

**BEFORE THE PUBLIC UTILITIES COMMISSION  
OF THE STATE OF CALIFORNIA**

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)
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**ORMAT TECHNOLOGIES, INC. COMMENTS ON PROPOSED DECISION  
REGARDING 2019-2020 ELECTRIC RESOURCE PORTFOLIOS TO INFORM  
INTEGRATED RESOURCE PLANS AND TRANSMISSION PLANNING**

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Dated: March 12, 2020

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In accordance with Rule 14.3 of the Rules of Practice and Procedure of the California Public Utilities Commission (“Commission”), Ormat Technologies, Inc. (Ormat) hereby submits these comments on the February 21, 2020 Proposed Decision regarding 2019-2020 Electric Resource Portfolios to Inform Integrated Resource Plans and Transmission Planning (“Proposed Decision” or “PD”).

**I. Introduction and Summary**

The Proposed Decision would adopt a Reference System Portfolio (RSP), which it characterizes as an “optimal portfolio.” Ormat is concerned that the RSP does not provide enough diversification in the resource portfolio and that it is over-reliant on solar PV and battery energy storage given the limited experience with the latter to date. While appearing to be least-cost, any failures in deployment of these resources or errors in anticipating their attributes and operations at the scale suggested could prove to be economically sub-optimal and could even impact power system reliability. Geothermal can ameliorate these outcomes with a mature, dispatchable, and fully reliable renewable technology which has prospects for continued cost reductions particularly if there is sufficient policy guidance. Hence, Ormat suggests that the PD be modified to encourage LSEs to address the diversity of their individual IRPs, beyond consideration of long-duration storage and out-of-state wind resources, to include geothermal,

offshore wind or other diverse resources. Suggested modifications to the PD are provided in Appendix B.

## II. General Comments

In its comments dated December 17, 2019, including attachments, Ormat provided perspective on how geothermal has been treated in the CPUC's IRP modeling since its inception in 2017, indicating that many sensitivity cases conducted by Ormat since then – including for assumed geothermal costs (see further discussion below) and the regional geothermal resource potential – demonstrate the potential for significantly more geothermal selection than the CPUC has now proposed. We will not reiterate those comments here but have updated our summary results of the CPUC's results over 2019-2020 and drawn some key lessons. In Appendix A to these comments, we also offer an additional geothermal cost sensitivity analysis on the 30 MMT 2045 scenario with results illustrating the benefits of geothermal.

The 2020 IRP modeling (including some Ormat sensitivity cases) has already yielded a fairly large number of indicative results regarding geothermal selection in many different scenarios. Table 1 and Figures 1 and 2 show the same summary data in different forms, in each case reflecting only the scenarios in which the model solution selected geothermal. Table 1 is an updated version of the table which Ormat submitted in the December 17, 2019 comments (and there is more discussion about the table in those comments), to include also the February 21, 2020 release of RESOLVE scenario results. Figures 1 and 2 plot the set of results for easier viewing. Figure 1 is a scatter plot of the results shown in Table 1 to help see how the results cluster over the time horizon. Figure 2 includes only the 2045 scenarios and helps to illustrate the trends of geothermal additions over time in each case.

The results make clear that geothermal is almost always selected in 2045 scenarios, and in many scenarios which are more consistent with California's long-term decarbonization objectives than the 46 MMT scenario, this selection begins sufficiently early in the time horizon to warrant inclusion in the 2020 RSP portfolio. In many 2045 scenarios, much of the geothermal is already selected in 2030. However, in other 2045 scenarios, including the 46 MMT 2045 scenarios, less or none is selected by 2030 but then the model selects the maximum available geothermal (around 2.3 GW) at the end of the modeling horizon which implies a massive ramp-up of production after 2030. Ideally, guidance from the CPUC should create a feasible development path to 2030, and establish the basis for continued expansion to 2045 if the geothermal sector is able to reduce costs and increase production (the sensitivities conducted by Ormat on the RESOLVE model in the prior IRP proceeding showed that at lower geothermal costs, the tool selected more than the assumed ~2.3 GW regional resource potential if that constraint was relaxed).

