carbon generation resources; a robust transmission and distribution infrastructure; and carbon capture, utilization, and sequestration for the remaining fossil generation."[6]

In addition, CARB has stated their long-term goals of (1) "Determine the 1990 GHG emission level to serve as the 2020 emission limit" and (2) "Maintain and continue GHG emission reductions beyond 2020."[7]

[*] Life cycle emissions estimate the greenhouse gas emissions over the entire lifespan of a project. More specifically, it tracks relevant environmental burdens from product cradle to grave including the extraction of raw materials from earth, product manufacture, use, maintenance, and end-of life disposition.

Lastly, even with high upfront capital costs, geothermal power is a competitive renewable energy source. The absence of fuel costs and other variable costs over the long 50+ year project life span give geothermal power the lowest levelized cost ($89.6/MWh) of any renewable energy technology with the exception of wind power (at $86.6/MWh; 3% less).[8]

Geothermal power is a clean, firm, and sometimes flexible power source that can accomplish California's climate goals. The state has a plethora of geothermal resources that are commercially feasible with existing technology and prevailing market conditions.

THE VALUES OF GEOTHERMAL ENERGY: FIRM AND FLEXIBLE POWER

California's future power grid will need flexible power because electricity market participants are concerned that the increased presence of variable energy resources without flexibility means the current system will not be sufficient to meet the reliability needs of California's power system. For example, the California Independent System Operator (CAISO) expects 12,079 MW of flexible resources to be retired by 2020 and the risk of power shortages is unacceptably high without flexibility.[9] CAISO expects that with the addition of new, non-firm renewable resources coupled with the retirement of existing plants, there will be a much greater need for flexible power resources.

In addition, firming power will be necessary to balance out the variability caused by these same renewables. For example, a recent white paper and a letter to public officials from the Western Electrical Industry Leaders Group (WEIL), described some of the frustrations photovoltaic variability causes to power system operators. Since photovoltaic generation power output is variable, it injects power at various points along electric distribution lines and increases the voltage of the distribution lines at the point of interconnection. The output can change significantly over short periods of time due to environmental conditions like cloud movement and fog burn off.[10]

Under the right circumstances and resource characteristics, geothermal power plants can be engineered to be a renewable, flexible power source capable of providing the grid support service CAISO estimates will be necessary by 2020 and beyond while acting as a firming resource to balance out variable energy resources.

E3, a consulting company that specializes in North American electricity markets, released a study in January 2014, sponsored by a number of utility companies that provide power in California. The study asked, "What are the operational challenges of integrating sufficient renewable resources to achieve a 50% RPS in California in 2030?" Several scenarios in the study show that as the integration of intermittent solar resources increases to meet a 30%, 40% or 50% RPS requirement, a threshold is reached where substantial overgeneration raises electricity rates. E3 found of the scenarios they analyzed, the lowest-cost electricity to consumers is a 50% RPS portfolio with a diversity of renewable resource technologies (including more geothermal resources) and the highest-cost to electricity consumers is a portfolio that relies extensively on rooftop solar photovoltaic systems.[11]

One of the most important implications from the E3 study is that the value and importance of geothermal power as a flexible and baseload resource need to be reflected in today's policies and pricing. The E3 study shows, there are costs to using intermittent resources to meet baseload power demand that are not now being recognized, and conversely the values of using baseload geothermal power to replace retiring baseload facilities are not properly valued either. In particular this result should be a concern to CARB as it seeks to address emissions reductions related to the 9,716 GWh of coal power imports from surrounding states.[12]

In order to ensure that California's power grid is a balanced system that operates without raising electricity rates a diverse portfolio of resources that includes geothermal power is absolutely necessary.

CALIFORNIA GEOTHERMAL RESOURCES FOR POWER AND DISTRIBUTED GENERATION

Not only can geothermal power provide significant value to California but there are substantial amounts of untapped resources. According to the information provided by mean estimate of Lovekin et al., about half of California geothermal resources are still untapped (Table 1). This estimate was determined for up to 3 kilometers deep using guidelines and standard industry protocol for making geothermal resource estimates as determined by USGS Circular 790.

