DOCKETED	
Docket Number:	23-AFC-01
Project Title:	Morton Bay Geothermal Project (MBGP)
TN #:	255704
Document Title:	Hudson Ranch Power 1 Comments - Morton Bay Geothermal Project Resource Adequacy Questions
Description:	N/A
Filer:	System
Organization:	Hudson Ranch Power 1
Submitter Role:	Public
Submission Date:	4/15/2024 11:03:08 AM
Docketed Date:	4/15/2024

Comment Received From: Hudson Ranch Power 1
Submitted On: 4/15/2024
Docket Number: 23-AFC-01

Morton Bay Geothermal Project Resource Adequacy Questions

Hudson Ranch Power 1 LLC hereby submits the attached report prepared by Geothermal Resource Group regarding the "Numerical Reservoir Simulation of the Salton Sea Geothermal Resource for Power Generation," prepared by Geothe1mEx for BHE Renewables, LLC, docketed on 5/8/2023 as TN# 250042 (a/k/a the "Morton Bay Geothermal Project Resource Adequacy Report").

Additional submitted attachment is included below.

Cyrq
Hudson Ranch

April 15, 2024

Eric Veerkamp
Project Manager
California Energy Commission

Via e-comment

Re: Morton Bay Geothermal Project, docket number 23-AFC-01

Dear Mr. Veerkamp,

Hudson Ranch Power 1 LLC hereby submits the attached report prepared by Geothermal Resource Group regarding the "Numerical Reservoir Simulation of the Salton Sea Geothermal Resource for Power Generation," prepared by GeothermEx for BHE Renewables, LLC, docketed on 5/8/2023 as TN # 250042 (the "Morton Bay Geothermal Project Resource Adequacy Report").

The Morton Bay Geothermal Project Resource Adequacy Report is addressed by the "Geothermal Resources Adequacy Declarations and Resumes" docketed on 5/26/2023 as TN #: 250365 and by the "Hudson Ranch Power 1 Comments - Morton Bay Geothermal Project Impact Screening Study" docketed on 2/26/2024 as TN # 254691.

Sincerely yours,

HUDSON RANCH POWER 1 LLC

By: _____
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Phone: 760-341-0186

Date: 4/12/2024

To: Cyrq Energy

From: Richard Holt, Geothermal Resource Group; William Rickard PE, Geothermal Resource Group

Re: Morton Bay Geothermal Project Resource Adequacy Questions

Executive Summary

Cyrq owns and operates the 60 MW (nominal) Hudson Ranch Power I (HRP I) geothermal project in the Salton Sea Geothermal Field (SSGF). The Morton Bay Geothermal Project (Morton Bay) proposes to install 157 MW of new generation capacity with new wells approximately ½ mile from the existing HRP I wellfield. Geothermal Resource Group (GRG) was engaged by Cyrq to develop questions on GeothermEx's report (2023), "Morton Bay Geothermal Project Resource Adequacy Report", dated May 2023. GRG does not support or oppose the proposed Morton Bay development, nor does GRG have any financial interest in either Cyrq or Morton Bay. In the above referenced report, GeothermEx concludes that numerical model results demonstrates that the geothermal resource can accommodate both existing geothermal power plants and the proposed geothermal power plants (Black Rock, Elmore North, and Morton Bay), with "modest" declines in reservoir pressure and enthalpy which could be mitigated by drilling additional make-up production and injection wells. GRG concludes the following:

- The GeothermEx model shows, on a macro level, that there is adequate resource (fluid and heat in the reservoir) to support the planned projects, and GRG agrees with this conclusion (Kaspereit 2016).
- The GeothermEx model forecast was conducted in "rate constraint" mode, meaning production rates were set to constant (no decline, no wellbore modeling) and the model only shows the effects in the reservoir *if* those flows are maintained with makeup wells, which are not included in the model.
- The GeothermEx report on the model does not show the location of the one reservoir pressure monitoring point, which is likely in the old part of the field, far from Morton Bay and HRP. It is unlikely that the change in reservoir pressure can be realistically characterized with one point and the pressure decline will likely be higher directly in Morton Bay and HRP.
- The GeothermEx report concludes that the reservoir pressure decline to be modest, however, GRG calculated the effect of the reservoir pressure decline on production, and the resulting decline in production is significant, in the range of 10-18% reduction in production flow.