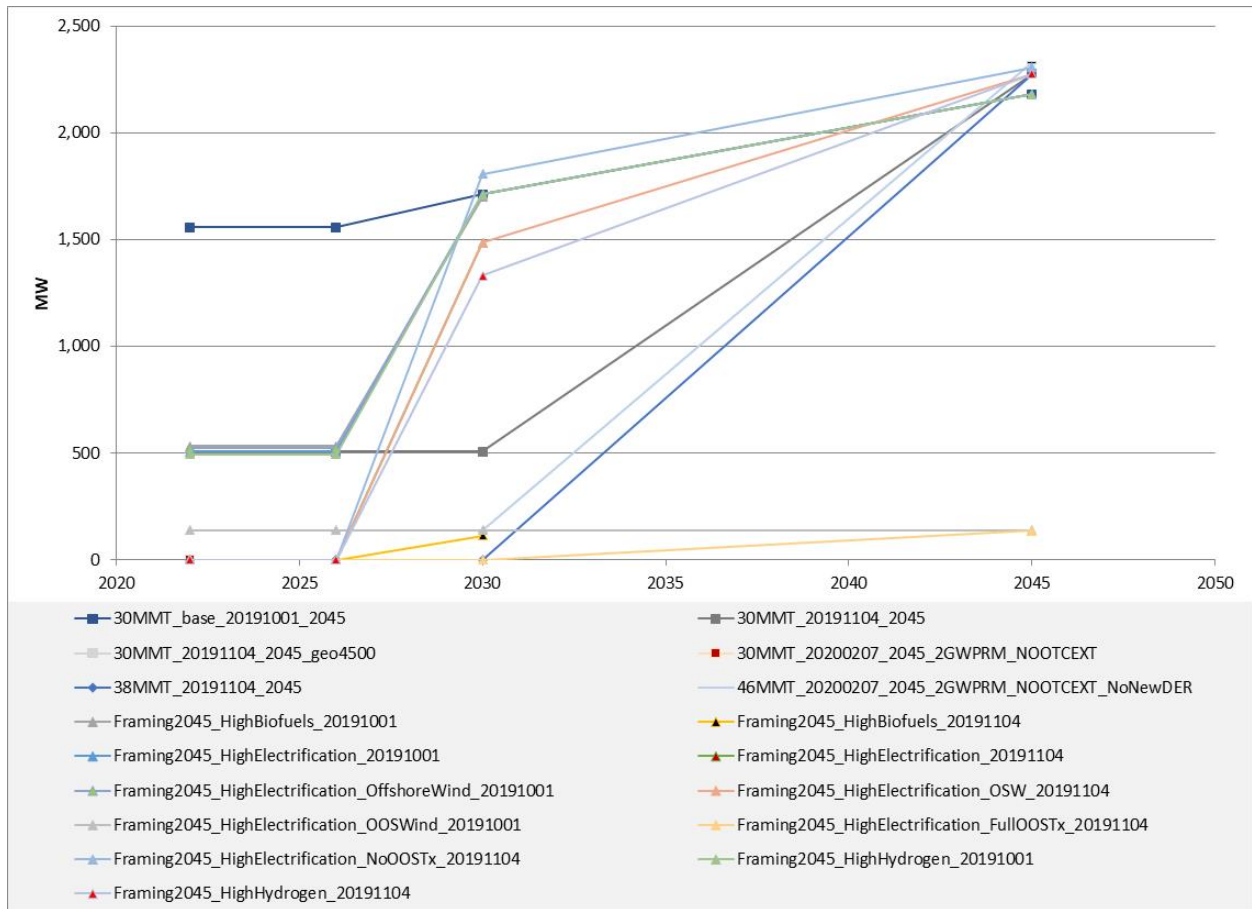
As the figures makes clear, Ormat's recommendation in its December 17 comments that the CPUC stabilize long-term geothermal selection in its tools and decisions by adopting a 1,500 MW target for additional geothermal for 2030 is reasonable and supported by the results. Many scenario-based IRPs utilize methodologies in which the preferred resource portfolio is based on how particular resources are selected in the full range of scenarios, given that the scenarios reflect alternative futures which have some probability of being realized, rather than by an executive decision on one scenario. That is, showing up in multiple scenarios across many model revisions should be a signal of a preferred resource.

