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Assessment of Economic Impact of Permitting Timelines on Produced Geothermal Power in Imperial County, California

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ABSTRACT

Despite having a large geothermal power potential in the United States, only a small fraction has been developed for power generation. Various barriers, including technical, financial, and regulatory permit delays, are attributed to lower contribution of geothermal energy in the national grid. Unpredictable environmental reviews and permitting timelines are some of the non-technical barriers that can cause delays in geothermal exploration and utilization plans. Our study shows that the geothermal permitting timelines can vary from six months to several years, depending on the presence or absence of biological resources, cultural resources, and sensitive environmental issues at the project site. The potential impacts of these permit barriers can range from investors abandoning geothermal development to making the product (i.e., electricity) more expensive and uncompetitive. In this study, we conducted economic analysis to assess the impact of permitting timelines on cost of produced electricity from geothermal resources using data from existing geothermal plants as well as prospective sites. In this paper, we present collected timelines data, approach, and results of economic impact of permitting timelines on geothermal power. We evaluated the various environmental management and permit review processes by considering a hypothetical geothermal project in the Salton Sea Known Geothermal Resource Area. Because of the variety of the biological and environmental issues and the involvement of local, state, and federal agencies with overlapping jurisdictions, this project could go through one of the many California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) review scenarios that range from the least to the most complex in its circumstances. The fastest CEQA/NEPA review timelines would have the project completed in six years. In contrast, the project would substantially need longer time to complete if it were located in an area with significant environmental resources or cultural issues that required permitting from various agencies. With increasing project completion timelines, the simplified levelized cost of electricity (sLCOE) can be 4 to 11% higher with longer CEQA/NEPA review timelines than the sLCOE value with the fastest CEQA/NEPA review timeline. Lengthier CEQA/NEPA review timelines could also result in loss of $64 million to $227 million in potential revenue. Such significant economic impacts could determine the success of a geothermal project.

1. INTRODUCTION

Both the United States Geological Survey (Williams et al., 2008) and GeoVision (USDOE, 2019) studies show the presence of a substantial geothermal power generation potential in the U.S., but only a small fraction of that potential power generation has been developed. Various barriers, such as technical, financial, and regulatory hurdles and delays, are attributed to less use of geothermal energy in the national grid (Richard, 2012; Young et al., 2014; Young et al., 2019; USDOE, 2019). Particularly, the non-technical barriers that cause delays in exploratory activities and ultimately in siting power plants at prospective geothermal sites are unpredictable permitting and multi-layered environmental regulatory approval timelines associated with local, state, and federal agencies. Besides the costly technical risks, such as well failures, the financial burden associated with unpredictable permitting and regulatory approval timelines has been identified in previous studies as one of the major barriers in developing and increasing contributions of geothermal resources into the national electricity portfolio.

From early efforts to obtain land access and land lease for exploration to large investments for the development of well fields and construction of power plants, the developers must go through multiple permitting processes for site exploration, drilling, and construction (Levine et al., 2013; Young et al., 2014; Young et al., 2019). In many instances, the developers need to make significant investment without having a clear picture of how long it can take to obtain the approval(s) or whether they will eventually obtain the permit to complete the geothermal power plant or the supporting infrastructures (e.g., transmission lines). Therefore, the potential impacts of these non-technical barriers can range from developers abandoning the geothermal development from a site to making the product (e.g., electricity) more expensive and uncompetitive in the market.

In this paper, we provide a summary of our recent study (Neupane and Adhikari, 2022) that provided a detailed quantitative assessment of the impacts from the permitting processes on geothermal power by evaluating permitting timelines and associated costs in California, Nevada, and Utah. Using the permitting timeline examples from previous projects and ongoing geothermal projects, this paper includes multiple environmental management scenarios with several California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) review pathways for geothermal development in Imperial County, California. The various environmental management and CEQA/NEPA review scenarios illustrate permitting timeline variations caused by presence or absence of existing land use plans, programmatic environmental review documents, and environmental, biological, and cultural issues. Assuming constant, prevailing technological costs and financial mechanisms, we assessed the impact of various permitting timelines on simplified levelized cost of electricity (sLCOE) and revenue generation.

2. APPROACH AND METHODOLOGY

2.1 Permitting Data

The study reviewed state-wise regulatory frameworks related to land leasing and permitting issues for the exploration and development of geothermal energy in Imperial County, California. Multiple geothermal sites with existing power production facilities or with ongoing leasing, exploration, and development permitting activities were evaluated and presented in Neupane and Adhikari (2022).

Figure 1 shows a simplified permitting timeline that is likely to occur for most of the geothermal development activities. Some of the steps shown in Figure 1 can occur simultaneously (or in a different order than what is shown) and decrease the severity of timeline issues. Literature review and stakeholders outreach efforts were made specifically to collect as much data as possible on each of the steps in Figure 1. For existing geothermal sites, the relevant data, such as permit approval cost, timeline, and available exploration & development cost, were used to assess the economic impact of permit timelines in terms of sLCOE.

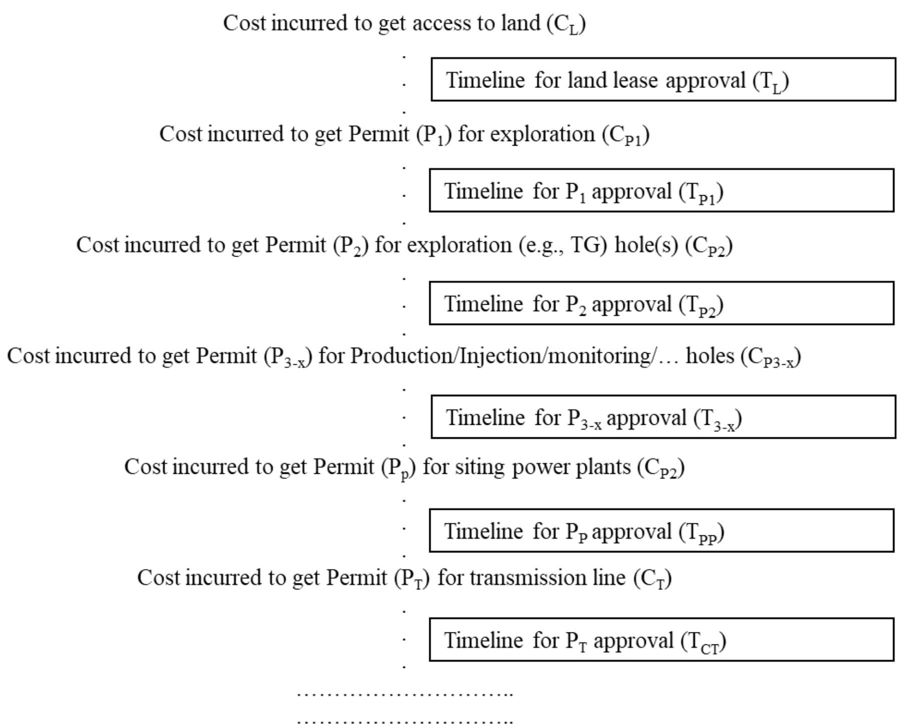

Figure 1. Generalized permitting timelines and costs that occur to most of the geothermal development activities. For simplicity, all regulatory permitting issues (cultural, environmental, biological, etc.) are lumped together. In reality, however, various permitting issues may require separate application to different local, state, and federal agencies with each having their own processing timeline and cost.

