Chapter 6

Oil and Gas Industry Engagement in Geothermal: The Data

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> ***Publicly available data does not capture the flurry of innovation and engagement in the oil and gas industry for geothermal currently, as many entities have not yet made their strategies and activities public. By analyzing the geothermal interests of fifteen oil and gas majors, both trends and pathways forward emerge.***

I. Introduction:

The research and analysis in this Report is based on the foundational principle that Texas, as the global epicenter of the oil and gas industry, is uniquely positioned to lead in building the future of geothermal energy, and presumes that the oil and gas industry will be a willing and engaged partner in that leadership. However, if you search the news for evidence of oil and gas engagement in geothermal, aside from a few scattered articles and press releases, a majority released over the past year, there is scant evidence of significant industry-wide engagement and enthusiasm for geothermal. Why is that? Simply put, a majority of entities, many who have built geothermal strategies, hired internal geothermal teams, funded internal research and development, and are planning geothermal pilots and projects, have not announced their activities publicly.

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Some entities report that they plan to make geothermal a part of shareholder and board discussions in 2023, while others state that they are taking their time to consider their public relations strategies for geothermal, or are waiting to review data from pilot projects before announcing their engagements publicly. Either way, with the authors of this Chapter having been frequently engaged with oil and gas industry entities about the opportunity in geothermal since as early as 2017, we note that the accelerating engagement, emerging vision statements, rapidly expanding teams, innovative solutions, internal and external investments, and growing confidence amongst players in this space is a trend that Texas, and indeed the world, should not ignore.

For an industry that is famous for its measured, conservative approaches to new business models, and perhaps equally famous for taking its time to make consequential strategic decisions, the fact that within the past four years, entities have gone from zero or almost zero engagement, to a growing consensus that geothermal is globally scalable, and the challenges solvable by industry in the near term, is extraordinary. As you'll see in the data below, **almost 70 percent of entities interviewed for this Chapter reported that there are no technology challenges associated with geothermal that the oil and gas industry cannot solve.**

In a divergence from the typical format of a formal reporting of research results, a personal story of an author may help shed light on the driving force behind this Chapter. In 2021, Chapter co-author Jamie Beard performed a TED talk entitled "The Untapped Energy Source That Could Power the Planet" to an audience that was not entirely warm to the idea of the oil and gas industry leading the future in any way, much less a way that would preserve the status quo of drilling and subsurface energy extraction. After her talk ended, she spent the rest of the conference exchanging with often irate audience members, many who did not believe that the oil and gas industry would take the geothermal opportunity seriously, or have the capability of enabling global scale for geothermal, even if we could get past the clearly present issues of polarization and mistrust. One man stated in exasperation at the end of a particularly heated discussion, "We've heard it all before from big oil – and by the way – you don't know them. You are going to find yourself disappointed."

As he walked away, Jamie remembers thinking "I do know them." Indeed, she had been collaborating actively with "them" for years, and was privy to the accelerating energy in the industry for geothermal. In fact, it was the weight of the industry, the technical competence, and the confident voices of industry veterans that provided the foundation for her to get up on the stage and say the things she did in her talk. But it also occurred to her that there was no publicly available data to backup all that she was seeing and hearing from industry about geothermal. This Chapter is an attempt to address that need, to serve as a stopgap until more entities are ready to begin discussing their plans and strategies with the world.

II. Research Objective and Methodology

In this research, fifteen oil and gas industry majors were identified to be interviewed anonymously about their engagement in geothermal. Entities were chosen based on authors' knowledge of entity engagement in the space, and assuring a diverse sample size that represented 1) different sectors of the industry, including operators, oil field service companies, drilling contractors, and tool makers/suppliers, 2) varying entity sizes, and 3) varying regions globally in which the entities operate. All entities agreed to provide data about their interests and engagement in geothermal anonymously to authors, and that data would be analyzed and shared in aggregate format, with no attribution to any particular entity. Interviews took place virtually over a period of months in 2022, and were attended by oil and gas entity teams, and a combination of one and three authors of this Chapter, depending on the schedules of the authors.

Authors note that the fifteen entities interviewed are not an exhaustive list of oil and gas industry entities engaged in geothermal. In fact, since a majority of the interviews for the Chapter concluded, several additional majors have entered the space, some with now public presence. The subset of entities interviewed represents a snapshot across a diverse set of entities so we might view and act on emerging trends, and is not an attempt at a wholly inclusive list.

Table. 6.1. Companies interviewed for this research analyzing oil and gas industry engagement in geothermal. Entities interviewed are listed in alphabetical order by column. *Source: Future of Geothermal Energy in Texas, 2023.*

International Oil Company	Independent Operator	Oilfield Service	Drilling Contractor	Supplier/Tools
bp	Calpine Corporation	Baker Hughes	Helmerich & Payne, Inc.	NOV Inc.
Chevron Corporation	Chesapeake Energy Corporation	Weatherford International	Nabors Industries Ltd.	
Repsol S.A.	Continental Resources, Inc.			
Ecopetrol S.A.	Murphy Oil Corporation			
Shell				
TotalEnergies SE				

Note that while we have separated entities by industry sector for illustrative purposes above, we will not maintain this separation in the presentation of the data, as all responses have been aggregated across all entities to preserve anonymity.

III. Research Outcomes

Questions were asked to participating entities across five themes, 1) timing of engagement and strategy, 2) types of geothermal technologies, concepts, and resources of interest, 3) ability of industry to address challenges in geothermal, 4) pilots and research and development ("R&D"), and 5) collaboration and consortia.

Responses were then aggregated and organized into the graphical representations below. Specific questions asked of the entities are listed in the headings preceding each graphic. Where the answer to a question was not binary, or required explanation from the entity, details are provided in narrative format to give further context to the data or outcome. We have also noted below where trends emerged in the data that were not well captured by the graphical representations.

A. What Year Did Your Entity Begin Engaging in Geothermal?

For the purpose of this question, "engage" was defined to mean significant and sustained interest sufficient to justify the application of resources to geothermal, either through the funding of internal R&D and/or teams, or external investment in ventures and/or pilots.

One entity reported sustained engagement since the 1980's, which is represented in the graphic (but beginning in 2010 for the sake of brevity). Three entities reported that they had some engagement in geothermal historically, one as early as the 1960s, either through investments made in projects, or tools/services they provided to the geothermal industry, but that interest had waned before picking up pace significantly over the past few years. These more sporadic periods of prior engagement are not represented in the graphic.