Geothermal is not solar PV or batteries – to support resource development to meet the state's 2030-2045 needs, geothermal cannot be treated as a random number to be filled in as

RESOLVE’s constraints are endlessly adjusted. The geothermal sector needs to invest in R&D to continue to lower costs and to expand exploration. Without such support in this decade, despite its clear long-term value to a decarbonized California and western grid, the technology may not make substantial further progress. Building on the quantitative results shown here, the 2020 IRP proceeding is the right place to establish this objective, with further work to follow as the CPUC has proposed.



**Figure 1 – Geothermal selection in pre-solved 2019 and 2020 RESOLVE scenarios (10/04/2019, 11/06/2019 and 02/21/2020 model versions, including two Ormat cost sensitivity case)**



**Figure 2 – Geothermal selection in pre-solved 2019 and 2020 RESOLVE 2045 scenarios (10/04/2019, 11/06/2019 and 02/21/2020 model versions, including one Ormat cost sensitivity case)**

**Table 1 – Geothermal selection in pre-solved 2019 and 2020 RESOLVE scenarios  
(10/04/2019, 11/06/2019 and 02/21/2020 model versions)**

<b>RESOLVE version release date</b>	<b>Scenario label</b>	<b>2022</b>	<b>2026</b>	<b>2030</b>	<b>2045</b>
10/04/2019	30MMT_base_20191001	230	230	230	N/A
10/04/2019	30MMT_base_20191001_geo4500 <i>[Ormat sensitivity case with geothermal at \$4,500/kW, see December 17, 2019 comments]</i>	1,467	1,467	1,467	
11/06/2019	30MMT_20191104	-	-	-	N/A
10/04/2019	30MMT_base_20191001_2045	1,559	1,559	1,712	2,181
11/06/2019	30MMT_20191104_2045	-	508	508	2,276
11/06/2019	30MMT_20191104_2045_geo4500 <i>[Ormat sensitivity case with geothermal at \$4,500/kW, see Appendix A]</i>		1,054	1,116	2,332
02/21/2020	30MMT_20200207_2045_2GWPRM_NOOTCEXT		1,102	1,807	2,308
10/04/2019	30MMT_HighBatt_20191001	1,298	1,298	2,237	N/A
11/06/2019	30MMT_20191104_HiBatt	-	454	1,313	N/A
10/04/2019	30MMT_HighLoad_20191001	950	950	950	N/A
11/06/2019	30MMT_20191104_HiLoad	-	-	-	N/A
10/04/2019	30MMT_HighPV_20191001	1,067	1,067	1,712	N/A
11/06/2019	30MMT_20191104_HiSolar	-	-	135	N/A
10/04/2019	30MMT_HighRAimports_20191001	-	113	113	N/A
11/06/2019	30MMT_20191104_HiRAImports	-	-	-	N/A
10/04/2019	30MMT_LowRAimports_20191001	135	135	135	N/A
11/06/2019	30MMT_20191104_LoRAImports	-	-	-	N/A
11/06/2019*	30MMT_20191104_NoDER	-	135	135	N/A
10/04/2019	38MMT_base_20191001_2045	127	127	127	2,181
11/06/2019	38MMT_20191104_2045	-	-	-	2,276
10/04/2019	38MMT_HighBatt_20191001	286	286	286	N/A
10/04/2019	38MMT_20191104_HiBatt	-	-	-	N/A
02/21/2020	46MMT_20200207_2045_OPRM_NOOTCEXT				2,308
02/21/2020	46MMT_20200207_2045_OPRM_OTCEXT				2,308
02/21/2020	46MMT_20200207_2045_2GWPRM_NOOTCEXT_NoNewDER		135	135	2,332
02/21/2020	46MMT_20200207_2045_2GWPRM_NOOTCEXT_RSP_PD				2,308
02/21/2020	46MMT_20200207_2045_2GWPRM_OTCEXT				2,308