2.2 Data Reduction and Filling the Data Gap

NEPA/CEQA review and various ancillary permitting documents were collected from agency websites and other publicly available sources. In addition, remote interviews were conducted to obtain timelines/cost data as well as to get insights about the permitting challenges from both developers and regulators. The timeline data were scattered in multiple documents such as public notices, decision records, county board meeting minutes, and in lengthy environmental review documents (e.g., environmental impact assessment, initial study, environmental impact statement, environmental impact report, certification document, decision records, etc.). Whenever a specific date of an action (e.g., application, review period, approval, etc.) was available, that was used in the techno-economic analysis (TEA). In many instances, however, the exact date of an action is not provided in the documents. In those cases, an estimated date was assigned based on preceding action’s date, succeeding action’s date, or some other timeline reference point.

Unlike timeline data, costs incurred to prepare, apply, and complete NEPA/CEQA review process for various activities of a project were challenging to acquire or were unavailable. When available, the company data were mostly an overall project completion cost (e.g., total project cost for Hudson Ranch - I). In these cases, the total project cost was assumed to occur at the completion of the project. In some instances, well drilling details and costs were published (e.g., Rickard et al., 2014 for Hudson Ranch - II). When no cost data were available for permitting (from application fee various permitting to NEPA review process), National Renewable Energy Laboratory's (NREL) GeoRePORT Socio-Economic Assessment Tool (SEAT) (GeoReport, 2014; Young and Levine, 2018) was used to estimate permitting application fee and CEQA/NEPA review cost. Specifically, we used an Excel-based SEAT developed by Levine and Young (2016) to estimate application fees for ancillary permitting and NEPA review costs when no-specific data were available for some case sites (e.g., Truck Haven-LEA).

2.3 Techno-economic Analysis

Permitting timelines and delays can result in increased costs and contribute to making geothermal energy expensive. To assess the economic impact of these timelines on sLCOE, we used a project-developed Excel-based TEA tool. Prevailing discount rates, lease/permit timelines and associated costs/loans at each applicable stage (Figure 1) along with various modeling timeline scenarios were considered while conducting TEA.

2.3.1 Simplified LCOE

We developed an Excel workbook to conduct TEA by sLCOE using the following equation by Loewen (2020):

sLCOE = {(overnight capital cost * capital recovery factor + fixed O&M cost)/(8760 * capacity factor)} + (fuel cost * heat rate) + variable O&M cost

where

overnight capital cost is unit cost of installed kilowatts (in dollars per kW)

fixed O&M cost is annual fixed operation and maintenance cost (in dollars per installed kW)

8760 is the number of hours in a non-leap-year

capacity factor is average power output, as percent of maximum capacity

fuel cost is the cost of fuel in $/Btu

heat rate is Btu per kWh

Also

CRF = {d(1 + d)n} / {[(1 + d)n]-1}, d = discount rate, n = number of annuities

Project costs from land lease bid bonus to plant construction were converted to their value in the power plant completion year using a 6% annual discount rate. Time of the geothermal power plants operation was considered as 30 years in all cases and scenarios. Discount rate on the spent cost was assumed to be 6% in all cases and scenarios. A representative capacity factor of 70% for geothermal systems (EIA, 2020) was used in all cases. The 70% capacity factor could be considered as a conservative value for the new geothermal power plants since it is skewed low by older geothermal plants in Geysers, California. The fuel cost for the geothermal plant is assumed to be zero. Both fixed and variable operation and maintenance costs are assumed to be $0.01/KWh each. The operation and maintenance (O&M) cost was chosen as a fixed cost, which is around 10% of the sLCOE, and 6% discount rate was chosen as an average of long-term inflation rate (~2%) and industrially accepted return on investment (~10%). To assess the impact of timelines, sLCOE values were calculated for different timelines.

2.3.2 Potentially Gained or Missed Revenue

Gained and missed revenues represent the aggregated revenues generated or not-generated from the produced or not-produced electricity from case study sites. Gained or missed revenue is calculated based on the national average price of electricity for that particular year.

2.4 Modeling Scenarios

The timeline scenarios can vary from one site to another depending on the presence or absence of biological or/and cultural resources and other sensitive issues. Young et al. (2019) identified six separate attributes that have significant impact on land access:

1) Cultural and tribal resources
2) Environmentally sensitive areas
3) Biological resources
4) Land ownership
5) Federal and state lease queue
6) Proximity to military installation

Some areas with high potential for geothermal development are unavailable for development because of existing biological resources or are environmentally sensitive/protective areas. However, in this we do not include unallowable land access scenarios.

Geothermal exploration and developmental activities in allowable lands require different permits, generally from various agencies. The permitting processes vary from state to state, and even from county to county within some states. However, the most important determining factors in permit timelines for an individual site are whether the site is within a pre-defined or known geothermal resource area (KGRA) or not, has an absence or presence of biological or/and cultural resources and other sensitive issues, has several agencies with jurisdiction and overlapping authority to permit and approve mitigation measures, etc. In Imperial County, California, developers can directly apply (if they choose to) for conditional use permit (CUP) for the development of power plants, if the project site is located within the KGRA since the designation of an area as KGRA satisfies the resource viability in that area. However, for a project site outside of any KGRA, developers must go through the two-step CUP process. In this case, the first CUP would let developers conduct exploration by drilling and testing to ensure resource viability. If the resource is viable, the initial exploration CUP would be folded into the second resource utilization CUP.

In addition, Levine et al. (2013) mentioned that permitting delays can occur because of inadequate staff and a lack of subject experts in the permitting agencies. They also noted that vacation schedules of the staff and time of the year when the permit applications are filed can affect permitting timelines. The lack of staff or expertise, overlapping jurisdiction over sensitive issues, lack of (or difficulty in) inter-agency coordination, and other specific examples causing permitting delays were also mentioned by developers during interviews.

Using the information gathered from previous studies (Levine et al., 2013; Young et al., 2014; GeoReport, 2014; Young and Levine, 2018; Young et al., 2019; USDOE, 2019; Neupane and Adhikari, 2022), we prepared a list (Table 1) of generalized environmental management/review scenarios likely to occur at different geothermal sites. Specifically, the various environmental management and review scenarios given in Table 1 reflect the CEQA/NEPA review process that occurred (or is occurring) to one (or many) of the geothermal projects in Imperial County, California. Depending upon the presence or absence of prior CEQA/NEPA reviews and biological, environmental, and cultural resources in the potential geothermal project area, the permitting process can have a wide range of permitting timelines, as described in GeoReport (2014). As previously suggested by Levine et al. (2013), each type of scenario given in Table 1 could also result in multiple environmental reviews and permitting timelines depending on the lack of or availability of expertise and the existence of prior-knowledge of processing geothermal exploration/development permitting in the Lead Agency with an established mechanism (e.g., memorandum of understanding) between inter-agencies.

