

## **Summary and Recommendations from the Staff Workshop Entitled Identifying Research Priorities on Flexibility and Other Operational Needs for Existing Geothermal Power Plants: A Pre-Solicitation Workshop**

### Summary and Recommendations

On January 28, 2016, California Energy Commission staff held a workshop entitled “Identifying Research Priorities on Flexibility and Other Operational Needs for Existing Geothermal Power Plants: A Pre-Solicitation Workshop”.<sup>1</sup> The purpose of this workshop was to seek public input regarding research priorities for geothermal power. This information will be used to help staff draft a solicitation that will include a geothermal research component. The workshop included several presentations and a panel discussion.<sup>2</sup>

The main recommendations and points made by the panelists are as follows:

#### Flexible Generation

- To improve flexible geothermal power at the Geysers, there is a need to study the life of wells, corrosion issues, and uncertainty about other effects on the equipment and resource.
- In the Salton Sea area, flexibility is prevented by the scaling issue. The brine is also very corrosive, requiring titanium or stainless steel wells and piping which is very expensive.
- Binary and combined cycle geothermal plants can already operate flexibly, even more than natural gas facilities. Lower temperature resources are easier to operate flexibly.
- The market does not adequately compensate geothermal power plants for operating flexibly. The value of flexible operation needs to be quantified.
- Adapting existing geothermal plants is not economically feasible. The cost of adapting geothermal plants that were designed for baseload generation is high and there are uncertainties about potential damage to the facility from running in flexible mode.
- California needs more baseload geothermal as well as flexible.

#### General R&D

- Borrow techniques and technologies from the oil and gas industry and adapt them to the geothermal industry (e.g., drilling techniques, subsurface exploration technologies).
- Enhanced geothermal systems have potential.
- Binary geothermal power systems that don’t use water are a commercial, proven technology that can utilize lower temperature resources. These lower temperature resources are not fully identified in California.
- There is a need for better techniques to quantify resources and reduce risk.
- There is a huge potential for geothermal power in California.

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<sup>1</sup> Please see Appendix A for general workshop information including time and date, location, and list of attendees.

<sup>2</sup> Please see Appendix B for a link to workshop documents including public notice, agenda, and presentations.

## Regulations/Market Conditions

- Least-cost, least-cost has been the prevailing methodology guiding valuations. It considers how cheap the power source is and neglects to consider true integration costs. We need to use a true least-cost, best-fit methodology which considers true integration costs. True integration costs need to include all the values such as jobs, tax revenues, grid stability, independence from fuel volatility, and impact on communities.
- Changes in contracting could be a game changer. Existing power purchase agreements don't fully value the many benefits already provided by geothermal power, which intermittent renewables do not. Some examples of these benefits are auxiliary services, grid stability, reliability, and in some cases flexibility.

## Workshop Details

The staff presentation focused on state energy policy drivers, a background on Energy Commission funding programs for geothermal power, and some brief highlights of past and current geothermal projects funded through the Energy Commission. A presentation was also given by Julio Garcia from Calpine Corporation regarding operational flexibility of geothermal power.

A moderated discussion took place with expert panelists. These panelists were from a variety of professional backgrounds within the geothermal industry and are listed below.

Moderator: Rizaldo Aldas, California Energy Commission

Panelists: Steve Ponder, Geothermal Resources Council

Julio Garcia, Calpine Corporation

Josh Nordquist, Ormat Nevada Inc.

Randy Keller, CalEnergy Operating Corporation

John Muir, GreenFire Energy Inc.

Andy Van Horn, GreenFire Energy Inc.

Panelists were given a series of questions ahead of time meant to spur discussion regarding current research needs for geothermal power. After the panelists provided introductory remarks with slide presentations, the discussion was initiated. Each question and the panelists' responses are summarized below.