<b>RESOLVE version release date</b>	<b>Scenario label</b>	<b>2022</b>	<b>2026</b>	<b>2030</b>	<b>2045</b>
10/04/2019	Framing2045_HighBiofuels_20191001	532	532	1,701	2,181
11/06/2019	Framing2045_HighBiofuels_20191104	-	-	112	1,523
10/04/2019	Framing2045_HighElectrification_20191001	506	506	1,712	2,181
11/06/2019	Framing2045_HighElectrification_20191104	-	-	1,487	2,308
10/04/2019	Framing2045_HighElectrification_OffshoreWind_20191001	521	521	1,712	2,181
11/06/2019	Framing2045_HighElectrification_OSW_20191104	-	-	1,487	2,276
10/04/2019*	Framing2045_HighElectrification_OOSWind_20191001	138	138	138	138
11/06/2019*	Framing2045_HighElectrification_FullOOSTx_20191104	-	-	-	135
11/06/2019*	Framing2045_HighElectrification_NoOOSTx_20191104	-	-	1,807	2,308
10/04/2019	Framing2045_HighHydrogen_20191001	493	493	1,712	2,181
11/06/2019	Framing2045_HighHydrogen_20191104	-	-	1,332	2,276

\* Scenarios which are either unique or 11/06/2019 modifications of 10/04/2019 scenarios which required re-naming

### III. Resource Diversity

The Commission’s mission to adopt a process for integrated resource planning was established by SB 350 (Stats. 2015, Ch. 547) and is intended “to ensure that load serving entities meet targets to be established by the California Air Resources Board, reflecting the electricity sector’s contribution to achieving economy-wide greenhouse gas emissions reductions of 40 percent from 1990 levels by 2030.”<sup>1</sup> The IRP planning process relies on models to develop optimal resource portfolios based on resource cost assumptions and operational capabilities. The models cannot account for potential unknowns regarding the resource portfolio. As a result, the “optimal” portfolio relies primarily on 11,017 MW of utility-scale solar photovoltaic generation and 2,837 MW of wind resources. This over-reliance on variable generation must be supported by 8,873 MW of four-hour battery storage and 973 MW of long-term storage to reduce

<sup>1</sup> R.16-02-007 at 1

curtailment of the variable generation when it is in excess of system need and to make it more available at times when the energy is needed. This additional storage capacity, particularly battery storage, is a massive 10,000 percent increase<sup>2</sup> in the total amount of storage currently shown as connected to the CAISO. The prospect of adding this much new storage is impacting the Commission's resource adequacy policies and, combined with additional variable generation, is causing the CAISO to also evaluate significant changes to its day-ahead market structure and further development of the Energy Imbalance Market. Indeed, these changes could portend a paradigm shift in the industry to maintain reliability. While this may be an exciting time to be involved in the evolution of this industry, over-dependence on what remains a developing technology could create unforeseen problems. It is also inconsistent with the Commission's stated goal of resource diversity. The PD does not include any new geothermal resources to be online by 2030 and instead assumes that the existing 1,851 geothermal will not retire. Ormat notes that the 1,700 MW of additional geothermal resources included by 2030 in the 2017-2018 RSP could provide the same amount of renewable energy as roughly 6,000 MW of solar and eliminate the need for a substantial amount of storage to facilitate shifting excess solar generation to when it is needed. Diversification to incorporate more of a proven, baseload resource like geothermal would be a prudent approach.