These are all resources that are identified and extracted legally at costs competitive with other commercial energy sources at present. Table 1 lists the known geothermal fields throughout California, their current installed capacities, and estimated total generation capacity for 30 years with minimum certainty, most likely certainty, and mean certainty.

Notice two fields (Heber and the Geysers) already exceed their most likely certainty. Since these estimates were derived from probabilistic heat-in-place estimates it is possible to exceed the estimated reserves.

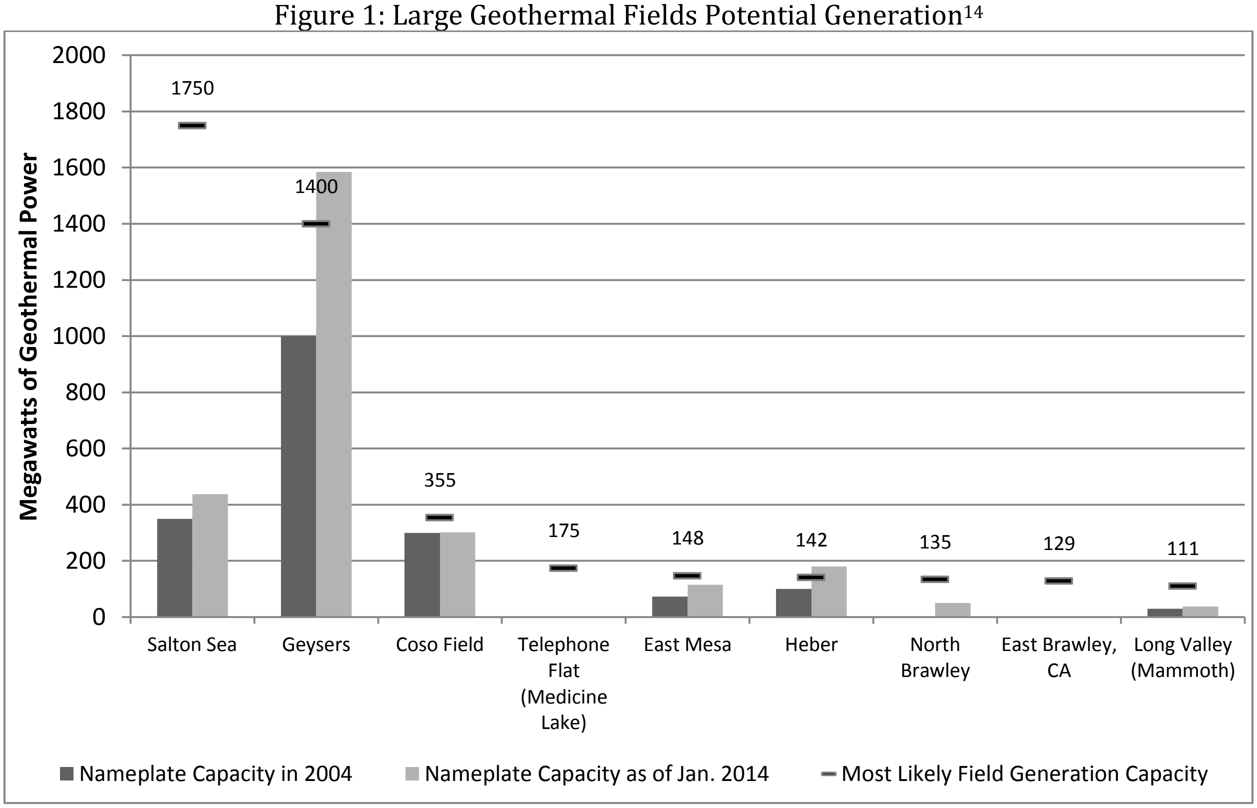
Table 1: California Geothermal Power Resource Estimates by Field[13]