*Question 1: What are the main barriers and opportunities to operating geothermal power plants in flexible or load following mode? What are the main operational and maintenance cost drivers of geothermal power plants running in flexible or load following mode? What research and development activities should be conducted to address these barriers and cost drivers?*

- Comments from Julio Garcia:
  - The cost of repairing wells and pipelines is a barrier.
  - Existing facilities that were designed for baseload operation will need to be altered at a significant cost.
  - We need to understand the impact of thermal cycling and stresses on the equipment and the impact on seismicity.
- Comments from John Muir:
  - A modular architecture will allow for a much finer control of output.
- Comments from Andy Van Horn:
  - How will flexibility be paid for? Is flexibility worth it? Current markets are probably not sufficient.
  - Geothermal has advantages in terms of fuel security that natural gas doesn't have.
- Comments from Steve Ponder:
  - Flexible geothermal is not a new concept. Curtailment of geothermal has been going on for a while but it needs compensation.
  - The association supports the idea of studying baseload and flexible generation. Prices for flexible and baseload power needs to be quantified and we need to understand the costs. Flexible geothermal generation is missing the financial incentives to move forward.
- Comments from Randy Keller:
  - In the Salton Sea region, the geothermal brine is very corrosive and contains high concentrations of dissolved solids. All the wells and piping have to be titanium or stainless steel which costs about 10 times more than the production piping that everyone else is using.
  - It would be very difficult to load follow because of the scaling issue. Their well assessment says in regards to load following that they can cycle a well 25 times in the life expectancy of the well. It would take a great deal of R&D to get to the point of load following.
- Comments from Josh Nordquist:
  - Binary and combined cycle power plants can operate in flexible mode without issue. Lower temperature resources are easier to make flexible. Some areas have unique resource conditions that may prevent or limit their flexibility.

- Adapting existing systems is difficult but building new systems that can operate flexibly is easier. Adapting existing plants is not the answer. In addition to the need for more flexible resources, California needs more baseload geothermal to get to the RPS goal. We need to look into *new* facilities.
- Integration costs need to be included when evaluating costs and values.

Question 2: *What other operational issues are limiting the success of geothermal power plants and what research and development activities should be conducted to address these issues?*

- Comments from Julio Garcia:
  - There is a need to study corrosion issues and find a way to expand the life of wells.
- Comments from John Muir:
  - Many plants are not operating at full capacity either by not reaching nameplate capacity from the start or by suffering from declining production. One reason for this is from fractures closing up or not finding enough new fractures. We should look at how to use more of the resource that is already there.
  - Water is becoming an increasingly critical resource in California. The ability to expand geothermal production when water is scarce needs to be addressed.
- Comments from Andy Van Horn:
  - He's concerned with transmission grid issues. Will there be transmission congestion issues during certain times of the day due to all the new renewable power added to the grid?
- Comments from Steve Ponder:
  - Risk associated with wells and the reservoir due to flexible operation needs to be assessed.
- Comments from Randy Keller:
  - The Salton Sea does not have a declining resource.
  - Geothermal power is already successful. It's a mature technology. They are about 90% renewed on their expiring contracts.
  - Market conditions have changed. Geothermal values are not being recognized in today's market.
- Comments from Josh Nordquist:
  - Geothermal is unique in that when developing geothermal you pay for a lifetime of fuel upfront. It requires a lot of capital to be spent in the front end of the project to secure it for a lifetime. This also brings extra value. From the first day a plant is running, it can essentially sell electricity for the same price indefinitely.
  - For flash or steam plants to operate in a flexible manner they need the extra value to support a new plant design.

- Studies show that their binary and combined cycle facilities can provide auxiliary flexible services like ramping, better than natural gas facilities.
- Most geothermal plants in Nevada are binary or combined cycle units that are air cooled and don't use water. It's a commercial, proven technology but there is work to be done in California to identify lower temperature resources so they can be utilized by existing binary technology.

*Question 3: What specific geothermal generation technologies or enabling technologies have significant potential to succeed in the California market and why? What further research and development is needed, if any, to accelerate the market adoption of these technologies or strategies?*

- Comments from Julio Garcia:
  - Enhanced geothermal systems (man-made reservoirs created from resources that have heat but lack natural permeability and/or fluid) can provide added value.
  - Learn from the oil and gas industry to increase production and improve reservoir simulation techniques.
  - We need better techniques to quantify resources and reduce risk with the help of geophysical methods, geochemistry methods, or geothermometry.
- Comments from John Muir:
  - It is difficult to operate under the current pricing environment with a high capital cost item.
  - All the big costs are up front and there is a long project cycle time that can be derailed by a number of things. A technology that requires less capital up front, is more modular, and has less risk would be a better business model.
- Comments from Andy Van Horn:
  - R&D for electricity has declined over the last two decades. Spend money on R&D.
  - Pay attention to CPUC and CAISO and how terms like "least-cost, best-fit" which are imbedded in contracts, enable geothermal developers and expiring contracts to continue over the next 20-30 years.
- Comments from Steve Ponder:
  - Changes in contracting could be a game changer.
  - There is a need to come up with a value for what geothermal brings to the table. Intermittent sources don't contribute to auxiliary services. They need geothermal for system stability and other things geothermal can deliver.
- Comments from Randy Keller:
  - Other technologies can complement traditional geothermal and help with the bottom line but it will never replace it.