In previous comments in this proceeding, Ormat has expressed concern with the inaccurate pricing assumptions used in the RESOLVE model for geothermal, as they do not reflect the pricing for contracts in the market today. In 2020 alone there have been five geothermal power purchase agreements signed with prices ranging between \$65 - \$75/MWh, which is much lower than the input costs in the RESOLVE model. In both the prior comments

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<sup>2</sup> As of March 2, 2020, the CAISO Generation Interconnection Queue includes 38,319 MW of storage capacity in the active queue, 28,392 MW of storage capacity withdrawn from the queue and 82 MW of completed in service storage capacity.

and in Appendix A to these results, we review results of geothermal cost sensitivities aligned with these recent contract prices. We hoped to conduct more such sensitivity analysis, as was done with the 2017-18 versions of RESOLVE, but the current version has proven to have very long solution times and other instabilities which limited our analysis at this time. While we do not provide evidence that another 1-2 GW of geothermal could be developed at these prices, they are indicative of the potential for cost reductions over the coming decade. Ormat therefore recommends that the PD be revised, either to require specific levels of geothermal procurement, or at least to encourage LSEs to give careful consideration to increased portfolio diversity.

#### IV. Replacing Diablo Canyon

The PD acknowledges the need for LSEs to plan procurement to replace Diablo Canyon Power Plant as it retires in 2024-2025. Ormat agrees that it is important to replace the energy and capacity from this 2,200 MW baseload facility. Replacement with other baseload resources would provide a like for like replacement for some of the retiring capacity. Relying on new geothermal generation to provide a portion of the replacement capacity would provide operational consistency and not increase potential renewable curtailment.

#### V. Summary Recommendations

The quantitative results shown above and in Appendix A – as well as in Ormat’s December 17, 2019 comments and other sources cited therein – are suggestive of the significant role which geothermal can play in the evolution of California’s renewable resource and storage portfolio. Ideally, the CPUC and other state agencies should establish a 1,500 MW target for new geothermal procurement by 2030 based on the quantitative results to date, and expend more effort to consider the following points:

- There is a potentially high benefit to achieving greater geothermal development, particularly at lower costs. From the perspective of resource planning in 2020, this benefit may be more important in achieving the state’s clean energy policies over the coming decade than in subsequent decades, given uncertainty about future technologies.
- Increasing geothermal procurement slows the rapid rate of the solar and storage expansion over this decade, giving more time to understand those resources’ operational and reliability effects.
- Added geothermal MW have a significant multiplier effect in reducing other resource needs, which grows over time due to the growing overbuilding of solar and storage.
- Because of the land use requirements of solar and batteries at such large capacities, expanded geothermal will also provide more time to consider land use options.
- Public policies to facilitate reductions in geothermal costs could have a large payback with respect to clean energy outcomes.

Ormat appreciates the opportunity to provide these comments and supports the development of a vibrant and viable IRP portfolio development process.

Respectfully submitted,

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## Appendix A: Additional data on Ormat geothermal cost sensitivities in RESOLVE

To illustrate in a practical way some of these considerations, we also submit results from another sensitivity case we were able to complete with RESOLVE. We utilized the pre-packaged scenario “30MMT\_20191104\_2045”, which was selected prior to the CPUC’s determination of the RSP scenario. As the CPUC knows, none of the 11/04 dated pre-loaded 2030 base cases selected geothermal, but most of the 2045 cases, including this one, selected some geothermal by 2030 and most if not all of the available geothermal by 2045 (Table 1, above, summarizes all the pre-loaded results for geothermal).

For this scenario, we again substituted a lower geothermal cost of \$4,500/kW, which we call a “mid” geothermal cost. CPUC can presumably replicate this result. As we used the pre-loaded solver, this scenario, with a 25 year horizon, took about one week to solve. These very long solution times make sensitivity analysis with RESOLVE difficult.