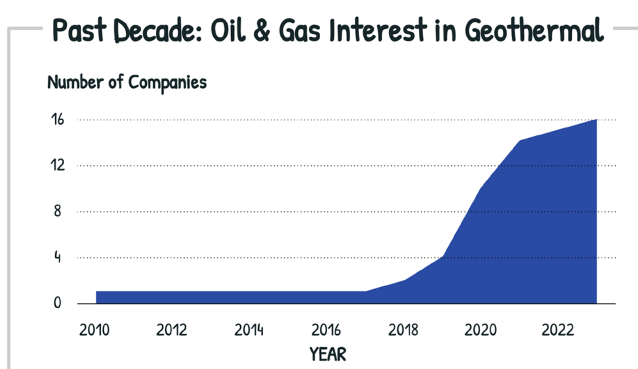

Figure 6.1. Oil and gas entity engagement in geothermal over the past decade. *Source: Future of Geothermal Energy in Texas, 2023.*

The graphic demonstrates an increase in engagement since 2018, increasingly rapidly beginning in approximately 2020 to present. Reasons provided by entities for their recent increased engagement in geothermal varied, and included increased bandwidth in internal teams as a result of the COVID driven industry downturn, corporate commitments to emissions reductions and/or carbon neutrality, participation in or attendance of the PIVOT conference series (PIVOT, 2022b) which increased awareness of the sector, societal and institutional investor pressure with regard to Environmental, Social and Governance ("ESG") concerns, alignment with existing or planned investments in green hydrogen and/or carbon capture, utilization, and storage ("CCUS"), or combinations of these factors.

Entities broadly agreed that geothermal is a rational part of their larger diversification strategies due to the significant skills and expertise overlap between industry and geothermal. About half of entities reported that their engagement began as a "grassroots" movement, which gained traction and worked its way into upper level management, or in the case of two entities, presentations to the Board. Others reported that the inquiries came from the "top down" after either institutional investors or major shareholders posed questions about geothermal to the C-suite, or an executive became interested in the topic.

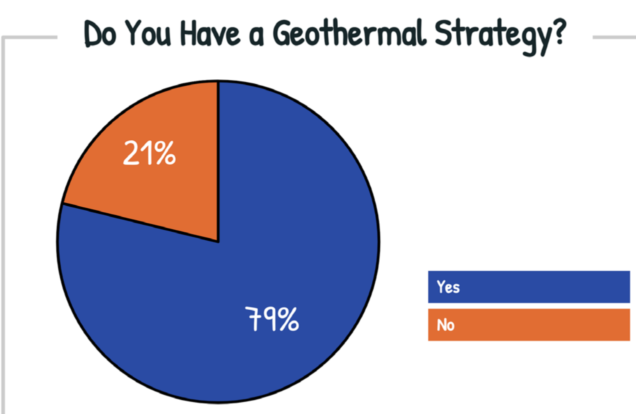

Figure 6.2. Oil and gas entities with a geothermal strategy, either adopted or in development.
Source: Future of Geothermal Energy in Texas, 2023.

B. Do You Have a Geothermal Strategy in Place?

For the purpose of this question, "geothermal strategy" is defined as an opportunity or market analysis, plan for engagement, business model, investment strategy, or any other internal strategic document focused on geothermal, either adopted or in development currently.

79 percent of companies interviewed have some form of geothermal strategy. Of the entities who answered "no" (21 percent), 75 percent of them reported that the purpose behind the formation of their internal geothermal team was to explore the need for such a document and/or create one. Of the entities who answered "yes" (79 percent), more than 60 percent of them reported that their strategy document has led to either an investment in a geothermal pilot or startup, or the publication of a report and/or marketing materials focused on geothermal over the past two years.

C. Which Concepts, Resource Types, Technologies, and Trends are Oil and Gas Entities Engaging With in Geothermal?

For this next series of questions, we asked entities to answer "yes," "no," or "maybe" to indicate their level of interest and/or engagement in a variety of geothermal concepts, resource types, and technologies. Interest and/or engagement was defined for the purpose of this Section as sustained interest or inquiry that may lead to engagement by the entity in this technology focus area. An answer of "maybe" was appropriate in this series of questions where an entity was marginally interested in the topic, but did not consider it within their primary areas of interest or expertise, or viewed the concept as sufficiently flawed as to diminish their interest in the topic. Nuances like these in the data will be explored, as applicable, after each graphic.

This Section is divided into the following groups, 1) types of geothermal technologies, 2) type of geothermal resource, 3) types of technologies and methodologies transferrable to geothermal from oil and gas, and 4) emerging trends. Details on these four topics are explored further in Chapter 1, Geothermal and Electricity Production.

1. Geothermal Technologies

The following geothermal technologies are explored in the Section below: 1) Traditional Engineered Geothermal Systems, 2) Next Generation Engineered Geothermal Systems, 3) Advanced Geothermal Systems/Closed Loop Geothermal Systems, 4) Direct Use Heating and Cooling Systems, 5) Oil and Gas Well Reuse, and 6) Hybrid Geothermal Systems.

a. Traditional Engineered Geothermal Systems

For the purpose of this Section, Traditional Engineered Geothermal Systems ("Traditional EGS") are defined as an Open to Reservoir Scalable Geothermal concept that utilizes hydraulic fracturing to engineer or enhance a subsurface reservoir for the purpose of producing geothermal heat or electricity, but that does not utilize advanced directional drilling and/or frac'ing techniques, such as horizontal drilling and multi-stage fracturing.

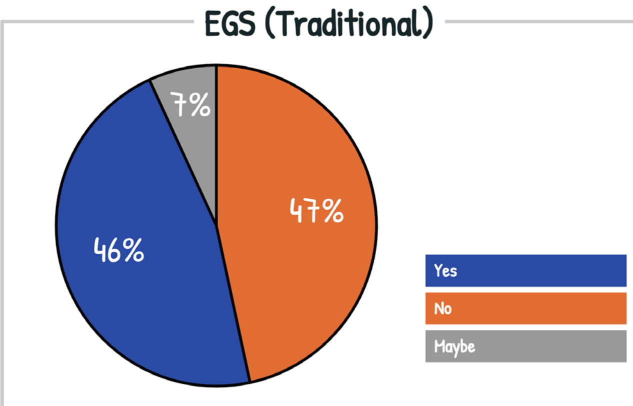

Figure 6.3. Oil and gas entities engaged or interested in Traditional Engineered Geothermal Systems ("EGS"). *Source: Future of Geothermal Energy in Texas, 2023.*

Of the 47 percent of the entities who answered "no," 70 percent expressed doubt about the technical feasibility, likelihood of success, and/or operations and maintenance challenges associated with Traditional EGS concepts, while 30 percent expressed that they did not consider it to be within their primary areas of interest or expertise.

b. Next Generation Engineered Geothermal Systems

For the purpose of this Section, Next Generation Engineered Geothermal Systems ("Next Gen EGS") are defined as an Open to Reservoir Scalable Geothermal concept that utilizes hydraulic fracturing to engineer or enhance a subsurface reservoir for the purpose of producing geothermal heat or electricity, that incorporates advanced directional drilling and/or frac'ing techniques, including but not limited to, horizontal drilling and multi-stage fracturing.