GRG's Experience at Salton Sea

GRG personnel have worked in the Salton Sea field since the 1980's and have become leading experts in well targeting, drilling, well testing, reservoir engineering, numerical simulation and more recently lithium

recovery. Several GRG personnel were involved with the highly referenced publication on SSGF's conceptual model and reserves (Kaspereit, et al, 2016) which included a refined model of the field. This is in addition to voluminous confidential reports and projects completed by GRG for numerous clients over the past decades. Due to this body of experience, GRG is well-positioned to provide insight into successful development plans.

GRG's Preliminary Questions on GeothermEx's Model Report

GRG raises the following preliminary questions/issues for Cyrq to raise regarding the GeothermEx report on Salton Sea/Morton Bay Numerical model

Forecasting of Generation vs Adequacy of Resource

Page 1-1 paragraph 1: "BHER has requested GeothermEx to provide long-term forecasting of generation from BHER's Salton Sea geothermal projects using numerical simulation"

Page 1-1 paragraph 3: "This study has been structured to focus primarily on resource adequacy for the BHER development projects and potential impacts on BHER's existing facilities."

- Issue: In reservoir engineering practice using simulation for the "forecasting of generation" and "resource adequacy" are not the same thing, and this report seems to mix the terms.
- To determine resource adequacy, the goal is to determine if the resource contains enough fluid and heat to support the project, it doesn't say whether that can be done economically or if makeup wells are needed because all the wells are held at constant, full rate, in the simulations (the effects of interference are not considered). Thus, resource adequacy only says that if the wells could supply this constant flow rate, then here are the effects in the reservoir.
- To perform a forecasting of generation, it is required to include in the simulation the effect of enthalpy, pressure, TDS, and Gas% on the wellhead deliverability of each well. This is accomplished by integrating wellbore simulation with reservoir simulation. Figure 3.4 shows the forecasted enthalpy, TDS, and gas % for Morton Bay with the wells on rate constraint. What is left out is the effect on local reservoir pressure in the area, which is likely to be significant and likely to propagate to HRP causing wells to decline which will cause the HRP wells to decline in flow rate when Morton Bay starts up, and then long-term decline in HRP will be increased.
- Other than the production and injection wells within Cyrq's concession area (Section 13), the only production and reservoir data available within BHER's concession area to the W and SW of HR are decades-old exploration wells (IID, Sportsman, State 2-14) for which relatively short completion tests were conducted. This required that GeothermEx make important assumptions regarding permeability, NCG content, etc. in their reservoir numerical model that may not accurately predict production rates, reservoir pressure and NCG changes in the planned Morton Bay production wells.
- Page 1-1 paragraph 1: "BHER has requested GeothermEx to provide long-term forecasting of generation from BHER's Salton Sea geothermal projects using numerical simulation"
    - A generation forecast was never shown in the report.
    - There is no way to know how many MW of decline the "modest" declines really are.

- Would require wellbore simulation integrated with reservoir simulation which was not done, or not reported.

Reservoir Pressure History Match

Figure 2.2 History match to "Reservoir Pressure" appears to be optimistic

- Issue: The simulated history match in Figure 2.2 (the black line) appears to level off after 2018 while the data (the blue dots) appear to continue a linear decline with no stabilization. See the figure below with the added orange line with a continuous trend, which appears to match the data better than the black line
- This is likely caused by either too high overall permeability in reservoir and/or too much pressure-dependent recharge coming in to the model. This will likely result in an optimistic forecast of pressure decline and actual pressure decline will be higher than predicted causing more decline in production.

