DE-FOA-0002524: Opportunities to Improve Geothermal Technology Cost and Performance Modeling

DATE: April 28, 2021
SUBJECT: Request for Information (RFI)

Description

The Geothermal Technologies Office (GTO), within the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE), welcomes input from energy system modelers, geothermal developers and operators, utilities and public utility commissions, as well as from academia, research laboratories, government agencies, and other geothermal stakeholders on opportunities to improve geothermal technology cost and performance modeling. As variable renewable energy resources continue declining in cost, and grid operators transition to greater use of what is increasingly cost-competitive energy storage, the energy and capacity value of geothermal generation needs to be accurately represented and captured by resource adequacy planners. GTO is soliciting this Request For Information (RFI) from the broader stakeholder community in order to ensure that geothermal technology costs and performance assumptions are most accurately represented in all grid modeling and planning efforts. This will ensure that geothermal achieves appropriate market share that can support a reliable, resilient, and decarbonized grid. With the help of stakeholder feedback from this RFI, GTO aims to improve its understanding of where there may be gaps in existing geothermal technology performance and cost models, and thus where to best focus future potential efforts for eliminating such gaps.

Background

Technology and project cost estimation modeling tools serve several important purposes for a wide range of stakeholders internal and external to DOE. Externally, states such as California are actively undertaking grid planning activities using a variety of energy resource projection and planning models with the goal of meeting clean-energy targets such as those set forth in state renewable portfolio standards (e.g., California SB100[1]). As shown in Figure 1, these planning activities may directly inform procurement of new geothermal megawatts through capacity expansion and production cost models that draw on data which are often sourced from products such as the National Renewable Energy Laboratory's (NREL) Annual Technology

[1] https://www.energy.ca.gov/sb100

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Baseline[2] (ATB). Generation technology performance and costs in the ATB are in turn derived from technology-specific cost estimation tools that rely on accurate detailed, plant-level cost and performance data. In the case of geothermal technologies, GTO developed the Geothermal Electricity Technology Evaluation Model (GETEM)[3] to serve this role.