Table 1. Generalized environmental management/review scenarios impacting permitting timelines.

Types	Scenarios
A	Land Use Plan (LUP) and Programmatic Environmental Impact Statement (PEIS) and/or Programmatic Environmental Impact Report (PEIR) exist, and no significant environmental resources or cultural issues identified.
B	LUP PEIS/PEIR exist, presence of environmental (species of concern) or cultural issues where all responsible agencies concur with mitigation approaches of Lead Agency.
C	LUP PEIS/PEIR exist, presence of environmental (species of concern) or cultural issues where many responsible agencies have diverse mitigation approaches, and require reconciliation.
D	LUP PEIS/PEIR exist, presence of major environmental (species of concern) or cultural issues, petition & legal challenge.
E	LUP or PEIR/PEIS do not exist, may require early steps, e.g., nomination and pre-leasing reviews.

Since each existing or ongoing geothermal development project has its own unique review process and timeline, we created a hypothetical geothermal project in the Salton Sea KGRA to assess and compare the impact of various environmental management scenarios (Table 1) on sLCOE. This hypothetical geothermal project was subject to different environmental management and review/permitting processes, resulting in different project completion timelines. Since Imperial County (Lead Agency for geothermal development of < 50 MW in the Salton Sea KGRA) has a well-developed CEQA review process, we limited our analysis operating with assumption that the Lead Agency has experienced staff. However, in some environmental modeling scenarios, multiple agencies would require to approve permits satisfying all CEQA, NEPA, and Section 404 of Clean Water Act (CWA), so our assumption could appear rather optimistic.

3. GEOTHERMAL ENERGY DEVELOPMENT IN IMPERIAL COUNTY

Imperial County, California, has been known for its huge potential for geothermal energy. Since the 1970s, USGS has identified as many as nine KGRA within this county. At present, Imperial County hosts nearly 20 geothermal power plants in four KGRAs, totaling about 930 MW of power generation. Most of the geothermal power plants in this county were built in the 1980s and 1990s. Despite some of the geothermal development projects having completed all regulatory and permitting requirements, there has been only a few successful development activities since 2000. Only one new geothermal power plant was built in the county since 2010. Recently, the area has seen an uptick in geothermal activities.

3.1 Permitting and Reviewing Agencies for Imperial County Projects

Depending upon the land ownership and size of the proposed geothermal development, one of the three agencies—Imperial County, California Energy Commission (CEC), or Bureau of Land Management (BLM)—can act as the lead agency for reviewing, coordinating, and permitting geothermal-related activities in Imperial County, California. Regardless of the size of the proposed geothermal development plant, the BLM acts as the lead agency for leasing, exploration, and development activities on the federal lands. On the state and private lands, CEC is the lead agency for permitting and conducting review processes for exploration and development activities with a designated power production plant larger than 50 MW. However, if the designated power production plant is smaller than 50 MW, the lead agency is the Imperial County Planning and Development Services (ICPDS). Most of the individual geothermal power plants in Imperial County are of 49.9 MW or smaller. According to the staff from Imperial County, California Energy Commission (CEC), and Geologic Energy Management Division (CalGEM), CEC was once busy with the permitting of larger non-geothermal power plants (e.g., fossil fuels or nuclear), so it delegated permitting authority to the county for smaller geothermal power plant developments. To avoid relatively lengthy and costly CEC permitting processes for larger geothermal development, geothermal developers limited their geothermal development within the 50 MW and obtained permitting and CEQA review through the county. Regardless of CEC or the county leading the permitting and CEQA review process, several local, state, and federal agencies take part in the review process as responsible agencies (Table 2). Various private groups (citizens, organizations, and environmental justice groups, etc.) can also provide comments on the CEQA documents during the review period. Some agencies (e.g., US Army Corp of Engineers in issues related to Section 404 of CWA) where environmental, biological, and/or cultural resources are at stake also have the jurisdiction over those resources and play a critical role in defining the mitigation approaches and permitting the projects.

Table 2. Lead and responsible agencies for permitting and environmental review process in Imperial County, California.

Lead Agency	When/where	Responsible Agencies
Imperial County Planning and Development Services (ICPDS)	<50 MW, state and/or private lands	Local: Imperial County Air Pollution Control District, Imperial Irrigation District (IID), ICPDS (when CEC is Leading Agency), etc. State: California-EPA, Geologic Energy Management Division (CalGEM), California State Land Commission, California Department of Transportation, California Department of Water Resources, California Department of Fish and Wildlife (CDFW), California Department of Toxic Substances Control, California Native American Heritage Commission, Colorado River Board of California, etc. Federal: US Environmental Protection Agency, US Forest Service, Department of Energy, Department of Defense, US Army Corp of Engineers, Bureau Indian Affairs, etc. Concerned citizens, organizations, environmental justice groups
California Energy Commission (CEC)	>50 MW, state and/or private lands	
Bureau of Land Management	Federal lands	

3.3 Selected Sites

For this study, we collected timelines data for one existing power plant, two geothermal projects that completed regulatory approval processes, and one geothermal project in the process of getting regulatory approvals, and one prospective site with past exploration activities. **Error! Reference source not found.**3 provides the selected projects, degree of data availability, and level of TEA conducted for the selected projects in Imperial County. Both CEQA/NEPA review timelines, permitting process, and available costs data associated with permitting, exploration, and development activities were reviewed to create a hypothetical geothermal development in the Salton Sea KGRA.

Table 3. Study sites in Imperial County, California

Geothermal Area	Geothermal Project/Developer	Project Phase	Data Availability	Level of TEA
Salton Sea KGRA	Hudson Ranch-I/ EnergySource	Complete with commission of power plant	Permit timelines and costs	sLCOE
Salton Sea KGRA	Hudson Ranch-II/ EnergySource	Permitting and regulatory requirements completed, some injection/production wells drilled, no power plant	Permit timelines and partial costs	sLCOE
Truckhaven GLA	Truckhaven-LEA/ Layman Energy Associates and Iceland America Energy	Permitting and regulatory requirements partially completed; exploratory deep well drilled	Partial permit timelines and partial costs	
Salton Sea KGRA	Blackrock 1-2-3 (CalEnergy)	Permitting and regulatory requirements completed; no wellfield or power plant development	Permit timelines	
Salton Sea KGRA	Hell's Kitchen (Controlled Thermal Resources)	Partial permitting and regulatory requirements completed	Partial permit timelines	

3.3.1 Hudson Ranch - I, Salton Sea KGRA

Hudson Ranch - I (currently known as JL Featherstone Plant), owned and operated by EnergySource, is located in Salton Sea KGRA. EnergySource started the developmental activities with the submission of a CUP application to the ICPDS in 2006. The CUP application intended to drill up to seven production and injection wells with the construction of two well pads, geothermal power plants, including brine processing and turbine-generator facilities, and a 92-kV transmission line. After county received the CUP application, it started CEQA review process. It took about 14 months to complete the CEQA review process and approval with mitigated negative declaration (MND) (Figure 3). During the CEQ review process, county received a comment from California Native American Heritage Commission (CNAHC). The review comment from CNAHC mainly stated the legal requirement to protect the Sacred Sites and articles of cultural importance to tribes. It suggested consulting with local tribes to avoid unanticipated discoveries of cultural resources or burial sites in the project area.