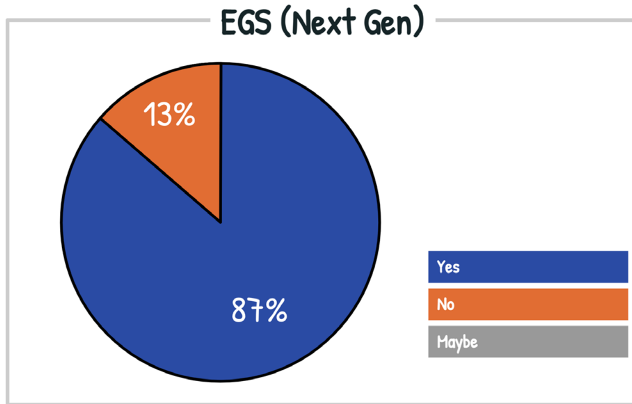

Figure 6.4. Oil and gas entities engaged or interested in Next Generation Engineered Geothermal Systems ("EGS"). *Source: Future of Geothermal Energy in Texas, 2023.*

Noteworthy here is the level of agreement amongst entities (87 percent) that EGS concepts need to evolve and utilize cutting-edge technologies to increase the likelihood of success of EGS projects. Also notable is that at least one entity stated that while it did not consider Traditional EGS to be within its area of expertise, it believed it had contributions to make in the Next Generation EGS space.

c. Advanced Geothermal Systems/Closed Loop Geothermal Systems

For the purpose of this Section, Advanced Geothermal Systems/Closed Loop Geothermal Systems ("AGS") are defined as a Closed to Reservoir Scalable Geothermal concept that can take a variety of configurations, but that rely primarily on conduction for heat exchange between the subsurface and the well.

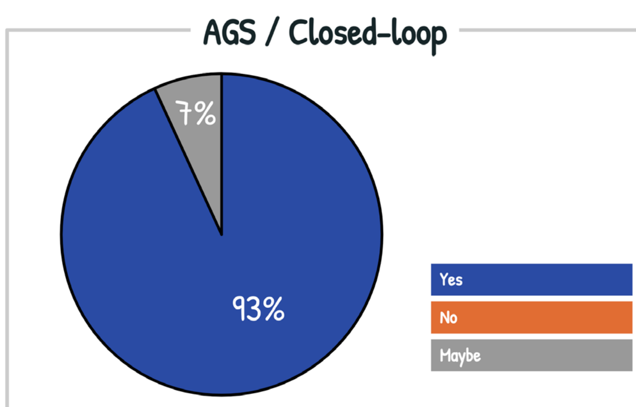

Figure 6.5. Oil and gas entities engaged or interested in Advanced Geothermal or Closed-Loop Systems ("AGS"). *Source: Future of Geothermal Energy in Texas, 2023.*

93 percent of all entities responded "yes" to a level of interest and/or engagement in AGS. Several entities responding "yes" reported that their interest in this concept surrounds the potential for use of novel engineered Working Fluids, or supercritical carbon dioxide ("sCO2"), to harvest heat at lower temperatures than water requires. Others noted that they are most interested in pursuing AGS in deeper, higher temperature reservoirs, with three mentioning SuperHot Rock (considered separately below) in particular. A smaller proportion of entities described their interest in the context of oil and gas Well Reuse, and the production of heat from such wells for Direct Use (also considered separately below). Authors note that this is an area of increasing and enthusiastic industry interest that is remarkably out of step with current funding and support for geothermal on the Federal level, and an area where the State of Texas could lead with supportive policies and incentives.

d. Direct Use Heating and Cooling

For the purpose of this Section, Direct Use was defined broadly to include both shallow heating and cooling projects, and deeper, higher temperature commercial and industrial heat projects.

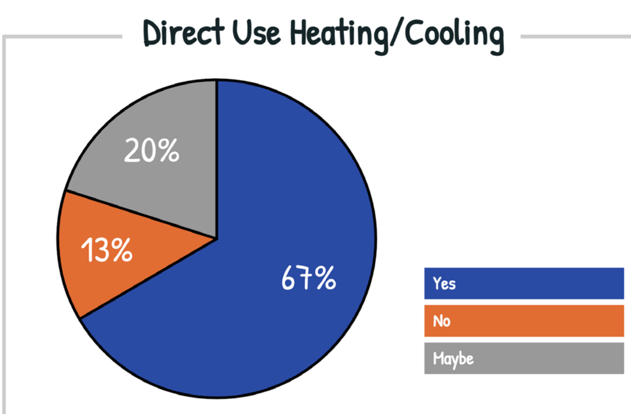

Figure 6.6. Oil and gas entities engaged or interested in Direct Use Heating and Cooling ("DU"). *Source: Future of Geothermal Energy in Texas, 2023.*

Of the 67 percent of entities responding "yes," almost 50 percent referred to oil and gas Well Reuse as a potentially viable source of Direct Use heat, with the caveat that currently co-located off-takers for the heat may be rare at the most promising sites in Texas due to remote well locations, but that there could be opportunities to build industry on the best sites, for instance, bitcoin mining or data centers. Several of these entities also pointed to the opportunity of geothermal Direct Use to decarbonize industrial heat needs along the Texas Gulf Coast. In particular, two entities who answered "yes" pointed to Deep Direct Use ("DDU") for large-scale commercial buildings as a potentially viable model for oil and gas companies to pursue in Direct Use that would utilize existing skill sets. At least two entities expressed their interest in Direct Use as contingent upon a viable geothermal power project, with waste heat from the plant utilized for other purposes. These entities therefore would not seek to develop a stand alone Direct Use project, but may be interested in utilizing waste heat from a power project for other purposes.

Entities answering "no" or "maybe" failed to see a viable business model for oil and gas entities in drilling and developing heating and cooling projects, particularly shallow and low-temperature projects, or did not consider Direct Use to be within their area of expertise.

e. Oil and Gas Well Reuse

For the purpose of this Section, Oil and Gas Well Reuse is defined as any concept that uses an existing hydrocarbon well for a geothermal purpose, whether that be through full geothermal conversion, or co-production concepts that harvest both hydrocarbons and heat.