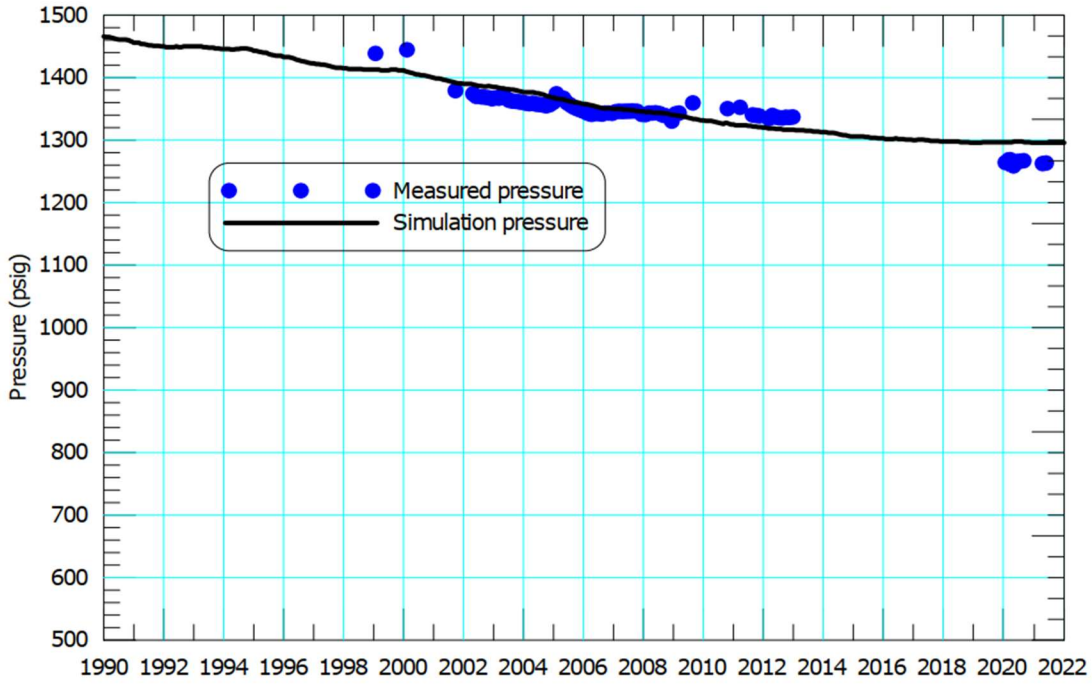


Figure 2.2 History Matching of Reservoir Pressure Data

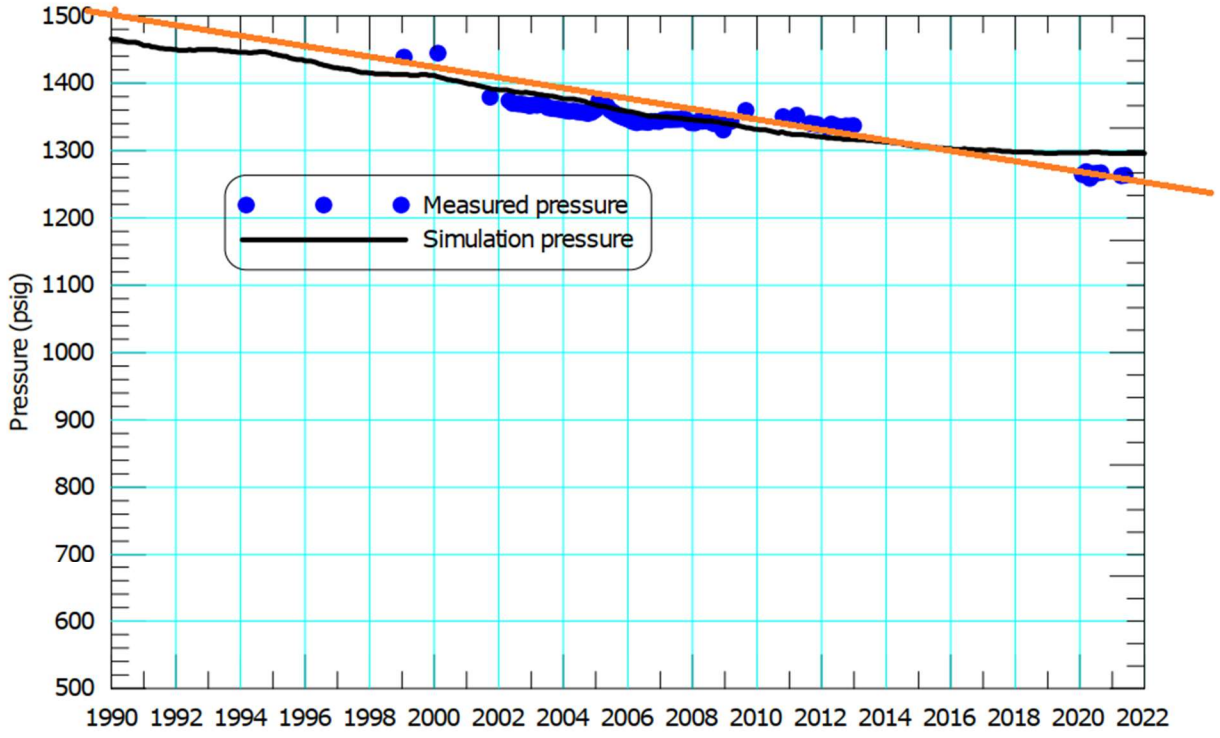


Figure 2.2 History Matching of Reservoir Pressure Data

Location of Reservoir Pressure Point

Figure 2.2 History match to "Reservoir Pressure" appears to be in a location somewhere in the older, central part of the field.

- Issue: The simulated history match appears to be in the older, central part of the field far from HRP and forecasted pressure change likely too low and not representative of pressure decline near HRP
- Figure 2.2 shows a cumulative "reservoir pressure" decline (location unspecified) of 200 psi from 1990 to 2022. This corresponds to the reservoir area impacted by net extraction for the current 350 MW, which is 0.5 to 2 miles south of the proposed Elmore North and Morton Bay expansion projects.
- Figure 3.1 shows an incremental 100 psi of reservoir pressure decline for an incremental 407 MW of additional production, which is half the pressure decline from the original 350 MW. This supports the conjecture that the location of the reservoir pressure point is not near HRP and pressure decline near HRP will likely be much more than an incremental 100 psi, which is already enough to affect flow rates.