Table A-1 shows the selection of geothermal in 2024, 2026, 2030 and 2045 in the base scenario and the geothermal cost sensitivity case for “30MMT\_20191104\_2045”. As shown, the lower geothermal costs roughly double geothermal selection by 2030, but by 2045, since the base scenario already utilized most of the regional geothermal at its higher cost, there is only a small increase in geothermal. Figure A-1 below graphs this result.

**Table A-1 – geothermal selection (MW) by year with different geothermal costs, scenario “30MMT\_20191104\_2045” (with rounding)**

	2024	2026	2030	2045
Geothermal selection at base installed cost of \$5,127/kW (base cost)*	508	508	508	2276
Geothermal selection at base installed cost of \$4,500/kW (“mid” cost)	916	1054	1116	2332
<i>Difference</i>	<i>+407</i>	<i>+546</i>	<i>+608</i>	<i>+56</i>

\* Pre-loaded scenario results

As with the prior sensitivity case Ormat submitted in our comments (and in the attached paper), some of the more relevant implications of the additional geothermal for resource planning is its effect on other resources. Table A-2 shows the effect of the additional geothermal on other resources in 2030; because, as shown in Table A-1, the model already selected almost all the available geothermal in 2045, there is little additional geothermal in that year even at lower cost. Hence, at the temporal resolution of the model results, the highest displacement which is visible in the results takes place in the 2030 results. As shown in Table A-2, in 2030 the additional 608 MW of geothermal at the “mid” geothermal cost results in displacement of almost 2 GW of solar PV and about 1.5 GW of storage (batteries and pumped storage). Hence, the displacement ratio per added geothermal MW is calculated as  $[-1,818 \text{ MW (solar)} + -1,553 \text{ MW (storage)}] / 608 \text{ MW (geothermal)} = -5.5$ . That is, on average, by 2030 each MW of added geothermal over the base case result displaces 5.5 MW of solar and storage. Although not shown, the increased geothermal selection at the “mid” cost does not displace any wind, onshore or offshore, from the scenario results.