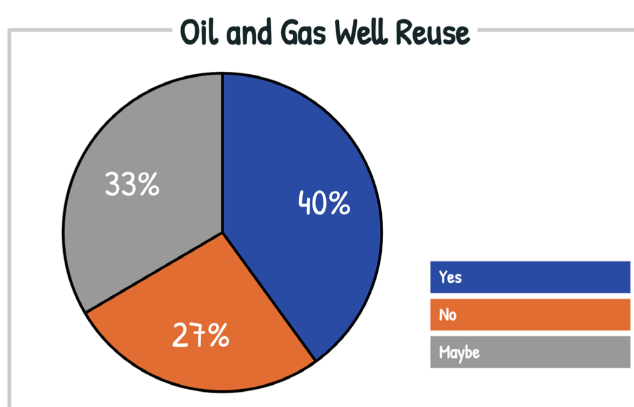

Figure 6.7. Oil and gas entities engaged or interested in Oil and Gas Well Reuse. *Source: Future of Geothermal Energy in Texas, 2023.*

The entities were not in agreement on the potential for the reuse of oil and gas wells, with only 40 percent responding "yes." Several of the entities answering "yes" pointed to the potential for decarbonization of on-site oil and gas operations using co-produced heat from hydrocarbon wells. One entity noted that this potential will be limited by the speed and scale of oil and gas operation electrification, and also by the efficiency of power production equipment like Organic Rankine Cycle ("ORC") turbines. Others referred back to their Direct Use answers, and noted that oil and gas wells are likely not well suited for power production, but may provide a viable source of Direct Use heat if there are nearby or co-located off-takers. Several entities answering "yes" or "maybe" expressed that existing wells may be an inexpensive pathway to pilot new geothermal concepts in terms of the subsurface information they provide and reduced drilling costs associated with the pilot, but may not be appropriate to convert into operating geothermal assets long term.

Entities answering "no" and "maybe" pointed to challenges such as well integrity, limited flow rates due to the smaller casing sizes used in oil and gas, legal and liability uncertainty, remote location of wells, insufficient temperatures to support project viability, and the potential for unintended hydrocarbon production in situations of full well conversion.

f. Hybrid Geothermal Systems

For the purpose of this Section, Hybrid Geothermal System is defined as combinations of two more technologies or concepts, with at least one of them being geothermal, such as more than one geothermal concept (AGS/EGS, for example) combined into one system, or geothermal coupled with technologies such as hydrogen or lithium production, subsurface energy storage, et al.

Of the 67 percent of the entities who responded "yes," they did so with enthusiasm, expressing that hybrid systems are likely to improve project economics, and have helped them align geothermal with other strategic investments of their entities, CCUS being an example that was raised by several entities.

Entities who answered "maybe" and "no" were more doubtful that hybrid concepts would benefit projects, instead expressing the concern that hybrid concepts would introduce additional risks to projects, and may complicate diligence and financing due to additional complexity. One entity expressed a view in the middle

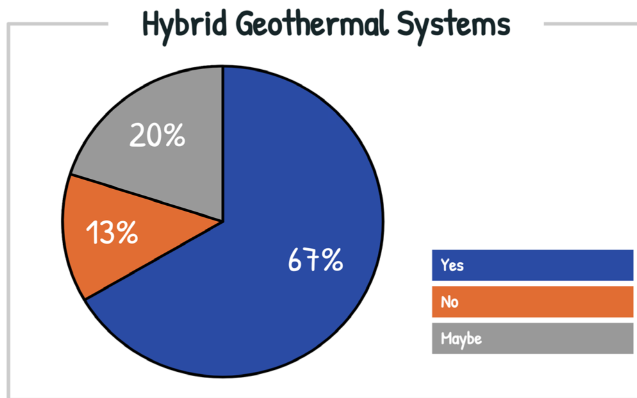

Figure 6.8. Oil and gas entities engaged or interested in Hybrid Geothermal Systems. *Source: Future of Geothermal Energy in Texas, 2023.*

of these two positions, stating that they believe adding a hybrid component to a geothermal project may help the economics of otherwise marginal projects, but for projects not on the margin, it would be easier to pursue geothermal as a stand alone project.

2. Type of Formation/Resource Targeted

As discussed in detail in Chapter 1, Geothermal and Electricity Production and Chapter 4, The Texas Geothermal Resource, there are several geothermal resource types in Texas where geothermal projects are likely to be developed over the coming years, with sedimentary formations and Blind Hydrothermal Systems being the largest and nearest term opportunity, and deeper SuperHot resources coming later when enabled by technological advancements. In this Section, we asked entities for their opinions and levels of excitement about these Texas present resources, and also about another geothermal resource type, Hydrothermal, which is not present in Texas, but that oil and gas entities have begun to engage in outside of the State.

a. Hydrothermal

For the purpose of this Section, Hydrothermal resources, also referred to as Conventional Hydrothermal Systems ("CHS") elsewhere in this Report, are defined as geothermal resources having a combination of sufficient naturally occurring porosity in the subsurface, sufficient heat transfer into the system, and the natural presence of water in the subsurface, together producing a near surface developable resource.

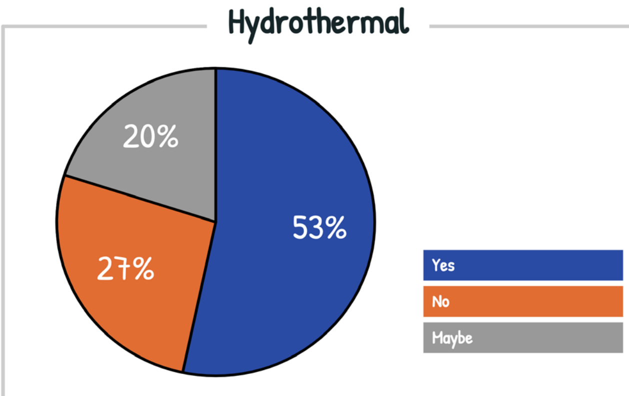

Figure 6.9. Oil and gas entities engaged or interested in Conventional Hydrothermal Systems ("CHS"). *Source: Future of Geothermal Energy in Texas, 2023.*

There are no CHS present in Texas, however, we included the resource in our interview because a number of oil and gas entities have begun to engage in hydrothermal projects in various locations globally, and we hoped to offer some color about why some entities have chosen that path.

Hydrothermal, similar to Traditional EGS, tends to be a divisive topic where there is little agreement amongst oil and gas entities about the viability of the global hydrothermal opportunity. If you are not in the oil and gas industry and immersed in these discussions, you might wonder what all the fuss is about. Hydrothermal makes up a majority of the geothermal developed in the world today, and is ubiquitous in geothermal famous places in the world, such as Iceland. But due to a history of oil and gas consideration, analysis, and investment/divestment in the space, it is a subject of debate and a source of bias against geothermal in the industry.