Table provides the cost associated with the CUP and completion of the project. The wellfield, plant, and transmission line development started in 2008. This project was completed in March, 2012.

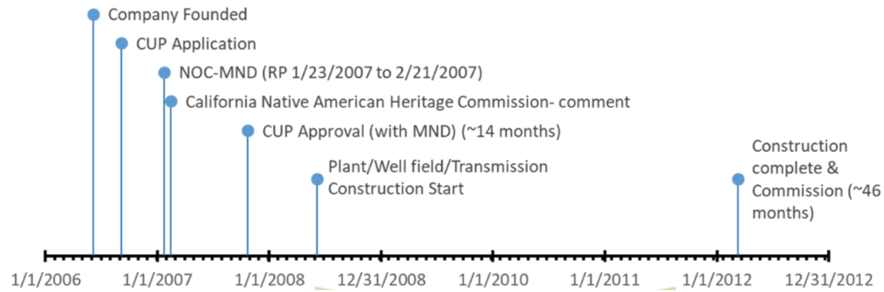

Figure 3. Permitting and CEQA review timelines for Hudson Ranch - I.

Table 4. Conditional Use Permit and development timelines and project costs for Hudson Ranch - I.

Hudson Ranch I/Energy Source **Power Capacity 49.9 MWe** CUP # 06-0047 California Clearing House # 2007011097					
	CUP-CEQA[1]			**Wellfield/Plant/Transmission**	
	Application	NOC-MND[2]	MND Approval	Start	Complete
Dates	9/6/2006[3]	1/23/2007	10/23/2007	6/6/2008	3/9/2012
Timelines (month)	13.7			45.7	
Cost	$5,915[4]			$414,000,000[5]	

1. Conditional Use Permit, triggered CEQA review for the project.
2. Notice of completion of CEQA review process with Mitigated Negative Declaration.
3. Exact date not found.
4. Cost data from ICPDS.
5. Cost data from EnergySource.

3.3.2 Hudson Ranch - II, Salton Sea KGRA

EnergySource applied for CUP for their second geothermal project (Hudson Ranch – II) in 2010. The general timelines of this permitting and CEQA review process is presented in Figure and Table . As shown in Figure 4, the initial CUP application and CEQA review of the project approved within 5 months with MND. However, this decision was appealed by unions, and ICPDS had to conduct a full-scale CEQA review with preparation of an EIR.

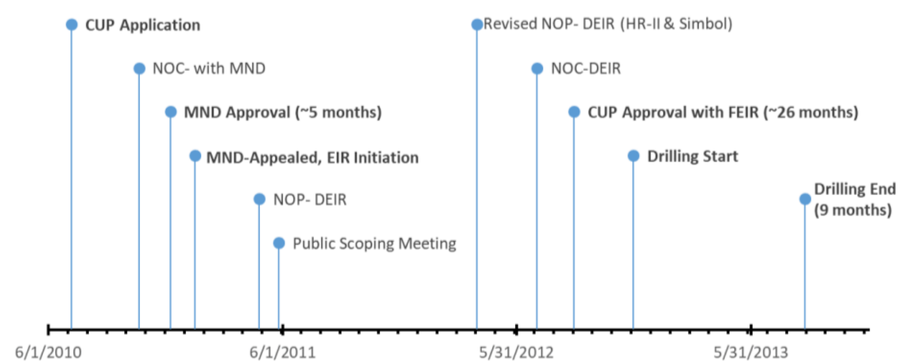

Figure 4. Permitting and CEQA review timeline for Hudson Ranch - II.

Table 5. Conditional Use Permit and well drilling timelines and associated costs for Hudson Ranch - II.

Hudson Ranch II & Simbol II Lithium Plant
Power Capacity: 49.9 MW
HRP-II CUP # G10-0002/Simbol II CUP#12-0005
California Clearing House # 2010101065

Steps	CUP/CEQA									Drilling	
	App	NOC - MND	MND Apv	MND-Apd	NOP- DEIR	Scoping	Re NOP - DEIR	NOC-DEIR	CUP Apv with EIR	Start	End
Dates	7/7/2010	10/20/2010	12/8/2010	1/15/2011	4/26/2011	5/26/2011	3/30/2012	7/2/2012	8/29/2012	11/29/2012	8/24/2013
Timelines (months)	26.1									8.933	
Costs	$729,006									$7,150,000	

App: Application; NOC-MND: Notice of Completion-Mitigated Negative Declaration; Apv: Approved; Apd: Appealed; NOP-DEIR: Notice of Preparation-Draft Environmental Impact Report; Re: Revised.
CUP-CEQA Cost data from ICPDS; Wells drilling cost estimated based on information provided by Rickard et al. (2014)