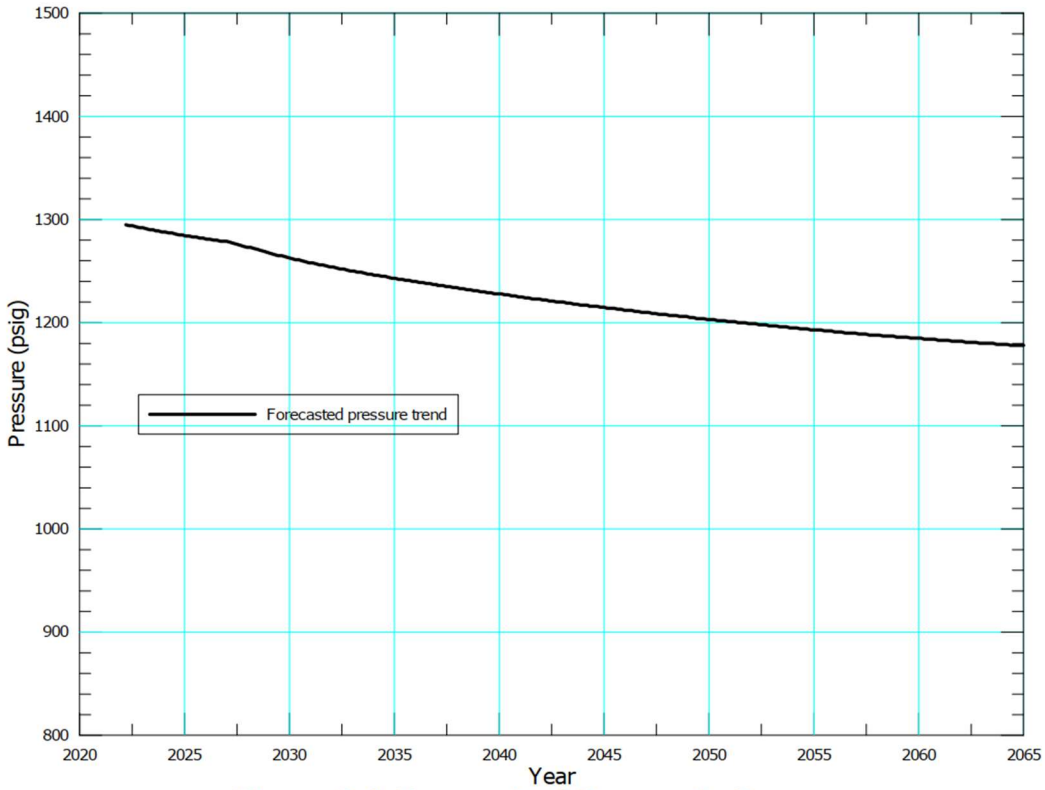


Figure 3.1 Forecast of Reservoir Pressure

Forecast Methodology Assume no Decline

Figure 3.4: Forecast of Enthalpy, TDS, and NCG for Morton Bay

- Issue: This forecast leaves out the forecast of reservoir pressure in the region of Morton Bay, the forecast also leaves out a forecast of power generation, which the report repeatedly claims to do.
- This forecast was conducted by placing the Morton Bay production wells on set flow rate constraint and the simulator calculated what would happen in the reservoir *if those flow rates were maintained*.
- Even with the above caveat, the enthalpy does show a decline, so strictly speaking the power generation would decline
- Reservoir pressure in the Morton Bay region combined with wellbore simulation would be required to estimate the true decline rate and thus how many makeup wells are needed.
- Depending on how many make up wells are needed, and where they are placed, this could potentially further negatively affect HRP