On the one hand, some entities view hydrothermal as globally insignificant, geographically limited, and a niche opportunity, where there is little room for innovation and scale, and where development is limited by the location of the resource, which tends to be in remote regions of the world. This sentiment is fairly summarized in an interview in 2020 between one of this Chapter's co-author, Jamie Beard, and Vik Rao, former CTO of Halliburton, now Executive Director of the Research Triangle Energy Consortium. The article was published by HeatBeat and aptly named "I Hated Geothermal, Then I Realized It Is Now Scalable" (HeatBeat, 2020). This issue was also explored by a panel of experts at the PIVOT2022 conference, with a more hopeful outlook about the prospect of oil and gas entities engaging in the hydrothermal space (PIVOT, 2022a).

For the entities who answered "no" or "maybe" to this question, many of their comments echoed the themes in the above article, with one interviewee stating that oil and gas would achieve a faster and more impactful learning curve going after the larger and more scalable prize in geothermal, which is Hot Dry Rock, or "geothermal anywhere." Others opined that the oil and gas industry would have little to contribute, aside from perhaps pre-project subsurface characterization, to the already mature and technologically enabled hydrothermal landscape.

On the other hand, more than half of interviewed entities expressed not only interest, but active engagement in hydrothermal exploration and projects. Some of these projects have been announced publicly since interviews were conducted, including projects and partnerships being pursued by Repsol, Chevron, Ecopetrol, and Shell, discussed in further detail elsewhere in this Report, while others are set to be announced in 2023. Entities interested in hydrothermal made the case generally that hydrothermal offers a straightforward avenue to "ease" into geothermal, to collect data and learnings in the field with relatively low risk, to get geothermal electrons onto the grid, make the business case and gain further traction for geothermal within their entities, and offers an opportunity to work with traditional geothermal industry players and exchange learnings and knowledge.

A majority of supporting entities readily agreed that hydrothermal is a geographically limited resource that has its fair share of challenges (resource decline over time, and exploration risk were raised by more than one entity), but argued that there is a sufficient development runway for hydrothermal globally for industry to engage, learn, and then move on to more complex and technically difficult projects, like EGS and AGS. One entity argued that in order to pursue geothermal, their team had to demonstrate a viable business case out of the gate to their management, and hydrothermal was the only avenue currently, out of all geothermal concepts, where they were able to do that.

b. Blind Hydrothermal and Sedimentary Resources

For the purpose of this Section, sedimentary geothermal resources are defined as any concept intended to harvest heat and/or power from sedimentary basins, and Blind Hydrothermal Systems are defined similarly, but include the natural presence of sufficient amounts of water in the sedimentary formation for geothermal production. Due to their similar nature geologically, and often close proximity to one another geographically, we grouped these two dominant Texas sedimentary geothermal resources together into one inquiry.

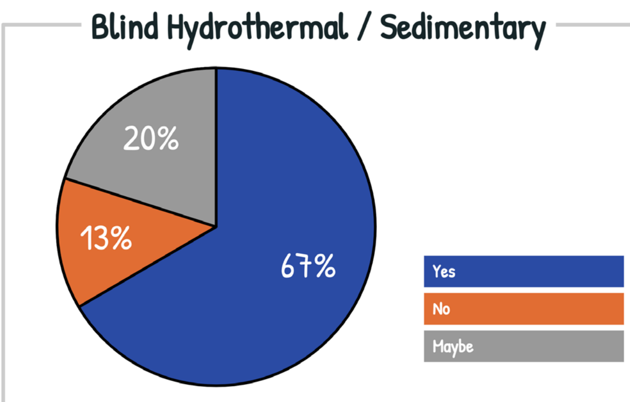

Figure 6.10. Oil and gas entities engaged or interested in Blind Hydrothermal/Sedimentary Resources. *Source: Future of Geothermal Energy in Texas, 2023.*

67 percent of the entities responded "yes," with several entities having made, or were in the process of making at the time of the interview, investments in startups working in this area. At least two entities expressed enthusiasm for the contributions their entities may make in the characterization of sedimentary and Blind Hydrothermal Systems, with one entity expressing that they are actively working on this internally. Notably, several entities who responded "no" to hydrothermal, responded "yes" to blind hydrothermal, noting that blind hydrothermal is a global frontier that is not yet well defined, and may be a significant resource that oil and gas could not only help explore for and characterize, but also develop.

Because sedimentary basins tend to be low to mid-enthalpy resources, engineered Working Fluids or sCO2, which have lower critical points than water, were raised by more than one entity as potential avenues forward when discussing methods for developing sedimentary basins. One entity expressed concern about the price of purchasing CO2, noting that currently CO2 is mined and sufficiently costly to ruin the economics of a project, and that until CO2 is either free, or entities get paid to sequester it in systems, it is not a realistic Working Fluid medium at scale. Entities who answered "maybe" expressed doubt about the economic viability of sedimentary resources, aside from potentially Direct Use heat applications, given their lower temperatures compared to basement formations.

c. SuperHot Rock

For the purpose of this Section, SuperHot Rock is defined as any concept intended to harvest heat and/or power from geothermal resources that are at or exceed the supercritical temperature of water at about 373 °C (about 707 °F). Developing these resources will require deeper drilling into harder rock types, under more extreme temperatures and pressures than other geothermal resource types. At the time the interviews took place, several interviewees had made, or were in the process of making, investments in startups pursuing SuperHot Rock resources.

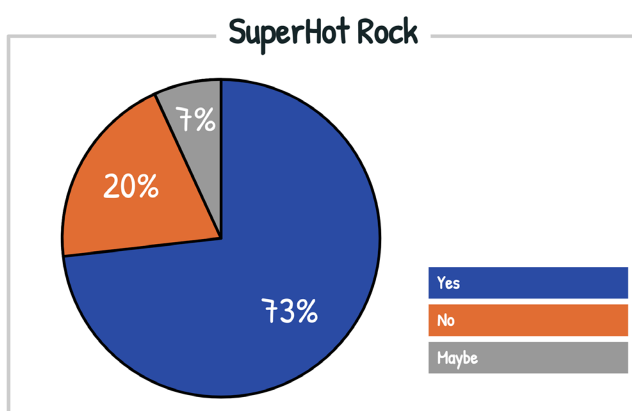

Figure 6.11. Oil and gas entities engaged or interested in SuperHot Rock ("SHR"). *Source: Future of Geothermal Energy in Texas, 2023.*

73 percent of entities responded "yes" to a level of interest and/or engagement in SuperHot Rock resources. Given that oil and gas tends to be a conservative industry that learns incrementally, the level of enthusiasm for SuperHot Rock within oil and gas entities is surprising. As will be discussed further in the Challenges Section below, several entities expressed that SuperHot Rock related challenges are the most significant and onerous in geothermal, but all entities who expressed this concern also expressed

confidence that the industry can and would overcome them. At least two entities expressed interest in utilizing SuperHot resources for coal plant conversion projects, and those who answered "yes" generally agreed that efficiently accessing SuperHot resources would likely solve efficiency and cost challenges associated with geothermal projects. Conversations with interviewees about SuperHot resources tended to be dominated by discussions about drilling, technology gaps, and required R&D. We will reserve those discussions for their respective Sections below.