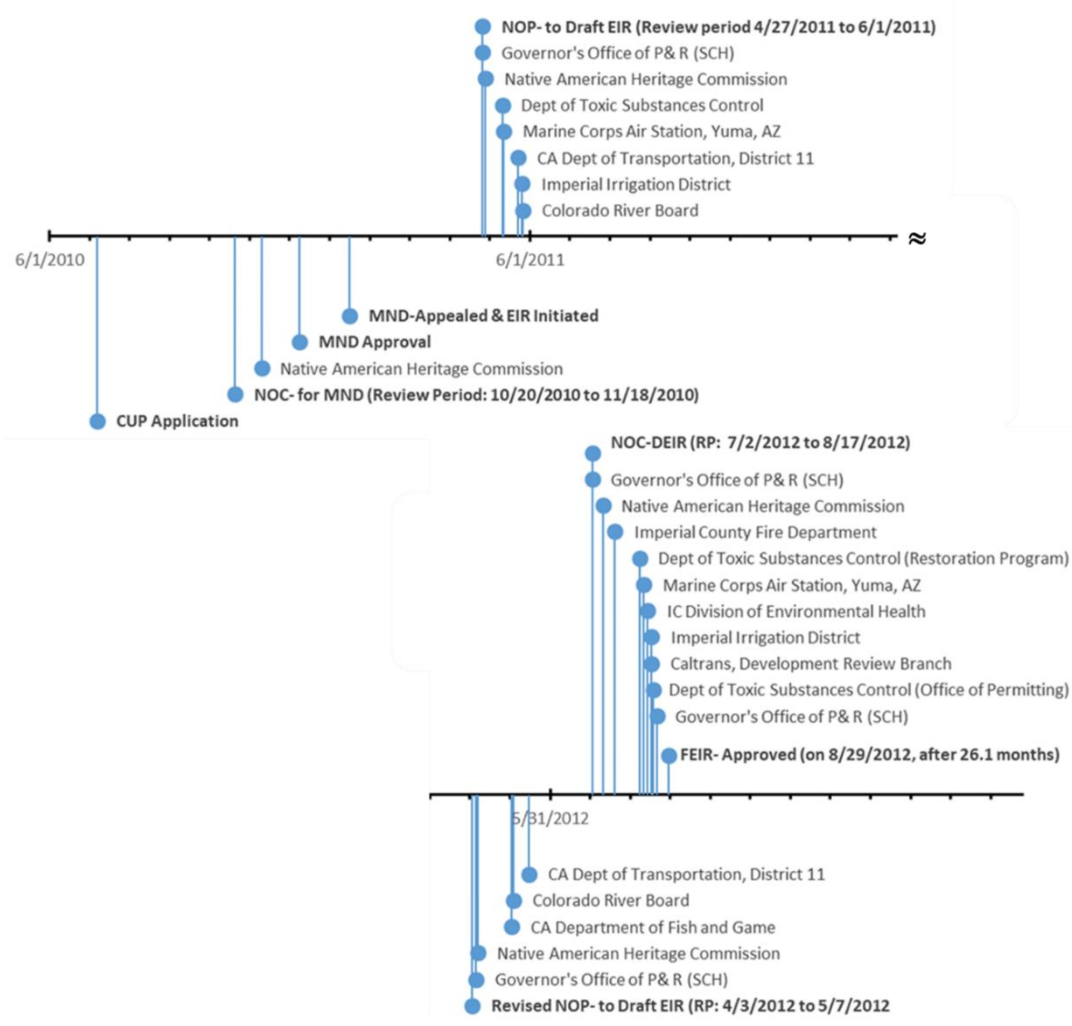

Figure 1. Detailed timeline of Hudson Ranch - II CEQA review process.

During interviews with both developers and regulators, two unions—California Union for Reliable Energy (CURE) and Labor Union International (LIUNA) —are mentioned as entities that are generally expected to appeal and challenge the CEQA review decisions. Both regulators and developers agree that no matter how well the CEQA review was conducted, mitigation measures were developed, and informed decisions were made, there always remain some challengeable aspects such as depth and range of review/analysis conducted, how and who conducted the background studies, and so on. Unions find these challengeable aspects and use them to appeal the review process, mostly to have project-labor agreements in their terms. Consequently, these appeals and challenges can add between one to one-and-a-half years to a project, as happened with the Hudson Ranch - II.

Once ICPDS started comprehensive CEQA review process, a second co-located project (Simbol Materials' lithium extraction) was combined with the Hudson Ranch - II for the CEQA review. For both projects, the CUP was approved in 2012, after 26 months (Figure 1).

3.3.3 Truckhaven Geothermal Leasing Area

Several companies conducted geothermal exploration work in the Truckhaven Geothermal Area, which is located to the west of Salton City town in the northwestern part of Imperial County. This resource area has a complex land ownership structure with parcels managed by federal, state, and private entities. Also, Ocotillo Wells State Vehicle Recreation Area is located nearby this resource area. In 2007, BLM defined this area as Truckhaven Geothermal Leasing Area (TGLA) and prepared a programmatic EIS with a goal of facilitatin g geothermal leasing, exploration, and developmental activities.

Earlier geothermal exploration efforts included geological and exploratory well drilling in the area. In 1982, Phillips Petroleum drilled a deep well in the area and verified a viable geothermal resource. Later, Union Oil and others leased state/school lands in this area for additional exploratory works, including deep drilling.

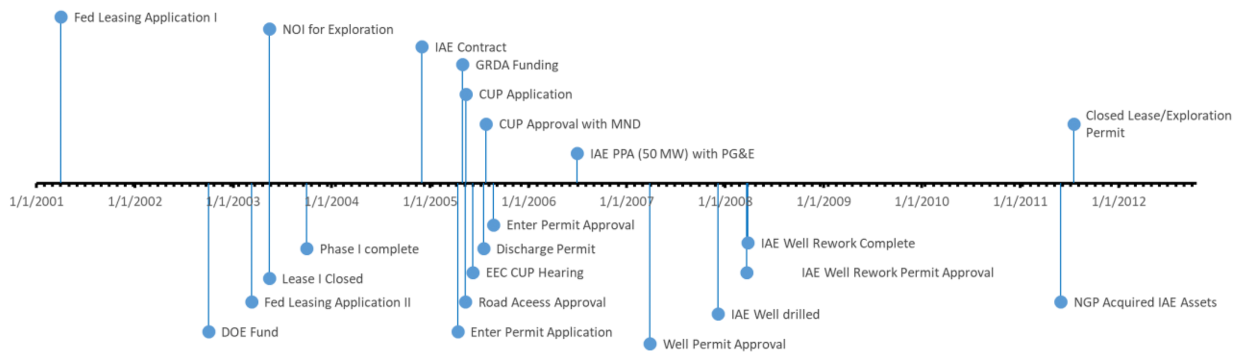

Figure 6. Detailed timelines of various permitting and exploration activities of LEA-IAE project in Truckhaven GLA.

In 2001, Layman Energy Associates (LEA) secured noncompetitive leasing rights in the area and conducted a geological assessment of the geothermal resources with a DOE grant. Layman Energy/Iceland America Energy jointly extended exploration and development activities with a grant from Geothermal Resources Development Account (GRDA). This effort culminated with a deep well drilling (IAE Truckhaven - 1). However, Iceland America Energy pulled out of this project in 2011 and transferred all assets to Nevada Geothermal Power (Figure 6). The lease owners did not apply for an extension of existing leases, resulting in BLM terminating all leases and starting a new process for competitive leasing. In 2014, Ormat Technologies and its associates obtained the federal land lease for future exploration and development activities.

3.3.4 Black Rock 1, 2, and 3, Salton Sea KGRA

Black Rock 1, 2, and 3 Geothermal Power Project, in lieu of formerly Salton Sea Unit # 6, involved geothermal development activities in the Salton Sea KGRA. An affiliate company of CalEnergy (Berkshire Hathaway Energy), CE Obsidian Energy, filed an application for certification (AFC) to CEC to establish a 185 MW geothermal plant in July 29, 2002. With assistance from several responsible agencies, CEC led the effort to review the project, including resource viability for power generation and environmental review (Figure). CEC approved AFC for this project on December 17, 2003. In 2007, CEC approved an added binary-cycle system to the existing plan with an increase in capacity to 215 MW. CalEnergy requested to delay the construction by extending the deadline multiple times along with a change to the project name and design over time. Instead of a single large multi-flash geothermal power plant (Salton Sea Unit #6), the amended project would have three separate single-flash power units (Black Rock 1, 2, and 3), each with a capacity of 53 MW. However, in 2017, CalEnergy requested to null the AFC and terminated the project. In our discussion with CalEnergy personnel, the reason for termination of this project was prevailing unfavorable market forces.