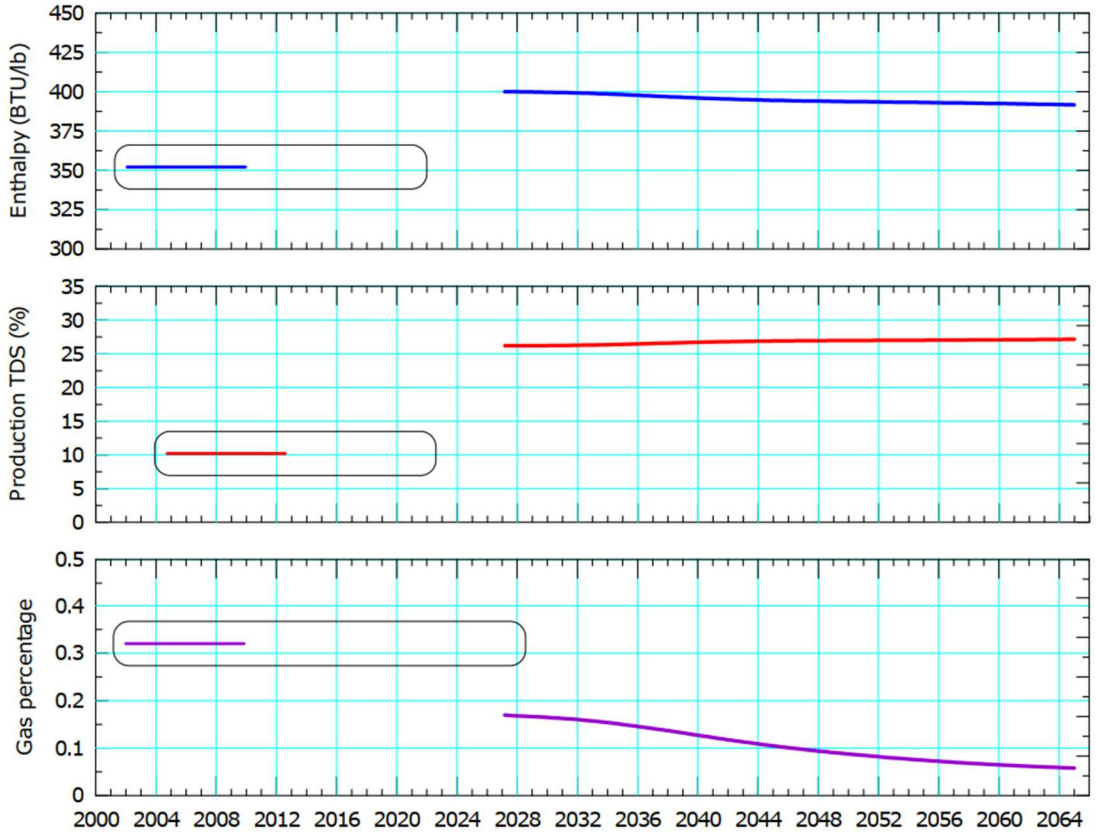


Figure 3.4 Forecast of Enthalpy, TDS, and NCG for Morton Bay

Predicted Reservoir Effects Not Combined with Generation and Flow Calculations

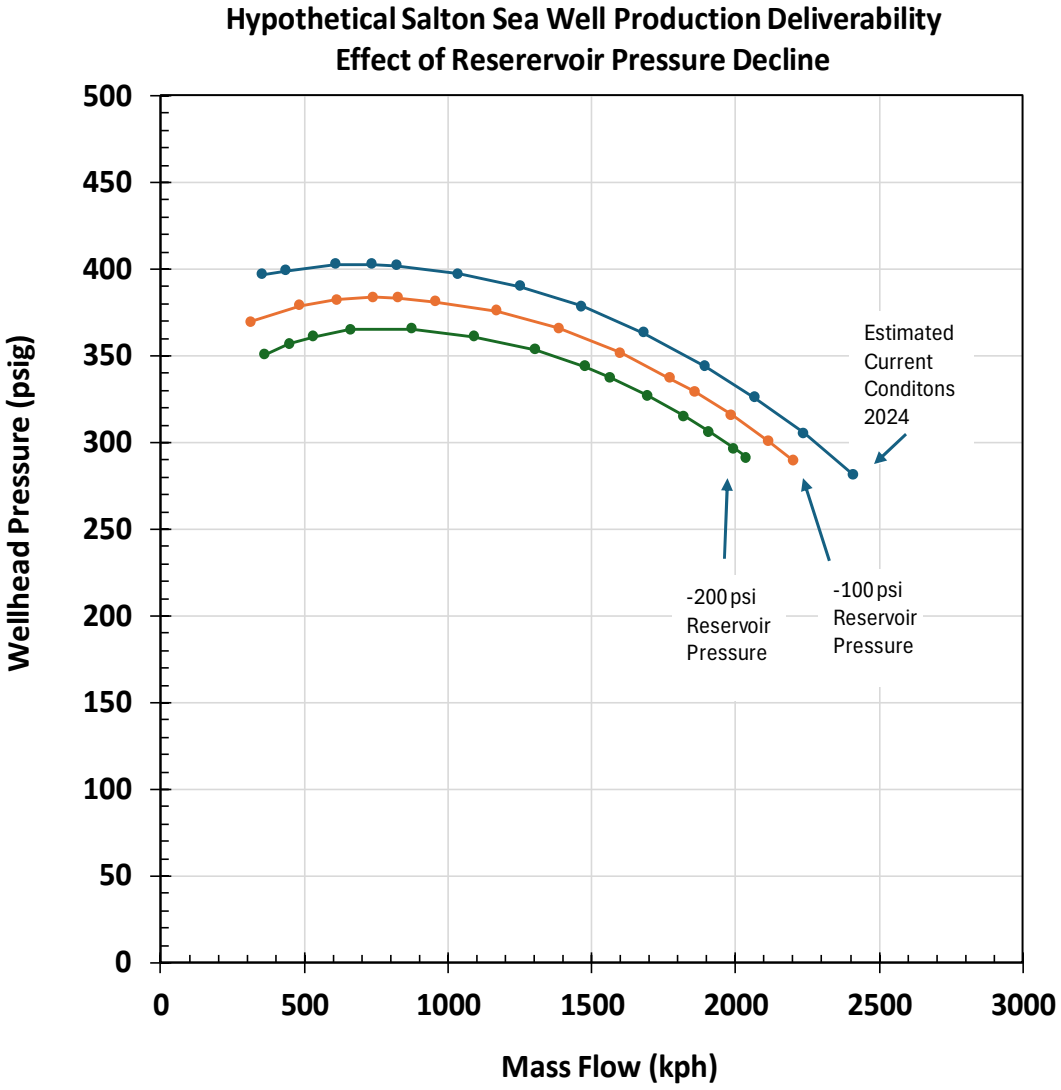
Page 3.2 : "This modest decline in reservoir pressure and enthalpy could be mitigated by drilling additional make-up production and injection wells during the life of the projects in order to maintain sufficient production and injection capacity for full power generation."