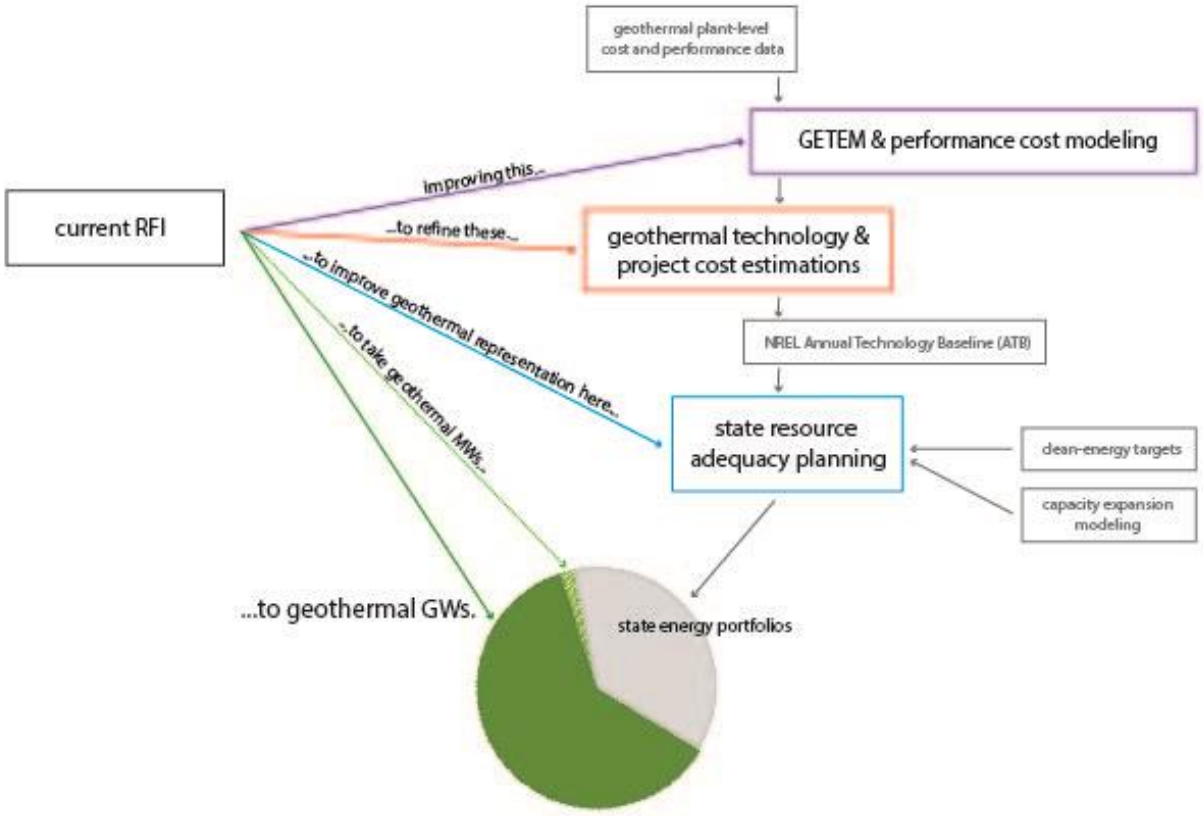

Figure 1. Graphical flow of raw, plant-level geothermal cost and performance data through technology-specific cost estimation tools like GETEM, NREL's Annual Technology Baseline, and into resource adequacy planning activities that inform state energy portfolios.

GETEM is a long-standing essential geothermal project cost estimation tool currently in use by GTO and other stakeholders to conduct technology performance and cost assessments. The model can be used to analyze and evaluate the state of existing geothermal technologies and

[2] https://atb.nrel.gov/electricity/2020/index.php?t=gt
[3] GETEM can be downloaded at the following site: https://www.energy.gov/eere/geothermal/getem-tool

estimate the cost of certain technologies 5 to 20 years in the future, given the advancement of certain relevant technology areas. The model is intended to help GTO and other stakeholders determine the extent to which different technologies impact geothermal costs, allowing sensitivity analyses of relevant RD&D activities, thus aiding in appropriate stewardship of taxpayer funded RD&D investments. Currently GETEM is used for a variety of important tasks, including:

1. Developing geothermal resource supply curves and associated analyses to aid in DOE strategic priorities and impact analysis,
2. Evaluating the potential impact of federal R&D investments in specific geothermal technology areas on costs,
3. Assessments of the current and projected economic feasibility and Levelized Cost of Electricity (LCOE) of hydrothermal systems and enhanced geothermal systems (EGS),
4. Tracking GTO progress toward meeting technology cost reduction targets, and
5. Providing critical updates to NREL's ATB, which documents a consistent set of technology cost and performance data across the renewable power sector, and whose products are directly incorporated into and support a wide range of federal and state-level energy planning and analysis activities.

GETEM was not designed as a tool for assessing specific projects or sites (Mines, 2012). In its current form it is amenable to project specific evaluation; however, its intended purpose remains the more generic assessment of geothermal power production. Furthermore, it is a deterministic model that solves for one solution at a time, incorporating subsurface information as simplified parameters, as opposed to direct incorporation of wellfield specifics and reservoir physics via numerical modeling. Consequently, in its current form, the model only generically captures the variety of dynamic subsurface processes that in reality control energy production during field operation and that are physically coupled to the performance of a geothermal power plant. A major consideration for GTO, especially in anticipation of a future with widespread EGS development, is determining the limitations these current capabilities may present in fully representing geothermal cost and performance advancements.

Purpose

The purpose of this RFI is to solicit feedback from energy system modelers, geothermal developers and operators, utilities and public utility commissions, as well as from academia, research laboratories, government agencies, GETEM users, and other geothermal stakeholders on issues related to geothermal power generation pricing, technology costs and performance, risks, uncertainties, and the expression of these characteristics in technology cost models. EERE is interested in:

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- Feedback on the broader state of the art in capacity expansion and production cost modeling used for integrated resource planning activities, particularly on specific issues and challenges to accurately represent geothermal technologies in these planning activities.
- GETEM-specific feedback on opportunities for improvement and capability enhancement.

This is solely a request for information and not a Funding Opportunity Announcement (FOA). EERE is not accepting applications.