3.3.5 Hell's Kitchen, Salton Sea KGRA

Controlled Thermal Resource (CTR) is working to develop Hell's Kitchen geothermal power and lithium extraction plants in Salton Sea KGRA. With multiphase development, CTR is planning to develop a 140 MW geothermal power production facility and an extraction of ~34,700 tonnes/year lithium carbonate equivalent (LCE) with the potential to expand. In the first stage, however, CTR is aiming to produce 49.9 MW of power and 17,350 tonnes/year LCE. In June 2020, it signed a 40 MW power purchase agreement (PPA) at $69/MWh with Imperial Irrigation District (IID). Currently, it is in the process of getting approvals to develop well field, power plant, and a mineral extraction facility. According to IID Energy Consumers Advisory Committee' January 6, 2020, meeting minutes (IID, 2020), the CTR's leased area also covers a portion of the Salton Sea, which is defined as the Waters of the United States (WOTUS), a navigable body of water. With this designation, the permitting process requires CEQA, NEPA, and Section 404 of the CWA reviews and approval from local, state, and federal agencies. Section 404 of the CWA, specifically, requires the U.S. Army Corp of Engineers (USACE) to review the project for its potential impacts on WOTUS. If USACE anticipates the project to cause potential adverse impacts on existing environmental and biological resources, a mitigation plan must be developed before approving the permit for development.

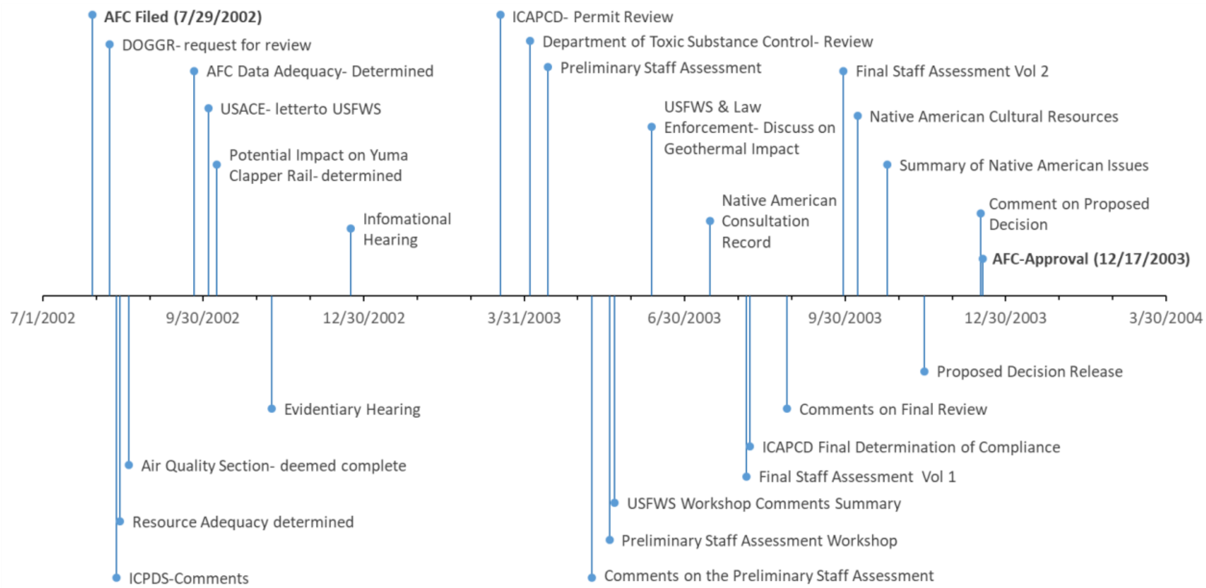

Figure 7. Timelines of CEC certification process for Blackrock 1-2-3 project in Salton Sea KGRA.

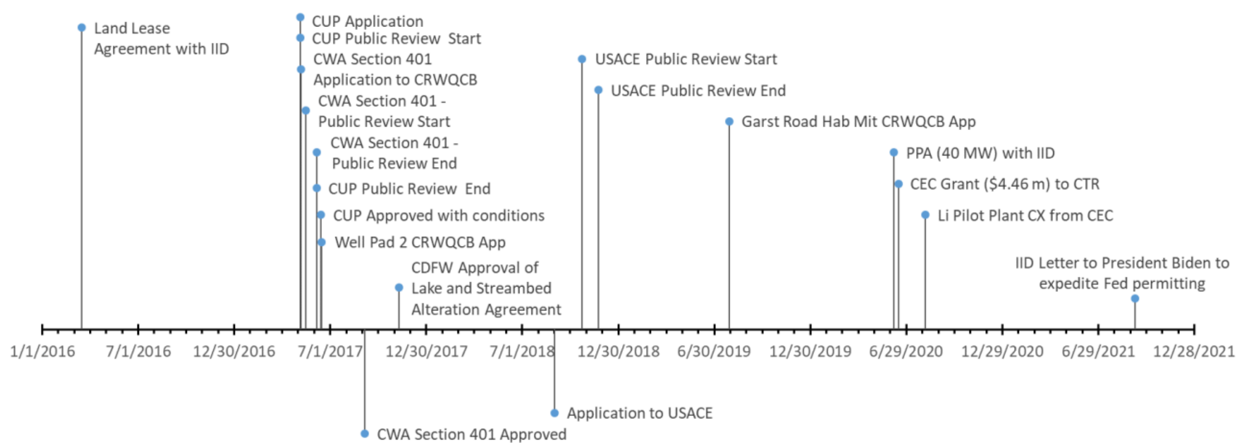

Figure 8. Timelines of ongoing permitting reviews of CTR's Hell's Kitchen project.

The timeline of the ongoing permitting process of Hell's Kitchen project is shown in Figure 8. In summary, CTR applied and obtained CUP from ICPDS in 2017 for the exploration of geothermal resources and validated the viability of the geothermal resource for a possible future geothermal power plant. This CUP included the construction of up to four well pads for up to six exploratory wells on the land leased from IID. ICPDS approved this CUP with conditions as an addendum to the Imperial County's Programmatic Final EIR, Renewable Energy & Transmission Element (SCH# # 2014071062) prepared in 2015. The stipulated conditions in the CUP approval are the receipt of approvals from other agencies [e.g., California Department of Fish and Wildlife and USACE). Recently, IID wrote a letter to President Biden to expedite CTR's federal permitting applications. Based on the available data and information obtained through interviews with CTR and USACE, the delays in permitting for this ongoing project could be traced to the lack of consensus among developers, state agencies, and federal agencies on mitigation measures needed at or nearby the project site to minimize or compensate the potential impact the project would cause to the WOTUS and its environmental and biological resources.