- Issue: There is no generation forecast, which would require integration of wellbore simulation and reservoir simulation and the inclusion of make-up wells, in addition, the older part of the field is shown to experience at least 100 psi of incremental pressure decline, and no enthalpy decline is shown. Make-up wells may be needed in the older part of the field.
- Make-up wells: It is not believed to be a *modest* effect if HRP requires a make-up well to maintain full production.

Regarding GeothermEx's Conclusions

Page 3.2 Overall: In conclusion, the resource adequacy study has demonstrated that the geothermal resource can accommodate both existing geothermal power plants and the proposed geothermal power plants (Black Rock, Elmore North, and Morton Bay) over the horizon of the evaluation (through 2065).

- Issue: It is agreed that the simulation study has shown that there are sufficient heat and mass reserves to support the additional production. However, it is not clear if the simulation included a potential expansion by Cyrq, which would likely have an impact on both Cyrq and BHER production rates.
- Pressure Decline: No predicted pressures in Morton Bay or HRP were shown. The study has not demonstrated that the pressure decline HPR is modest and the model likely underpredicts the future pressure declines across the whole model due to the mismatch in reservoir pressure in 2022 where the model shows stabilized pressure, but the data show continued decline.
- Temperature Decline: No temperature declines in HPR where shown. The study has not demonstrated (or shown) that enthalpy decline is HRP will be modest. The use of quite large grid blocks in and around HRP is likely to underpredict the temperature decline.



GRG's Wellbore Simulation (effect of reservoir pressure on production)

A wellbore simulation was performed considering a hypothetical production Salton Sea production well with 13-3/8" casing to 4000', 12.25 open hole to 8000', with midpoint of production at 6000'. Public sources and the GeothermEx report were used to specify reservoir parameters. The findings indicate that increased pressure decline has a significant effect on production rate.

For example, at 325 psig separator pressure:

With estimated current reservoir condition: 2066 kph of production (TMF)

-100 psi reservoir pressure : 1858 kph of production (-10%)

-200 psi reservoir pressure : 1693 kph of production (-18%)

These effects are on a per well basis, and thus a 10-18% reduction in production could occur across an entire project.

GeothermEx Report Does Not Explain how HRP is Modeled

The GeothermEx reservoir model update report shows BHER's production well plan for the Morton Bay expansion project. The reservoir model predictions likely assume that Cyrq will continue to generate at the current level, which implies that the fluid extraction rate will remain unchanged going forward, except for the expected "modest" decline rates. However, Cyrq may wish to modify or expand the current capacity at some point in the future, and it is unclear if GeothermEx modeled the effects of such an expansion on the nearest BHER wells, which could have an equivalent impact on Cyrq's expansion wells.

Potential issues from Cyrq's perspective:

- What is the potential impact of the planned BHER production and/or injection wells W and SW of the HR concession on current 49.9 MW production (i.e., reservoir pressure decline, intra-wellbore silica scaling, etc.)?
- If BHER moves forward to drill production wells in Sections 14 and 23, given Cyrq's limited expansion area within Section 13, if Cyrq eventually wishes to expand its generation, what is the potential reservoir response (and therefore economic impact) to Cyrq?
- CTR has reportedly drilled two successful production wells just north of Sections 14 and 15. If CTR drills additional wells closer to Section 13 for its planned 49.9 MW development, does the GeothermEx model consider potential additional reservoir pressure decline within Section 14 (BHER) and Section 13 (Cyrq)?

References

GeothermEx, “Morton Bay Geothermal Project Resource Adequacy Report”, May 2023

Kaspereit, D et al, “Updated Conceptual Model and Reserve Estimate for the Salton Sea Geothermal Field, Imperial Valley, California” GRC Transactions, Vol. 40, 2016

Grant, M: “Geothermal Resource Proving Criteria”, Proceedings World Geothermal Congress 2000, Kyushu – Tohoku Japan, May 28 – June 10, 2000

Wilmarth, M., and Stimac, J.: “Power Density in Geothermal Fields”, Proceedings World Geothermal Congress 2015, Melbourne, Australia, 19-25 April 2015