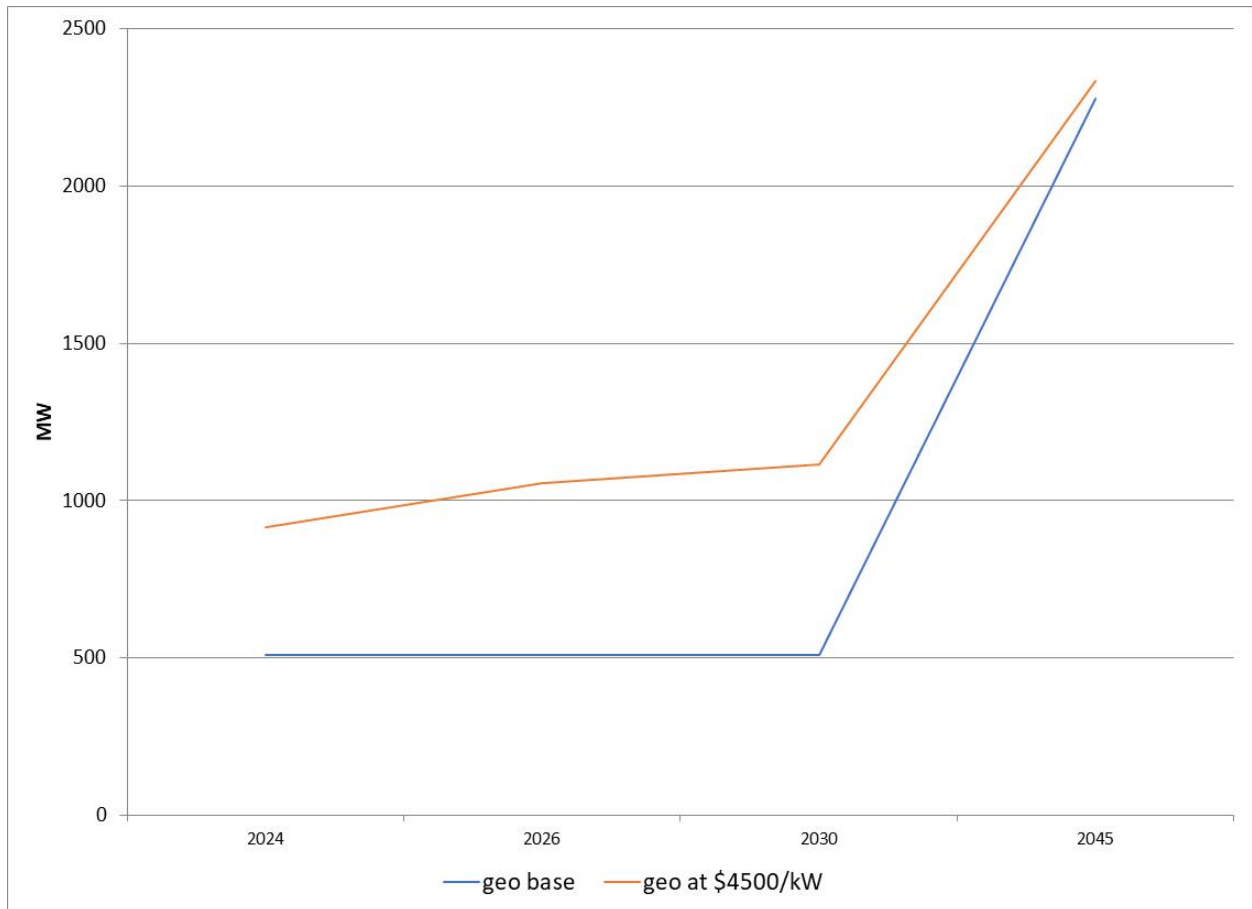
Figure A-2 shows the displacement result graphically, which helps to envision that adding even a relatively small amount of geothermal in the next decade – which we have recommended should be a minimum of 1.5 GW of new geothermal capacity by 2030 – in a sense “buys time” for what the model forecasts to be a massive expansion in solar and storage. This makes intuitive sense in that geothermal is a 24 hour flexible resource which is weather invariant, while solar and storage will need to be significantly overbuilt to address load in hours without solar production. The rate of that overbuild increases over time, which is why added geothermal displaces more and more of these other resources over time.

Our summary recommendations in the body of the text reflect the lessons learned in these sensitivity cases as well as others previously conducted by Ormat.