Disclaimer and Important Notes

This RFI is not a Funding Opportunity Announcement (FOA); therefore, EERE is not accepting applications at this time. EERE may issue a FOA in the future based on or related to the content and responses to this RFI; however, EERE may also elect not to issue a FOA. There is no guarantee that a FOA will be issued as a result of this RFI. Responding to this RFI does not provide any advantage or disadvantage to potential applicants if EERE chooses to issue a FOA regarding the subject matter. Final details, including the anticipated award size, quantity, and timing of EERE funded awards, will be subject to Congressional appropriations and direction.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

Confidential Business Information

Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery two well-marked copies: one copy of the document marked "confidential" including all the information believed to be confidential, and one copy of the document marked "non-confidential" with the information believed to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

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Evaluation and Administration by Federal and Non-Federal Personnel

Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to EERE providing their response to non-Federal parties. Non-Federal parties given access to responses must be subject to an appropriate obligation of confidentiality prior to being given the access. Submissions may be reviewed by support contractors and private consultants.

Request for Information Questions: Geothermal Technology Cost and Performance Modeling

EERE welcomes feedback on the below subcategories related to geothermal technology cost and performance modeling. Please note that answering all questions below is not required and your submissions will be reviewed regardless of how many questions to respond to directly. Although responses to all questions is greatly appreciated, it is not a requirement. A template is included in Appendix A to assist your responses.

Current Landscape of Geothermal Cost Modeling Capabilities Beyond GETEM

1. What types of data are incorporated into your organization's calculations for projecting geothermal costs? Does your organization feel the data are representative, accurate, and otherwise adequate for your purposes?
2. How does your organization use cost projections and what are your typical data sources for determining cost model inputs such as: CAPEX ($/MWh), OPEX ($/MWh or $/month) capacity factor, maximum plant output with time, monthly and seasonal variations, etc.
3. How does your organization account for uncertainties in data sources discussed in questions 1 and 2?
4. Geothermal operators indicate that for newly constructed projects, capacity factors are often equal to or greater than 95%. Please tell us your perspectives on new geothermal project development capacity factors and forward projections of these capacity factors over the life of a project. What capabilities would be valuable to have for quantifying and representing this uncertainty in cost models?

GETEM-specific Considerations

1. How do you use GETEM?
2. What are the analysis gaps in the current state of the art for geothermal project cost, timeline, and performance modeling platforms, such as GETEM, with respect to each of

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the following activities? Keeping your needs in mind, please categorize the following as critical gap, minor gap, or not an existing cost modeling analysis gap:

a. Project planning
b. PPA contracting and financing
c. Leasing and permitting
d. Project exploration and development
e. Operations & maintenance
f. Planning and funding prioritization for technology innovation R&D
g. Other activities not considered above

3. Keeping your needs in mind, please identify the following model structure and capability features as most important, less important, and not at all important:
    a. Full user interface for inputs and outputs
    b. Command line operations with output suitable for post-processing and visualization
    c. Access to source code, i.e., open source for community supported development
    d. High performance computing (parallel) capabilities
    e. Proprietary language/platform versus freely available (e.g., MATLAB or Excel versus Python, FORTRAN, etc.)
    f. Capability to link to databases, data sources, or other existing and external models (e.g., from FORGE or other GTO initiatives)
    g. Flexible capability to capture potential cost and performance implications of projected changes in field and plant operation for EGS.
    h. Ability to capture costs and performance of geothermal ancillary grid services, i.e., essential reliability and/or resiliency services which go beyond the provision of bulk energy.
    i. Ambient weather conditions and elevation impacts
    j. Technology cost and performance model that could evaluate site-specific geothermal projects in addition to generic hydrothermal and EGS systems
    k. Any other desired or required user customization?

4. How important do you feel it is to incorporate uncertainty analysis within project cost and performance models?
    a. What specific capabilities would you recommend to effectively incorporate uncertainty into cost and performance modeling (e.g., Monte Carlo / Latin Hypercube Sampling, risk assessment and risk management, system and performance optimization, etc.)? Why?

b. What insights are you seeking from uncertainty analyses (e.g., exceedance probabilities, performance and cost ranges, risk analysis, other)? Please provide examples of how your organization might use these capabilities.

5. Regarding the value of coupling high fidelity, fully-integrated, full-field (reservoir-wellbore-surface network) numerical modeling capabilities with project cost and performance models – we would appreciate your feedback on the following specific questions:
   a. From your perspective, do you feel that this value is universal and equal for (a) commercial purposes, (b) resource adequacy planning purposes and (c) for more generic case studies that track R&D improvements?
   b. From your perspective, to what level of detail are coupled system physics important for ensuring cost and performance fidelity? For example, in assessing representative costs and performance for geothermal technologies, would it be necessary to incorporate detailed coupling of thermo-hydraulic-mechanical-chemical (THMC) processes in a full-field coupled numerical model?

Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to DMAGeothermal@ee.doe.gov no later than 5:00pm (ET) on May 28, 2021. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. DOE requires that responses must be provided as a Microsoft Word (.docx) attachment to the email, in 12 point font with 1 inch margins. Only electronic responses will be accepted. Appendix A contains a template that can be used for filling out responses.

Please identify your answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as they wish.

EERE will not respond to individual submissions or publish publicly a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.

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Appendix A: Optional RFI Question and Answer Template

Current Landscape of Geothermal Cost Modeling Capabilities Beyond GETEM	
1. What types of data are incorporated into your organization's calculations for projecting geothermal costs? Does your organization feel the data are representative, accurate, and otherwise adequate for your purposes?	
2. How does your organization use cost projections and what are your typical data sources for determining cost model inputs such as: CAPEX ($/MWh), OPEX ($/MWh or $/month) capacity factor, maximum plant output with time, monthly and seasonal variations, etc.	
3. How does your organization account for uncertainties in data sources discussed in questions 1 and 2?	
4. Geothermal operators indicate that for newly constructed projects, capacity factors are often equal to or greater than 95%. Please tell us your perspectives on new geothermal project development capacity factors and forward projections of these capacity factors over the life of a project. What capabilities would be valuable to have for quantifying and representing this uncertainty in cost models?	

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GETEM-specific Considerations		
1. How do you use GETEM?		
2. What are the analysis gaps in the current state of the art for geothermal project cost, timeline, and performance modeling platforms, such as GETEM, with respect to each of the following activities? Keeping your needs in mind, please categorize the following as critical gap, minor gap, or not an existing cost modeling analysis gap:	**Category**	**Ranking (critical gap, minor gap, not an existing gap)**
	Project planning	
	PPA contracting and financing	
	Leasing and permitting	
	Project exploration and development	
	Operations & maintenance	
	Planning and funding prioritization for technology innovation R&D	
	Other activities not considered above	
3. Keeping your needs in mind, please identify the following model structure and capability features as most important, less important, and not at all important.	**Category**	**Ranking (most important, less important, not at all important)**
	Full user interface for inputs and outputs	
	Command line operations with output suitable for post-processing and visualization	
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	High performance computing (parallel) capabilities	
	Proprietary language/platform versus freely available (e.g., MATLAB or Excel versus Python, FORTRAN, etc.)	
	Capability to link to databases, data sources, or other existing and external models (e.g., from FORGE or other GTO initiatives)	
	Flexible capability to capture potential cost and performance implications of projected changes in field and plant operation for EGS.	
	Ability to capture costs and performance of geothermal ancillary grid services, i.e., essential reliability and/or resiliency services which go beyond the provision of bulk energy.	
	Ambient weather conditions and elevation impacts	
	Technology cost and performance model that could evaluate site-specific geothermal projects in addition to generic hydrothermal and EGS systems	
	Any other desired or required user customization?	
	Full user interface for inputs and outputs	
4. How important do you feel it is to incorporate uncertainty analysis within		

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project cost and performance models?	
4a. What specific capabilities would you recommend to effectively incorporate uncertainty into cost and performance modeling (e.g., Monte Carlo / Latin Hypercube Sampling, risk assessment and risk management, system and performance optimization, etc.)? Why?	
4b. What insights are you seeking from uncertainty analyses (e.g., exceedance probabilities, performance and cost ranges, risk analysis, other)? Please provide examples of how your organization might use these capabilities.	
5. Regarding the value of coupling high fidelity, fully-integrated, full-field (reservoir-wellbore-surface network) numerical modeling capabilities with project cost and performance models – we would appreciate your feedback on the following specific questions:	
5a. From your perspective, do you feel that this value is universal and equal for (a) commercial purposes, (b) resource adequacy planning	

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purposes and (c) for more generic case studies that track R&D improvements?	
5b. From your perspective, to what level of detail are coupled system physics important for ensuring cost and performance fidelity? For example, in assessing representative costs and performance for geothermal technologies, would it be necessary to incorporate detailed coupling of thermo-hydraulic-mechanical-chemical (THMC) processes in a full-field coupled numerical model?	