Fields and their Installed Capacities				Lovekin et al. Estimates		
California Geothermal Fields	County	Nameplate Capacity in 2004	Nameplate Capacity as of Jan. 2014	Min. Certainty	Most Likely Field Generation Capacity	Mean
Salton Sea	Imperial	350	437	1350	1750	1880
Geysers	Lake-Sonoma	1000	1585	1200	1400	1400
Coso Field	Inyo	300	302	246	355	490
Telephone Flat (Medicine Lake)	Siskiyou	0	0	110	175	256
East Mesa	Imperial	73	115	119	148	167
Heber	Imperial	100	180	109	142	158
North Brawley	Imperial	0	50	88	135	144
East Brawley, CA	Imperial	0	0	85	129	138
Long Valley (Mammoth)	Mono	30.1	37	70	111	148
Niland	Imperial	0	0	59	76	92
South Brawley	Imperial	0	0	45	62	70
Randsburg	San Bernardino	0	0	32	48	82
Sulphur Bank	Lake	0	0	27	43	61
Lake City/Surprise Valley	Siskiyou	0	0	23	37	49
Fourmile Hill (Medicine Lake)	Siskiyou	0	0	25	36	70
Calistoga	Napa	0	0	17	25	35

Mount Signal	Imperial	0	0	12	19	29
Dunes	Imperial	0	0	7.4	11	18
Superstition Mountain	Imperial	0	0	6	10	15
Honey Lake	Lassen	6.4	3.8	5.7	8.3	13
Glamis	Imperial	0	0	4	6	11
Sespe Hot Springs	Ventura	0	0	4	5	8
TOTAL		1860	**2710**	3644	4732	**5334**

California has just begun to tap into its geothermal potential. All of the sites in the Figure 1 below, with the likely exception of Heber field and the Geysers, still have a significant amount of untapped potential for power generation. The most obvious of these is the Salton Sea area in Imperial County. This area's unique geology created the perfect circumstances for hot geothermal fluids to seep to the surface to generate power. A range of estimates of this geothermal field's capacity is between 1,700-2,900 MW.†

Figure 1: Large Geothermal Fields Potential Generation[14]



The USGS in 2008 (Figure 2) assessed the electric power generation potential of conventional geothermal resources in 13 western U.S. states and identified 241 moderate-temperature (90 to 150°C) and high-temperature (greater than 150°C) geothermal systems located on private or accessible public lands. Their estimate for the state of California is depicted below. The USGS study used a similar volumetric method as the GeothermEx study but with broader assumptions, such as deeper resources, newer technologies, etc. and estimated close to 5,000 MW of identified resources

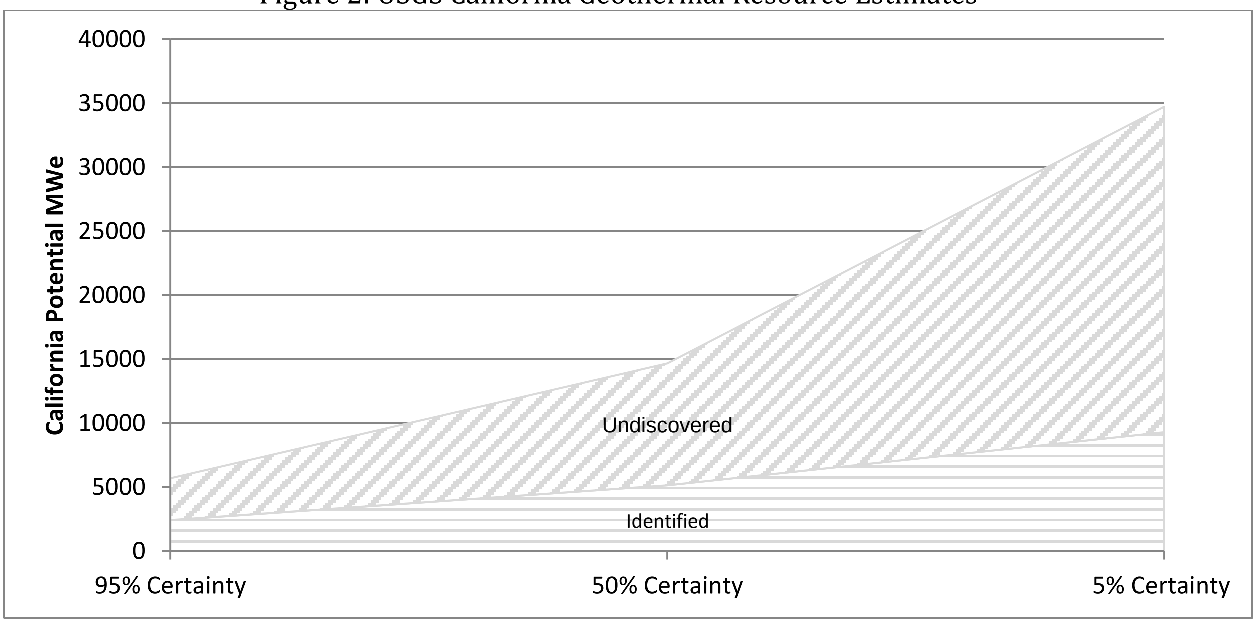
† See Lovekin et al. 2004 and EES Consulting 2013