3. Technologies and Methodologies

In the next series of questions, we asked entities about their engagement in the transfer of various technologies from oil and gas to geothermal, and about the development of new technologies specifically to support their engagement in geothermal.

a. Resource Characterization

For the purpose of this Section, Resource Characterization is defined in a micro sense as local, project specific subsurface analysis performed for the purpose of project siting, risk assessment, and risk mitigation. In a macro sense, Resource Characterization is defined as the process of utilizing oil and gas data, and exploration technologies and/or techniques to map or predict the presence and depth of geothermal resources globally.

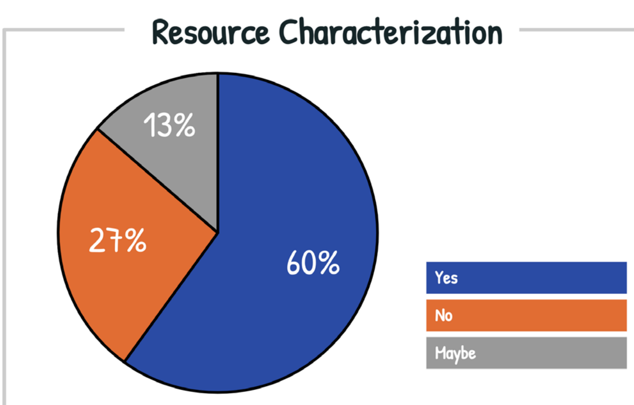

Figure 6.12. Oil and gas entities engaged or interested in Resource Characterization. *Source: Future of Geothermal Energy in Texas, 2023.*

Different entity types engaged with this question in different ways. Of the 60 percent of entities who answered "yes," the majority tended to be operators, though that was not always the case. Within the category of "yes" answers, entities taking a more global approach to Resource Characterization tended to be International Oil Companies ("IOCs"), while Independents tended to view their contribution to Resource Characterization as regional or project specific. Amongst IOCs, several entities referred specifically to global characterization of Blind Hydrothermal Systems, depth to basement rock, and SuperHot anomalies. Amongst entities who answered "yes," there was little doubt about the value of their data and capabilities in this area, and the transferability of oil and gas exploration technologies and techniques into the geothermal realm.

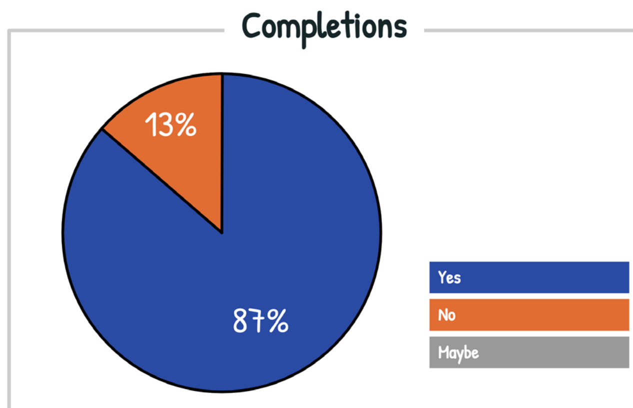

Figure 6.13. Oil and gas entities engaged or interested in Completions Technologies and Techniques. *Source: Future of Geothermal Energy in Texas, 2023.*

Oilfield service companies, drilling contractors, and suppliers tended to answer this question as "no" or "maybe," though several answered "yes." For those who answered "yes," they viewed some of their existing technologies that they deploy in oil and gas as likely to make significant contributions in the realm of characterization. Entities who answered "no" felt that resource characterization was simply not within their area of expertise.

b. Completions

For the purpose of this Section, Completions are defined as preparing a geothermal well for operation after the drilling process is completed. Across geothermal technologies, Completions can involve different technologies and techniques, with EGS involving hydraulic fracturing, for instance, and AGS involving novel casing and cementing procedures.

87 percent of entities answered "yes," suggesting that Completions is an area where significant leaps forward can be made through the transfer of oil and gas technologies, methods, and techniques into geothermal. At least two entities expressed concern that this is a technology area where existing geothermal methods are "decades behind" oil and gas.

While the entities answering "yes" tended to agree that the application of advanced stimulation techniques, like multi-stage fracturing, provided low hanging fruit to advance EGS Completions, there was less consensus amongst entities about the future of AGS Completions. At least one entity expressed the view that AGS Completions are likely to be "significantly more technically complex" than is currently acknowledged when AGS concepts are discussed publicly. Another entity expressed that in the context of AGS, innovations like new valve configurations will likely be needed to increase the commercial viability of AGS.

At least two entities expressed concern about the number of unknowns in the realm of completions for SuperHot Rock concepts, noting that we currently have sparse operational understanding of the mechanical behavior and evolution over time of rock and fractures at SuperHot temperatures and pressures, and that currently available Completion technologies in industry, with cements being a frequently mentioned example, are not well suited for reliable, long term performance at these higher temperatures and stresses. Nevertheless, entities expressed general enthusiasm for taking on these challenges, suggesting that even where concerns were raised, that the challenges were likely not insurmountable for the oil and gas industry.

c. Drilling Technologies

For the purpose of this Section, Drilling Technologies is defined to include 1) the application of existing oil and gas drilling technologies and techniques to geothermal applications, 2) the adaptation of existing oil and gas drilling technologies and techniques to perform better in geothermal drilling applications, and 3) next generation, energy based drilling technologies, such as plasma, laser, particle, and millimeter wave. Across these three drilling categories, 80 percent of entities reported engagement in this topic through either ongoing internal R&D, field trials of newly developed technologies, or investments in startups pursuing drilling technologies.