- Comments from Josh Nordquist:
  - Geothermal can provide many services, but there is hardly any value in grid support services from geothermal in the market today.

*Question 4: What is the current potential or opportunities for expanding power generation from geothermal and boosting its role in meeting California's renewable energy goals? What are the main barriers preventing more geothermal power from being added to the grid in California?*

- Comments from Julio Garcia:
  - The main thing preventing more geothermal development is the lack of proper valuation.
  - More is being demanded from the geothermal industry, creating a difficult environment.
- Comments from John Muir:
  - Move technology from oil and gas industry to geothermal industry.
  - We need to be more successful getting investors and consumers to recognize the value of geothermal.
  - There is a need to extract more heat from the resource and use it more efficiently.
  - The business model needs to be fixed and CPUC regulatory issues straightened out.
- Comments from Andy Van Horn:
  - New contractual methods are needed.
- Comments from Steve Ponder:
  - There is plenty of expansion potential at the Geysers and there are several 1000s of MW of potential in the Imperial Valley.
- Comments from Randy Keller:
  - In the 33% RPS world, true integration costs were not taken into consideration. “Least-cost, best-fit” didn’t happen; it was “least-cost, least-cost.” Several studies show we won’t get to 50% renewable without a balanced portfolio. That balanced portfolio will provide all the inertia and ancillary values that it needs to get to 50% renewable with a true least-cost, best-fit. True integration costs need to be considered; not time of use, subsidies, or incentives. True integration costs need to include all the values like jobs, tax revenues, and things not typically thought of. Geothermal power plants provide more jobs than other renewables.
- Comments from Josh Nordquist:
  - There is a huge geothermal potential in the state.
  - Geothermal needs to be valued appropriately.
  - CAISO’s integration with the west brings potential for the state to reach outside it’s borders to utilize more geothermal resources that can provide flexible capability.

Public question and answer and public comment sessions were held. The comments are summarized below.

- Comments from Meredith Younghein (CPUC):
  - The CPUC has ordered through the RPS proceeding that we need to look at integration adders for renewable resources and the effects of intermittent and variable resources on other resources that are providing balancing services.
  - The CPUC has been trying to better understand what resources are on the grid and their existing ramp rates. Even though it may not be contracted as a flexible resource, it's interesting to know that geothermal is physically capable of ramping fast.
  - Least-cost, best-fit reform is one of the issues highlighted in their staff whitepaper so it should be an area of focus for CPUC.
  - Encourages people to be involved in the LCBF current process in the RPS proceeding. The studies are mostly led by the utilities and diversity of opinions would benefit that process.
  - The CAISO market has not been providing sufficient compensation for flexible operation. These issues have only come up in the last couple years. Flexiramp is going to the board soon. The CPUC is interested in understanding how flexiramp will provide additional compensation to flexible resources and/or how it may fall short. A recent CPUC whitepaper discussed the increasing need for ancillary services in the future and that current compensation is potentially not proficient. She encourages everyone to be involved at CAISO.
  - Are the identified areas for new geothermal resources included in the new RPS calculator?
- Comments from Josh Nordquist:
  - Costs that have been illustrated in the RPS calculator are very elevated.
- Comments from Derek Benson (Energy Source):
  - Some of geothermal's "higher costs" can be attributable to state property tax policy, federal policy, or integration costs. They have to pay taxes that other renewables do not. It is an un-level playing field. The price of geothermal and the value of geothermal are two different things.
  - He recommends R&D into recovery of valuable coproducts and the economic and environmental benefits would come from that.
- Comments from Michael Erbes (Enginomix):
  - He recommends support for applied thermodynamic modeling such as steady state, transient, and operator training.