and 11,000 MW of unidentified resources with mean certainty.[15] Overall, the main conclusion to draw from both these studies is there is a substantial amount of economical and untapped conventional hydrothermal systems that have not been developed in California.

As the technology and techniques to tap hidden or undiscovered geothermal systems improves, the risk of developing these hydrothermal systems declines. As a result, the amount of geothermal resources that can be developed increases, effectively expanding the geothermal supply curve. Current estimates from Department of Energy suggest up to 30 gigawatts of undiscovered geothermal resources exist in the U.S. [16]

Table 1 also shows potential for small size community geothermal power projects in smaller fields around the state. According to a report submitted to the California Energy Commission in 2012, there are 71 communities in the state that could benefit from such projects.[17] In general, these involve smaller fields that might not be economical or have the capabilities to be developed into large utility-scale power plants however, they are the perfect size for distributed generation and community based projects that generate power at 1-2 MW or less. Despite the normal barriers any geothermal power project faces such as high upfront capital costs, risks associated with exploration and drilling, and operational risks, these smaller projects face additional barriers based on the current legislative framework promoting distributed generation. For example in Northern California, where there is particular interest in developing these projects, smaller geothermal power projects do not qualify for incentives provided other distributed generation technologies. They may be too large to qualify for net metering, involve both heat and power, and are not eligible for the roughly $3 billion of incentives provided under the California Solar Initiative.

Figure 2: USGS California Geothermal Resource Estimates[18]



<u>NEAR TERM POTENTIAL – PROJECTS UNDER DEVELOPMENT IN CALIFORNIA</u>

From first inception to operation, the timeline for a geothermal project in the U.S. ranges about 4-7 years and affected by the knowledge of the resource, type of project, ease of obtaining financing and the permitting process. So for a plant to be operational by the end of the decade, it would need to have already taken some steps toward completion. As of April 2013 there were an estimated 32 geothermal power projects in some stage of development throughout California. With the right incentives and power purchase agreements many of these projects could be operational by 2020.

Table 2: California's Developing Geothermal Projects by Name, Developer, and County (2013)