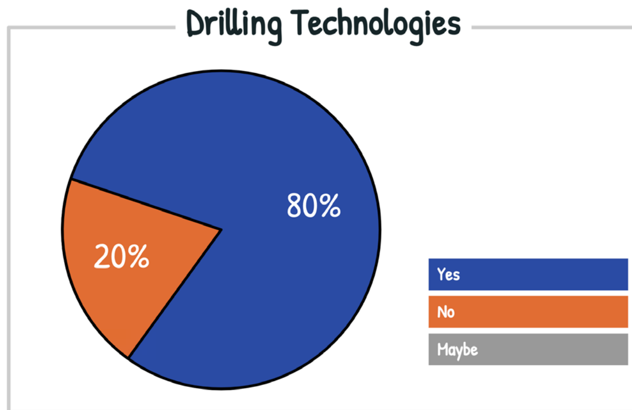

Figure 6.14. Oil and gas entities engaged or interested in Drilling Technologies. *Source: Future of Geothermal Energy in Texas, 2023.*

Of the entities who answered "yes," all, with the exception of two entities, expressed at least some engagement across all three drilling technology types. Also amongst entities who answered "yes," operators tended to report engagement in this space through partnerships and/or investments, while oilfield service, drilling contractors and suppliers tended to report direct engagement through internal R&D, field trials, and investments. Approximately half of entities answering "yes" across all entity types expressed a desire to attempt existing oil and gas tool adaptation before investing heavily in next generation drilling technologies, noting that some existing off the shelf technologies from oil and gas were just beginning to be utilized in the geothermal space with significant impact.

While almost all entities who answered "yes" to this question reported engagement across all three drilling technology types, of the three, next generation drilling technologies enjoyed the least amount of consensus. At least two entities reported prior significant internal investments in next generation drilling technologies, with disappointing results. Others expressed operational concerns with the deployment of next generation technologies, including issues such as inadequate power supply both on the rig, and downhole to operate the technologies, the need for rig and workflow redesign to accommodate the technologies, and the potential for workforce safety hazards. At least two entities raised the next generation tool power supply concern as significant, noting that without significant advances in downhole power supply methods, such as wired pipe, next generation technologies will fail to launch.

When discussing integration of next generation drilling technologies into oil and gas rigs and workflows, at least two entities used the term "Rig of the Future" specifically to describe their engagement in this space, and at least one entity stated that the goal of their pending investment in a startup pursuing next generation drilling technologies was to further their internal goal of pursuing Rig of the Future designs.

100 percent of entities who answered "no" to this question were operators, with at least one expressing the potential of partnering in this area in the future, but no current substantive engagement.

d. Operations and Maintenance Innovations and Technologies

For the purpose of this Section, Operations and Maintenance is defined to mean any technology or method applied to achieve operation of a geothermal power or heat operation, including both the subsurface and surface. This definition opened up several interesting lines of discussion with entities about their future business models in geothermal, which we will attempt to capture in the comments below.

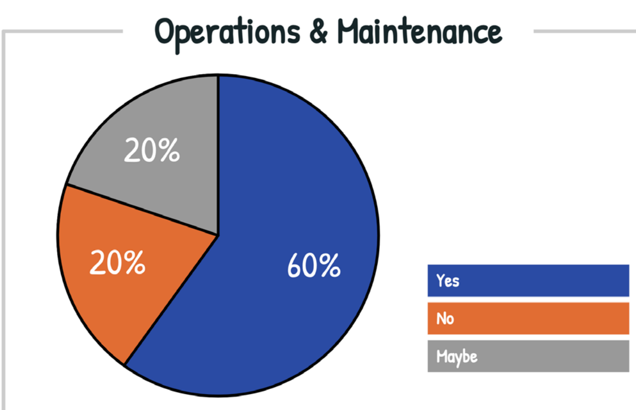

Figure 6.15. Oil and gas entities engaged or interested in Operations and Maintenance ("O&M"). *Source: Future of Geothermal Energy in Texas, 2023.*

Overall amongst interviewees, there was a good deal of consensus regarding the need for entities to continue to engage in geothermal projects after the well and project construction phase, and into operational years, with 60 percent answering "yes." With regard to the subsurface, there was also general consensus about why this continuing engagement would be required. EGS, AGS, and Hybrid Geothermal Systems will require close monitoring of the subsurface and system to assure that operational challenges like fracture evolution, short circuiting, scaling, well integrity, et al. are mitigated and managed if they do occur. Scalable geothermal projects of all types are also likely to require constant monitoring for induced seismicity for the lifetime of the project. It was how the entities intended to engage in projects that entered into their operational phases where differences emerged.

During discussions of operations and maintenance, the question frequently arose of who the owner and operator of our hypothetical geothermal projects was. Some entities view themselves firmly as service providers, contractors and/or suppliers, and therefore were likely to answer "maybe" to this question, responding that they'd assist if contracted to do so by an operator. Among the entities who answered "yes," however, entities were split about what role they intended to play. At least five entities entertained the idea of their entity taking on the role of owner/operator of geothermal projects, with at least three entities noting that this role was central to their geothermal strategy. Interestingly, not all of these three entities are operators currently in the oil and gas industry.

Further, operators tended to take the view that if their entities successfully operate wind and solar projects, technologies that were firmly outside of their wheelhouse before decades of investment in the renewables space, why wouldn't they then take the same view for geothermal projects, which are firmly within the wheelhouse of parent companies. One entity noted that there were unique challenges associated with convincing the parent company of any oil and gas major to operate a project that produces electrons, as opposed to hydrocarbons, noting that it was an entirely different business model and way of thinking, something that parent entities are not accustomed to. Another entity observed that the existence of "New Energies" arms of oil and gas majors has the consequence of siloing employees who understand the business of "selling electrons" away from employees in the parent, who understand the business of exploring for and producing energy from the subsurface. "Geothermal is both subsurface and electrons, and we aren't currently built to navigate that from a business model standpoint," the interviewee noted. This pain point in industry is significant, and the subject of Chapter 7, The Geothermal Business Model & the Oil and Gas Industry.

With the exception of only a few interviewees, entities who answered "yes" tended to agree as a general rule that the oil and gas industry would likely need to vertically integrate further through joint venturing or acquisitions in order to fill expertise gaps associated with plant operations on the surface. Several interviewees who answered "yes" took the view that either through mergers, investments, and/or acquisitions, both executed and planned, they have positioned themselves to take a system-wide (meaning both surface and subsurface) approach to geothermal, which may position them to seamlessly own/operate geothermal projects in the future.

e. Surface Plant Innovations

For the purpose of this Section, Surface Plant Innovations are defined to mean any part of a geothermal power or heat operation that does not pertain to the subsurface. This includes equipment like turbomachinery for power production, heat and power technologies, modular plant designs, cooling technologies, grid interconnects, and related infrastructure.