- Comments from Andy Horne (County of Imperial):
  - We need geothermal baseload power to help with GHG and RPS goals. Geothermal operates better as a baseload resource. There are things that can be done to make it more flexible or bring the costs down but it needs to be recognized that geothermal power has great benefits as it exists today. It is a proven technology, it's reliable, and it creates a lot of jobs and economic activity. We don't need to spend a lot of time figuring out how we need to change geothermal. If we're going to do that lets try to figure out how we can get solar to generate electricity at night.
- Comments from John Sisler:
  - He brings up the question of replacing green energy with more green energy and wonders if all the fuel-based baseload power providers are asked to ramp quickly like the Geysers has.
  - He asks if CalEnergy or the Geysers would benefit from sensors that can tell you what's going on down the well.
- Comments from Randy Keller:
  - Any additional information that would help them manage their downhole temperatures and flow rates would be welcome but it doesn't alleviate the scaling issue. They already know how fast it grows.
- Comments from Bill Harvey (Power Engineers):
  - Some other upgrade opportunities to further consider:
    - 1) Co-location of other technologies or industries to share infrastructure, capacity, or harness geothermal for purposes other than power (heating, industry, agriculture, fuel synthesis, mineral recovery).
    - 2) Better scale control/chemistry improvements to lower operating costs and open windows for fuller harvesting of the fluid (e.g. bottoming binary).
    - 3) Creative water use as an earlier speaker discussed - both conservation [air cooling] and enhanced cooling.
- Comments from Josh Nordquist:
  - The prevailing concern is resource management. They always want to make sure the resources are being managed to operate for the indefinite future.
- Comments from John Muir:
  - With respect to land use, geothermal is probably the most efficient in use of land per amount of power generated. Overall it's probably the most benign form of energy production with respect to the environment.
- Comments from Marc Rappaport (Rappaport Energy Consulting):
  - There is a great opportunity for hybrid solar thermal and geothermal systems to be added to the geothermal industry to manage the risk and bring forward zero emission power. Viable technical proof is now satisfied with the installation of 17 MW solar thermal on the 30 MW ENEL plant in Nevada.



- Comments from Josh Nordquist:
  - A geothermal solar hybrid is not exactly a hybrid. It generates geothermal and generates solar at the same time but as a combination they can solve some of the problems regarding load.
- Comments from Sierra Martinez (Natural Resources Defense Council):
  - Geothermal is a useful resource that we should follow in the other agency's proceedings.
  - We should be searching for renewable integration solutions including storing renewable energy so it can provide electricity at night. We need to find least-cost, best-fit solutions.
- Comments from Andy Van Horn:
  - Under the EPA clean power plan and under efforts to reduce coal fired generation in the United States, more baseload generation will be needed. It's not just 5000 MW minimum load in California but we have the whole western grid where geothermal can contribute as a baseload resource.
- Comments from Marc Rappaport (Rappaport Energy Consulting):
  - Historically the SO4 contract with the 10 year termination period was one of the areas that significantly undermined the stability of biomass cogeneration. The utilities have been extremely successful at undermining the original PURPA Act such that the avoided cost becomes the least cost basis. This does not account for all the externality benefits or the cost of carbon.
  - The Energy Commission in conjunction with the PUC needs to determine the changes in policy and rate structure that make it effective for the new technologies to come forward.

Written public comments were also received by the Energy Commission and are available as separate documents (Please see Appendix B).

## **Appendix A: General Workshop Information**

Workshop date and time, location, and list of attendees are provided below.

### Date and Time:

Thursday, January 28, 2015

1:00 p.m. – 4:00 p.m.

### Location:

Warren-Alquist State Energy Building

1st Floor, Charles Imbrecht Hearing Room

1516 Ninth Street

Sacramento, CA, 95814

Attendees:

In Person:<sup>3</sup>

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<sup>3</sup> Based on sign-in sheet, may not represent all in person attendees

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## Appendix B: Associated Documents

Associated documents are available online at:

<http://www.energy.ca.gov/research/notices/index.html#01282016>

### Documents:

Workshop Notice

Workshop Agenda

WebEx Recording

Commission Staff Presentation

Operational Flexibility of Geothermal Power Presentation

### Panelist Presentations:

Steve Ponder, Geothermal Resources Council

Julio Garcia, Calpine Corporation

Josh Nordquist, Ormat Nevada Inc.

Randy Keller, CalEnergy Operating Corporation

John Muir, Andy Van Horn, GreenFire Energy Inc.

### Written Public Comments:

Derek Benson, EnergySource

Jim Shnell, Ocean Geothermal Energy Foundation

John Muir, Andy Van Horn, GreenFire Energy Inc.

Josh Nordquist, Ormat Nevada Inc.

Karl Gawell, Geothermal Energy Association

Kevin Kitz, U.S. Geothermal Inc.

Michael Erbes, Enginomix