3.3.6 Hypothetical Geothermal Project in Salton Sea KGRA

We tested TEA sensitivity on permitting timeline by creating several environmental management and permitting scenarios applied to a hypothetical geothermal power plant development in the Salton Sea KGRA. The hypothetical project is designed to have various stages with the potential for different environmental modeling scenarios and degrees of complexity in the CEQA/NEPA review process. Specifically, these scenarios are consistent with the environmental management scenarios given in Table 1, and mostly mimic the CEQA/NEPA review process that occurred or are occurring to one or many of the geothermal development activities in Imperial County. The Scenario E in Table 1 is not considered for the hypothetical case since the geothermal resource area around the Salton Sea is a designated KGRA (Imperial County, 1982). The Imperial County has also developed a Master EIR for the geothermal development in the Salton Sea KGRA in 1981 (Imperial County, 1981), and the county periodically updates its Renewable Energy & Transmission Element EIR (e.g., ICPDS, 2015). The hypothetical project facilitated generation of a complete set of synthetic costs and timeline data for various stages of the project and assess the impact of permitting timelines on the LCOE. Different stages of this hypothetical project and CEQA/NEPA review scenarios are given below.

1. The developers secured a 30-year lease for 1000 acres of land from IID in 2010. The terms of the lease are similar to the land lease terms that CTR had with IID in 2020. Specifically, the lease term includes a rate of $20/year/acre during the exploration phase. After the resource was determined viable, the lease amount would increase to $100/year/acre for 950 acres and $600/year/acre for 50 acres of land occupied by the well field and power plant. Developers also secured access to industrial water from IID. To allow us to make various environmental scenarios and permitting timelines and test their impact on LCOE, the actual project would sit in two potential locations within the leased land. In one case, the well field and plant would sit outside of the Salton Sea playa that only requires minor improvements in the road for access. Well pads, wells, and plant facility would be built on deeply disturbed farmland. The second potential site would be located outside the playa but may require access to the playa or even sit well pads on the playa. If there is a need to access land or playa below -231 ft elevation, it also requires both NEPA and CWA Section 404 reviews and permitting from USACE.
2. Despite the site being within KGRA, the developers chose to assess the resource viability at the project site for a future 49.9 MW plant.
3. They applied CUP for exploration by drilling and testing. The timeline of the CUP and other regulatory permits varies with the location and various environment management scenarios. Eventually, all permitting requirements were completed with different timelines for different scenarios (**Error! Reference source not found.** and Table).

Table 6. Permitting, exploration, and development timelines for a hypothetical geothermal project in Salton Sea KGRA.

IID Land Leased	Exploration by drilling wells and testing									
	CUP ICPDS		Ancillary Permitting							
			Scenario- A		Scenario-B		Scenario-C		Scenario-D	
Signed	Applied	Approved- MND	None		Applied	Approved	Applied	Approved	Applied	Approved
4/6/2010	7/7/2010	12/8/2010			7/15/2010	8/15/2011	7/15/2010	4/15/2013	7/15/2010	10/15/2015
Well Drilling and Testing (4 wells)			Start	End	Start	End	Start	End	Start	End
			12/15/2010	7/8/2011	10/15/2011	12/15/2012	6/15/2013	10/15/2014	12/15/2015	6/15/2016
Utilization										
CUP ICPDS			Applied	Approved- EIR	Applied	Approved- EIR	Applied	Approved- EIR	Applied	Approved- EIR
			7/20/2011	2/15/2012	2/15/2012	10/15/2014	12/15/2014	7/15/2016	8/15/2016	4/15/2018
Ancilliary Permits			None		Applied	Approved	Applied	Approved	Applied	Approved
					2/15/2012	10/15/2014	12/15/2014	10/15/2016	8/15/2016	8/12/2019
Production/Injection wells, Power Plant, and Transmission lines			Start	End	Start	End	Start	End	Start	End
			4/15/2012	4/15/2016	12/15/2014	12/15/2018	12/15/2015	12/15/2019	10/12/2019	10/12/2023

4. The project moved ahead with drilling (4 wells) and testing for resource viability. After little over a year-long effort (in each scenario), the project determined the presence of adequate resources to sustain operation of a 49.9 MW plant.
5. Developers applied to ICPDS for resource utilization CUP. They also applied to obtain other permitting requirements to various agencies. Various environmental management scenarios were considered again for CUP and other permits that resulted in different permitting timelines.
6. Once all permitting requirements were met, developers were successful in building the power plant with a capital cost similar to Hudson Ranch - I.

Timelines of this hypothetical project starting from the land lease agreement to the commencement of the power plant are given in Table 6 with various CEQA and NEPA review scenarios. Scenarios A through D in Table 6 are consistent with Scenarios A through D in Table 1. For Scenarios A and B, the permitting timelines are similar to timeline structures of Hudson Ranch - I and Hudson Ranch - II. However, there are some variations, such as for Hudson Ranch - II, EnergySource directly applied for resource utilization CUP with an expectation that the resource is viable. Scenarios C and D also mimic the ongoing CEQA/NEPA review process of CTR's Hell's Kitchen project; however, there are some exceptions, such as the permitting process of this hypothetical project in both scenarios (C and D) obtained all required permits, and CTR is still uncertain when it will be able to obtain permitting approvals from federal agencies. In this regard, Scenarios C and D would even appear more favorable than what would potentially happen with the permitting for CTR's Hell's Kitchen project.

4. RESULTS OF TECHNO-ECONOMIC ANALYSIS

4.1 Simplified LCOE for Hudson Ranch - I and II

Simplified LCOE values were calculated for both Hudson Ranch - I, and Hudson Ranch - II. Project specific available cost data, such as leasing costs (bonus bids), lease rental costs, permitting costs, and other exploration-development related costs, were used to calculate the sLCOE. For each site, the cost data were adjusted to the year of power plant completion by applying a constant annual interest rate of 6%, assuming those costs were financed. Given the wide range of site-specific variables, it is likely that some itemized costs for each project site considered could not be captured. It is expected that any uncaptured itemized costs would be small in proportion to the overall project costs and would have little impact on sLCOE.

The Hudson Ranch - I and II geothermal plants resulted in sLCOE values of $99 and $105 per MWh, respectively. These values are higher than the national average electricity cost. [Note: Hudson Ranch - II was never built. The calculation is based on the permitting cost data and timelines of this project with the plant, well field, and transmission costs of Hudson Ranch -I]. The costlier electricity from these plants reflect higher development costs in the Salton Sea KGRA because both the plant and the well field have to be designed for handling highly corrosive brines.

4.2 Simplified LCOE for Hypothetical Geothermal Development

Table 7 presents the summary of different itemized costs, total project costs, sLCOE, and missed revenue (because of the delayed completion of the project with CEQA/NEPA review Scenarios B through D as given in Table 1 and Table 6). In Scenario A, the permitting process is quicker. The project site is in an area with no significant environmental issue. All responsible agencies concurred with the CEQA analysis and mitigation measures of the Lead Agency (ICPDS). The project is completed within six years from the beginning of the project.

Table 7. Different cost data based on CEQA/NEPA review timelines.