Project Name	Developer	Planned Capacity Addition (MW)	Project Type	County Located	Project Development Status
Buckeye	Calpine	30	CH (Produced)	Sonoma	N/A
Four Mile Hill	Calpine	N/A	CH (Unproduced)	Siskiyou	N/A
Telephone Fiat	Calpine	N/A	CH (Unproduced)	Siskiyou	N/A
Glass Mountain	Calpine	N/A	CH (Unproduced)	Siskiyou	N/A
Wild horse North Geysers	Calpine	30	CH (Unproduced)	Sonoma	N/A
Bottle Rock Expansion	Bottle Rock Power	25	CH (Expansion)	Lake	Phase 1
Northern California	Gradient Resources	N/A	CH (Unproduced)	N/A	Phase 1
NAF El Centro/Superstition Hills	Navy Geothermal Program	N/A	CH (Unproduced)	Imperial	Phase 1
East Brawley	Alternative Earth Resources	N/A	CH (Unproduced)	Imperial	Phase 1
Orita 2	Ram Power	49.9	CH (Unproduced)	Imperial	Phase 1
Orita 3	Ram Power	49.9	CH (Unproduced)	Imperial	Phase 1
Surprise Valley	Enel North America	15	CH (Unproduced)	Modoc	Phase 2
Hudson Ranch Power II	EnergySource	49.9	CH (Unproduced)	Imperial	Phase 2
NAF El Centro/Superstition Mountain	Navy Geothermal Program	N/A	CH (Unproduced)	Imperial	Phase 2
MCAS Yuma Chocolate Mountains/Hot Minearl Spa	Navy Geothermal Program	N/A	CH (Unproduced)	Imperial	Phase 2
MCAS Yuma Chocolate Mountains/Glamis	Navy Geothermal Program	N/A	CH (Unproduced)	Imperial	Phase 2
Truckhaven	Alternative Earth Resources	30	CH (Unproduced)	Imperial	Phase 2
HV	Oski Energy	N/A	CH (Unproduced)	N/A	Phase 2
KN	Oski Energy	N/A	CH (Unproduced)	N/A	Phase 2
KS	Oski Energy	N/A	CH (Unproduced)	N/A	Phase 2
Orita 1	Ram Power	49.9	CH (Unproduced)	Imperial	Phase 2
Keystone	Ram Power	50	CH (Unproduced)	Imperial	Phase 2
New River	Ram Power	50	CH (Unproduced)	Imperial	Phase 2
Black Rock 5-6	CalEnergy	235	CH (Produced)	Imperial	Phase 3
Black Rock 1-2	CalEnergy	235	CH (Produced)	Imperial	Phase 3
Canby Cascaded Geothermal Development Project	Canby Geothermal, LLC	0.05	CH (Unproduced)	Modoc	Phase 3
Lower Klamath Wildlife Refuge	Entiv Organic Energy	5	CH (Unproduced)	Siskiyou	Phase 3
Wister - Phase I	Ormat Technologies	30	CH (Unproduced)	Imperial	Phase 3
CD4 (Mammoth Complex)	Ormat Technologies	30	CH (Unproduced)	Mono	Phase 3
Geysers Project	Ram Power	26	CH (Produced)	Sonoma	Phase 3
Bald Mountain	Oski Energy	N/A	CH (Unproduced)	Sonoma & Napa	Prospect

Wendel Expansion	Oski Energy	N/A	CH (Unproduced)	Lassen	Prospect

CHALLENGES TO FURTHER GROWTH

A large barrier for geothermal development in California is not so much that change to existing legislation is necessary, but that existing authority needs to be used to drive demand for a diverse portfolio of renewable resource technologies. California should address the unique needs of each energy technology to build the most efficient and lowest cost portfolio of resources while achieving the goals of A.B. 32. Unfortunately, demand for new geothermal projects has stalled due in part to the reasons listed below. The subsequent section goes into substantial detail as how these barriers relate to one of the biggest opportunities for growth for geothermal power in California, the Salton Sea Area. The Imperial Irrigation District (IID) has announced plans to develop 1,700 MW of new geothermal generation from the Imperial Valley resource as part of Salton Sea Restoration Initiative.[19]

There are four main challenges to the growth of conventional hydrothermal power in California:

1. There is weak demand for new projects. Developers have geothermal leases and tracks of land ready and available for development stuck in early phases of development because they cannot find the necessary power purchase agreements required to advance these projects (Table 2).
2. Inadequate transmission infrastructure or a mismatch between available transmission and the location of geothermal resources.
3. Permitting delays often hinder a project adding to an already lengthy development timeline and raising costs.
4. The lack of coordination between stakeholders. For example, utility power solicitations that require transmission not coordinated with transmission planning efforts.

Often one of the biggest struggles to build a geothermal power plant in the western states is the availability and capacity of nearby transmission. Unlike other energy technologies geothermal power plants are particularly location specific since they must be near or around a geothermal resource. Therefore, adequate and local transmission capacity is an essential ingredient for any geothermal power project.