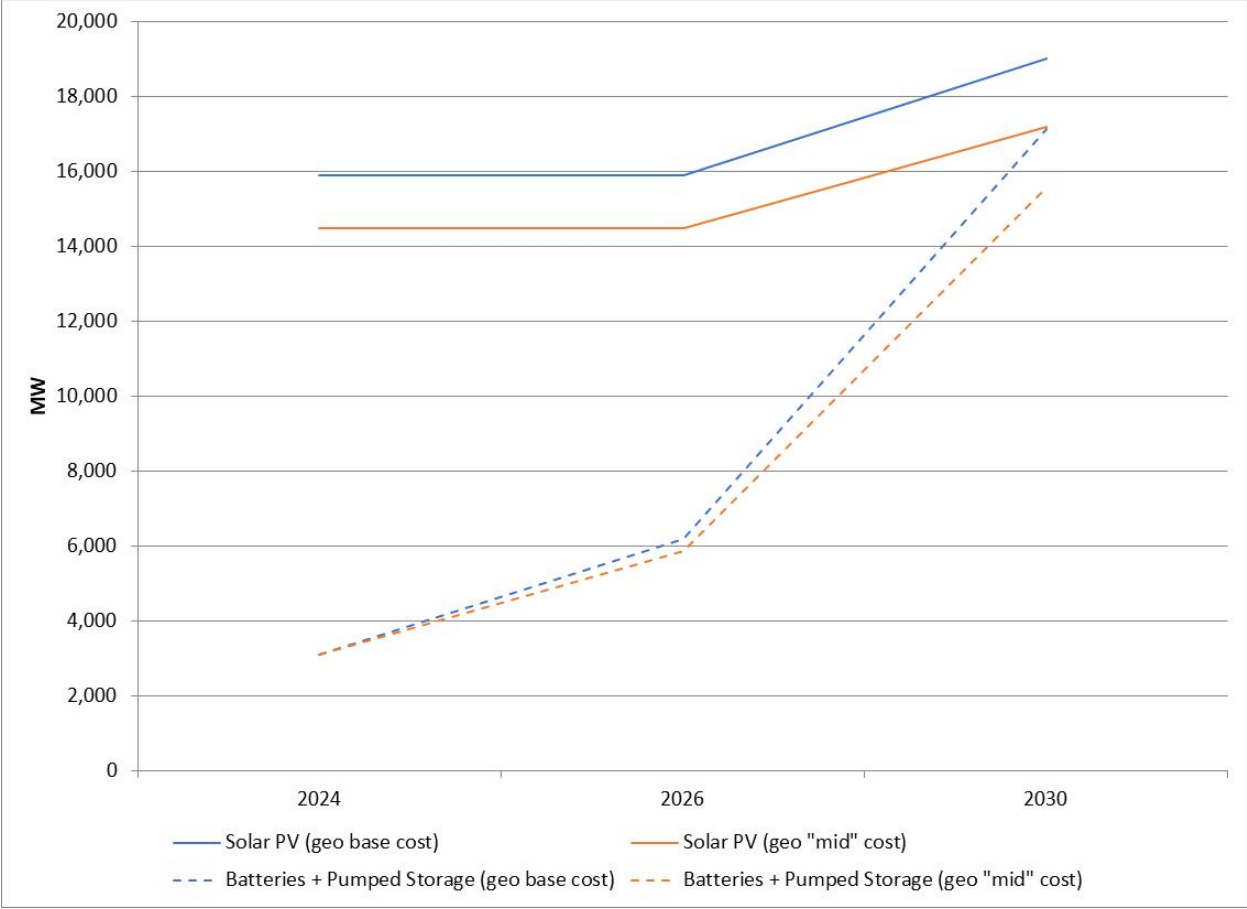
**Table A-2 – comparison of different resource capacity additions (MW) in 2030, geothermal cost sensitivities, Scenario “30MMT\_20191104\_2045”**

	Geothermal at base installed cost of \$5,127/kW*	Geothermal at base installed cost of \$4,500/kW (“mid” cost)	Difference
Geothermal	508	1,116	608
Solar PV	19,019	17,201	-1,818
Total storage	17,125	15,573	-1,553
<i>Batteries</i>	<i>16,136</i>	<i>15,005</i>	<i>-1,131</i>
<i>Pumped storage</i>	<i>989</i>	<i>568</i>	<i>-422</i>

\* Pre-loaded scenario results



**Figure A-1 – Comparison of geothermal selection by year, geothermal at base case cost and “mid” cost, Scenario “30MMT\_20191104\_2045”**



**Figure A-2 – Comparison of solar and storage selection by year to 2030, with geothermal at base case cost and “mid” cost, Scenario “30MMT\_20191104\_2045”**

## Appendix B: Proposed Changes to PD

For the reasons discussed above, Ormat proposes the following changes to the PD:

Combine Conclusion of Law 14 and 15 to state:

The LSEs should be required to detail in their individual IRPs their plans for procuring pumped storage resources, or other long-duration storage resources with similar attributes, out-of-state and offshore wind resources, additional geothermal, and other resources designed to bring diversity to the portfolio.

Revise Ordering Paragraph 7 to state:

“All load-serving entities required to file a Standard Plan and Conforming Portfolio, as defined in Decision 18-02-018, shall detail in their individual integrated resource plans their plans and activities to procure pumped storage resources, or other long-duration storage resources with similar attributes, as well as out-of-state wind resources, offshore wind resources and additional geothermal resources.”