Different economic parameters	Scenario A	Scenario B	Scenario C	Scenario D
Plant Capacity	49.9 MW	49.9 MW	49.9 MW	49.9 MW
Plant Completion year	2016	2018	2019	2023
Cumulative land rental until plant completion	$760,974	$1,001,998	$890,834	$1,341,701
Exploration CUP cost	$6,092	$6,092	$6,092	$6,092
Exploration cost	$5,820,000	$5,940,000	$6,060,000	$6,240,000
Utilization CUP cost	$721,716	$729,006	$743,586	$765,456
Well Field, Plant & Transmission	$423,561,834	$443,925,383	$456,143,513	$476,507,063
Total cost at completion of project	$430,870,616	$451,602,480	$463,844,025	$484,860,313
sLCOE ($/MWh)	$103	$107	$110	$114
Missed Revenue	$0	$64,287,827	$96,538,835	$227,011,607

It is important to note that this hypothetical project with CEQA review, permitting, and development activities similar to that of Hudson Ranch - I took six years to complete. This project completion timeline shows that it would be difficult to add any new geothermal power to California Public Utilities Commission (CPUC) by 2026 even if the geothermal permitting process is started now. Developers and some regulators (e.g., CalGEM staff) emphasized the importance of fast-tracking the geothermal permitting processes either by streamlining the review processes to an agency or by exemption (e.g., CEQA exemption) to have significant geothermal contribution towards meeting the target of California's renewable energy portfolio by 2030 and beyond.

With increasing environmental sensitivities and complexities in CEQA/NEPA review process, the permitting timeline becomes longer with Scenarios B through D and pushes the project completion dates further into the future. With this, the sLCOE values become higher for the produced electricity. Compared to Scenario A, the project completion time is longer than two, three, and seven years in Scenarios B, C, and D, respectively. The sLCOE values with Scenarios B, C, and D are 4 to 11% higher than the sLCOE with Scenario A. However, the biggest economic impact occurs on the delayed revenue generation. Compared to Scenario A, developers would lose about $64 million, $96 million, and $227 million in Scenarios B, C, and D by the time developers complete the project in the respective scenarios. During our interview with CTR's staff, they categorized this lost revenue generation as one of the biggest economic impacts that could kill the project, keeping it from being successful.

5. CONCLUSIONS

Development of geothermal resource requires multi-layered regulatory permitting by local, state, and federal agencies. In this paper, we presented permit timelines and associated cost data for a few geothermal projects in Imperial County, California. The collected data indicate that permitting processes can take a few months to several years.

The assembled data and information from interviews with stakeholders were used to conduct a quantitative evaluation of economic impacts from the permitting cost and timeline on the cost of geothermal electricity. We calculated sLCOE values for one existing power plant and a geothermal project that completed all permitting processes yet did not build the power plant. It is important to note that these two projects completed the permitting process without significant delays. However, our analysis confirms that with increasing complexities in permitting processes, the expanded permitting timelines can more than double the project completion timelines with a greater financial impact on the future economic returns.

To evaluate the role of various environmental management and permit review processes on LCOE, we considered a hypothetical geothermal project in the Salton Sea KGRA. This project could be subject to any one of the four CEQA/NEPA review scenarios with increasing biological and environmental issues and involvement of local, state, and federal agencies with overlapping jurisdictions. Although the project is a hypothetical, the scenarios considered largely mimic the CEQA/NEPA review processes that either occurred during permitting processes of prior projects or represent the ongoing permitting processes of some current projects. In these scenarios, the fastest timeline would have the project completed in 6 years. In contrast to this, the project that would go through the longest permitting timeline would require 13 years to complete it. The sLCOE values with longer timelines compared to the sLCOE value with the fastest timeline range from 4 to 11% higher. A more prominent adverse economic impact from the increasing permitting timelines is illustrated by the potential loss of revenue—between $64 and $227 million—that the developers could have otherwise generated if the project were completed sooner. These results demonstrate that inefficient and protracted permitting processes can, in some cases, determine the success of a geothermal project.

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REFERENCES

EIA, 2020. Capacity Factors for Utility Scale Generators Primarily Using Non-Fossil Fuels. US Energy Information Administration. Retrieved from https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b.

Imperial County, 1981. Final Salton Sea Anomaly Master Environmental Impact Report, and Magma Power Plant # 3 (49 MW) Environmental Impact Report. Imperial County, Volume I and II, p. 978.

ICPDS, 2015. Renewable energy and transmission element, County of Imperial General Plan. Imperial County Planning and Development Services Department, Imperial County, p. 77.

IID, 2020. Imperial Irrigation District, Energy Consumers Advisory Committee Meeting Minutes on January 6, 2020. Imperial Irrigation District, p. 7.

Levine, A., Young, K.R., and Witherbee, K., 2013. Coordinating Permit Offices and the Development of Utility-Scale Geothermal Energy. GRC Transactions, Vol.37, 2013.

Levine, A. and Young, K. R., 2016. Geothermal Resource Portfolio Optimization and Reporting Tool Protocol: Socio-Economic Assessment Tool, Vol. IV, National Renewable Energy Laboratory, Golden, CO.

Levine, A. and Young, K.R., 2017a. Crossing the Barriers: An Analysis of Land Access Barriers to Geothermal Development and Potential Improvement Scenarios. GRC Transactions, 41.

Levine, A. and Young, K.R., 2017b. Crossing the Barriers: An Analysis of Permitting Barriers to Geothermal Development and Potential Improvement Scenarios. GRC Transactions, 41.

Loewen, J., 2020. LCOE is an undiscounted metric that inaccurately disfavors renewable energy resources, The Electricity Journal, 33, 106769.

GeoRePORT, 2014. Geothermal Resource Reporting. https://openei.org/wiki/GeoRePORT/About#top.

Neupane, G. and Adhikari, B., 2022. Economic Impact of Permitting Timelines on Geothermal Power in California, Nevada, and Utah. Final Project Report. INL/EXT-21-65247, p. 44.

Richard, C., 2012. Developmental Barriers vs. Policy Incentives in Geothermal Power. GRC Transactions, 36, 115-120.

Rickard, W., Bailey, A., Pahler, M. and Cory, S., 2014, February. Kymera™ hybrid bit technology reduces drilling cost. In Proceedings of the Thirty-Ninth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California.

U.S. Department of Energy, 2019. GeoVision: Harnessing the Heat Beneath our Feet. DOE/EE-1306. U.S. Department of Energy, Washington, D.C., p. 218.

Williams, C.F., Reed, M.J., Mariner, R.H., DeAngelo, J., and Galanis, S.P. Jr., 2008. Assessment of moderate- and high-temperature geothermal resources of the United States. US Department of the Interior, US Geological Survey, Fact Sheet 2008-3082.

Young, K.R., Witherbee, K., Levine, A., Keller, A., Balu, J. and Bennett, M., 2014. Geothermal Permitting and NEPA Timelines. GRC Transactions, 38, 893-903.

Young, K.R. and Levine, A., 2018. Using GeoRePORT to report socio-economic potential for geothermal development. Geothermics, 74,163-171.

Young, K., Levine, A., Cook, J., Heimiller, D., Ho, J., 2019. Barriers: An Analysis of Non-Technical Barriers to Geothermal Deployment and Potential Improvement Scenarios. National Renewable Energy Laboratory, Golden, CO, Technical Report NREL/PR-6A20-71641, p. 126.