Geothermal power will often use transmission more economically than most other energy resource because of its high capacity factor. A geothermal power plant's average capacity factor is 92%[20] while a variable energy resource (VER) might have a capacity factor of 20-34%.[21] Therefore, a 100 MW VER needs to consume 100 MW of transmission even though the VER may seldom use the full capacity of that line. As a result existing transmission capacity becomes unavailable to other generators. Geothermal power on the other hand will almost fully use the transmission capacity that it reserves from that same line. For congested transmission lines, the integration of VER resources can raise costs as more transmission infrastructure is built to accommodate the same amount of power.

Geothermal companies reported to GEA at the end of 2013 congestions at state interties listed below hinder their ability to develop geothermal projects and import/export electricity from/to other states:

- Pacific AC intertie (Oregon/Washington/Canada)
- Pacific DC intertie (Oregon/Washington)
- Intermountain DC Tie

- Desert Southwest Interties (Arizona)
- Transmission Station at Mead (Nevada)

And within California, geothermal companies find there is a shortage or inadequate transmission lines to transport electricity to the rest of the state at the following geothermal resource areas:

- Lake City-Surprise Valley (Siskiyou County)
- Mono-Long Valley (Mono County)
- Salton Sea (Imperial County)
- South Brawley (Imperial County)
- East Brawley (Imperial County)

THE SALTON SEA: AN UNDERUTILIZED GEOTHERMAL RESOURCE AREA

The Salton Sea Known Geothermal Resource Area is widely considered by many geothermal industry leaders as the best opportunity for growth in California in the near term. Imperial Irrigation District forecasts estimate 2,900 MW of geothermal generation is ultimately possible at the Salton Sea field (Table 3). Negative consequences to the lake's recession such as increased air pollution issues and further concentration of sea salts could hopefully be mitigated by the expansion of geothermal development. As the sea recedes, it will expose new lands and provides access to prime undeveloped geothermal resources. A total of 2,900 MW of technical potential is estimated of identified geothermal resources. Table 3 depicts the resources underwater and by temperature gradient that will become available and those that are currently onshore.

Table 3: Salton Sea Resource Estimates[22]

Imperial Irrigation District's Estimation for Generation Potential in the Salton Sea			
Gradient Onshore/Offshore Total	**Onshore**	**Offshore**	**Total**
>10°F	700	1400	2100
8-10°F	540	260	800

IID believes the resource at Salton Sea can be developed on the timeline presented in Table 4 assuming that the blanket permitting will be completed in a timely manner, adequately priced power purchase agreements will be available, and capital funding requirements can be met by a developers and government sources.

Table 4: IID's Proposed New Generation Online Schedule [Megawatts][23]

Year	>10°F Generation	8 to 10°F Generation	Cumulative Generation	Generation on IID Lands
2016	200		200	100
2018	200		400	100
2020	200	50	650	200
2022	200	50	900	200
2024	200	50	1150	200
2026	200	50	1400	150
2028	200		1600	150
2030	200		1800	50
2032	200		2000	50

However, before this growth can begin there are a number of barriers that must be overcome at the Salton Sea resource area, mostly related to a shortage of transmission, a lack of power purchase agreements, weak demand, and a stringent permitting process.

Geothermal developers report to GEA that one of the most significant impediments to new projects moving forward in Imperial Valley is the lack of transmission capacity. In fact many developers who are not actively involved in the region would like to be but are prevented from developing projects because of inadequate transmission infrastructure to transport generated electricity elsewhere.

The IID has realized the lack of adequate transmission is a significant barrier to the Salton Sea resources moving forward. Jointly, with the California Independent System Operator, they propose a new 500 kV transmission line to provide transmission capacity for new geothermal power development at the receding Salton Sea and surrounding area. IID states,

> "When completed, the new transmission line could handle an estimated 2,500 MW of new generation plus provide other utilities access to the Imperial Valley renewable resources. The proposed line is 150 miles long and would connect to the main grid at Devers substation. The cost of a 500 kV line is estimated to range from $2-4 million per mile."[24]

New transmission would allow geothermal project developers to interconnect to the statewide system. According to IID, the cost of the new transmission line could be recovered using California Public Utility Commission (CPUC) Transmission Revenue Requirement (TRR) rules and can be financed using a merchant transmission company. As such, the process for developing a transmission line of this size would require some certainty as to cost recovery through approved rates. In order to encourage transmission line investments, the IID suggests that the state help streamline renewable project development or reduce the cost of funding for private developers.

In addition the California Energy Commission (CEC) recognized issues with transmission at the Salton Sea in their 2013 Integrated Energy Policy Report. CEC stated,

> ". . . the Energy Commission will continue to evaluate the barriers to renewable energy development at the Salton Sea. This evaluation includes, but is not limited to, the concerns of geothermal developers and the need for transmission in the Salton Sea area. As agency and stakeholder resources become available, it may be possible to initiate foundational work on renewable energy generation and associated transmission facility development."[25]

The second barrier for geothermal development in the region is a deficit of available power purchase agreements to move projects forward. In particular, the power purchase agreements need to recognize the value that geothermal power brings to the system as firm or possible flexible power. And, to help provide new power purchase agreements that the IID has proposed in its latest report,

> ". . . the CPUC and State of California designate a portion of future state energy purchases as coming from Imperial Valley renewables. Pricing and capacity needs would be known and could be allocated to developers based on land parcels. Similar to the transmission line funding proposal, IID could ask the state to offer loan guarantees to renewable project developers or to loan funds at low interest rates. These solutions would allow developers access to lower cost financing which is

> currently only available to public entities. Changing PPA procedures, and reducing the cost of money, would reduce the cost of power from these projects by lowering the cost of equity and reducing risk of project."[26]

Lastly, the abundance of resource at the Salton Sea implies that many projects might be larger than 50 MW. In California all new projects 50 MW or greater will require review and approval by the California Energy Commission (CEC). As the lead agency, the CEC will issue the final permit to build a power plant. As the Salton Sea recedes over the next few decades, any development in the new land areas will face difficult permitting requirements. The IID proposes a blanket environmental study of the area. This proposal could significantly reduce the time required to meet the California Environmental Quality Act (CEQA) and make it a joint effort to permit the plants and improve air quality and wildlife habitat. If this suggestion comes to fruition, not only will it help to reduce the timeline of a project developing in the region, but as a consequence reduce costs and riskiness of project.

Risks and Past Practices to Address Risks

The processes and timelines for geothermal development are notably different from most if not all other energy technologies. As a result, in the public forum, geothermal power is often grouped in with the other major types of renewable energy and then frequently misconstrued as having similar risks and economics. In reality, the risks and economics of geothermal are unique. In geothermal power projects about a third of project costs are associated with drilling and exploration alone. There is a spectrum of development strategies used to lessen the risks associated with initial exploration and drilling caused by geothermal power development although most programs focus on tackling the drilling and exploration risks including some in California. Notably, programs to reduce geothermal development risks expand the geothermal supply curve to make available more commercial resource and reduce total costs.

The California Legislature established the Energy Commission's Geothermal Grant and Loan Program in 1980. This program (also known as the Geothermal Resources Development Account, or GRDA), distributes funds to promote the new geothermal technologies and projects. GRDA funds are derived from royalty and lease payments made to the U.S. government by geothermal developers operating on federal land in California. Financial assistance is provided to private and public entities for geothermal research, development and commercialization projects. Since 1980, the Geothermal Program provided funding for over 174 geothermal research, development, and demonstration projects. Additional geothermal program support comes from the California Energy Commission itself, which is funded via a levy on the electricity bills of all Californians.[27]

Conclusion

California contains several thousand megawatts of geothermal resources that could provide renewable, firm, and possibly flexible power to the state's power grid. Estimates predict only about half of the state's identified geothermal resources are generating power today.

These geothermal resources will be crucial for meeting California's climate and environmental goals. Not only do geothermal plants have one of the smallest land footprints of almost any other energy technology, but geothermal generation releases very little greenhouse gas emissions. California's grid will need a firm and flexible power source in order to reach its climate goals. The lowest-cost electricity to consumers is a power system composed of a diverse portfolio of renewable energy resources that includes geothermal generation. However, before geothermal development can be expanded in California, help is needed to construct new transmission that will allow geothermal project developers to interconnect to the statewide system. More specifically, new transmission at the Salton Sea would significantly expand the geothermal resources available for development.

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