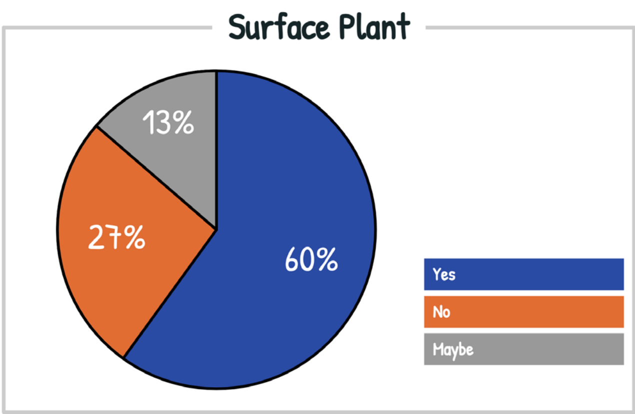

Figure 6.16. Oil and gas entities engaged or interested in Surface Plant Innovations. *Source: Future of Geothermal Energy in Texas, 2023.*

The data that emerged from this question, with the exception of one entity, matched almost entirely, with data from the prior question about operations and maintenance. Consistent with the prior data, operators tended to be more enthusiastic about engaging in the development of surface innovations, but not all of the 60 percent of entities who answered "yes" were operators. The development of sCO2 and organic engineered Working Fluid driven turbines were mentioned by several entities as areas of particular interest, as were the application of thermoelectric generators ("TEGs") in the geothermal context. Amongst entities who answered "no" or "maybe," at least two entities noted that this is an area that they may pursue in the future with the help of strategic partners.

f. Technologies to Monitor and/or Mitigate Induced Seismicity Risk

For the purpose of this Section, technologies to monitor and/or mitigate induced seismicity risk are defined to include technologies deployed in all phases of project development and operation, including during site assessment, drilling and construction, and during operations and maintenance.

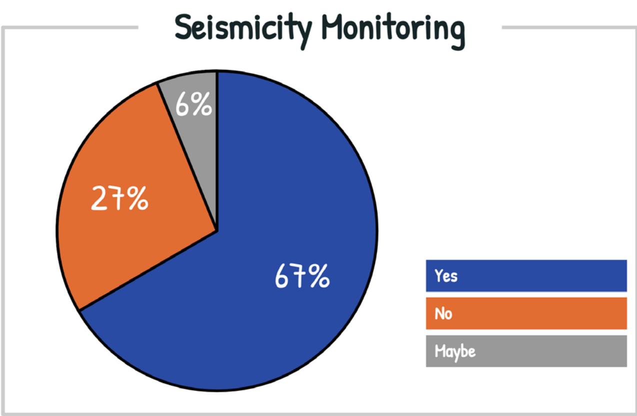

Figure 6.17. Oil and gas entities engaged or interested in Seismicity Monitoring. *Source: Future of Geothermal Energy in Texas, 2023.*

As a general rule, most entities, including those who answered "no," expressed that this is an important topic for geothermal, and that oil and gas expertise in this area developed as a result of wastewater disposal in unconventionals, would be directly applicable and impactful as scalable geothermal concepts are deployed across different regions and geologies. Entities who expressed the most enthusiasm for making investments in this space tended to be operators. While oilfield service, drilling contractors, and suppliers were more likely to answer "no" or "maybe" to this question, several expressed excitement about the application of relevant existing technologies within their portfolios into geothermal projects to monitor seismicity.

4. Emerging Trends

Authors note emerging trends within the oil and gas industry, namely automation and digitization to increase efficiency and/or optimize in the oil and gas context, appear to be a given amongst entities to apply in the geothermal context, right out of the gate. In the context of automation, and in particular rig automation, one entity noted that while pursued for efficiency and workforce risk mitigation purposes in oil and gas (meaning the potential for a shortage of rig workers in the future), rig automation would have the significant and added bonus in the geothermal context of insulating workers from the environmental, health, and safety hazards of working with hot and supercritical fluids on the rig floor, and reducing the cost of downtime.

Digitization was another area where interviewees expressed significant enthusiasm, with several stating that massive efforts at data collection, standardization, and sharing from geothermal operations, paired with AI/machine learning and predictive analytics could do as much to advance geothermal as the development of new drilling technologies. One interviewee stated "Oil and gas is where it is today because of data sharing and standardization. Geothermal does not have that currently." Digital twinning of geothermal systems and operations was another frequently mentioned example, with entities broadly agreeing that these methods are now bearing fruit in the oil and gas industry, and should be quickly transferred into geothermal.

Figure 6.18. An example of oil and gas rig automation. In 2022, NABORS and ExxonMobil announced the oil and gas industry's first fully automated land rig, which included a first of its kind robotics module. Rig floor automation may improve worker safety and process consistency in both the oil and gas, and geothermal contexts. *Source: NABORS, 2022.*

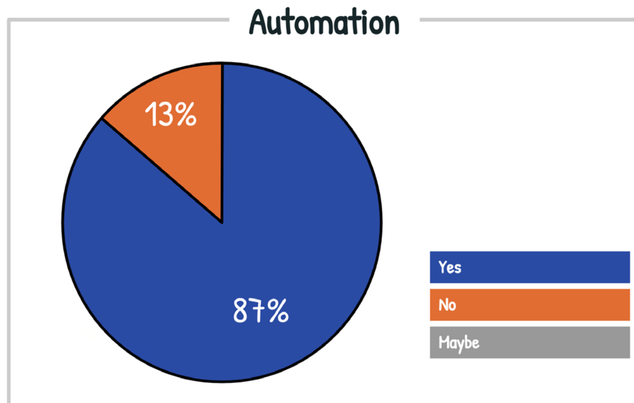

Figure 6.19. Oil and gas entities engaged or interested in applying Automation technologies to geothermal. *Source: Future of Geothermal Energy in Texas, 2023.*

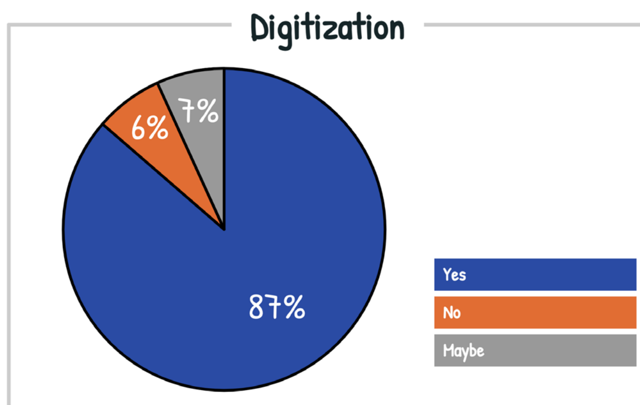

Figure 6.20. Oil and gas entities engaged or interested in applying Digitization technologies to geothermal. *Source: Future of Geothermal Energy in Texas, 2023.*

D. Geothermal Challenges and the Oil and Gas Industry

We asked interviewees about their views on both technical and non-technical challenges associated with achieving fast global scale for geothermal. In the first question, we asked entities if there are technical challenges associated with geothermal that the oil and gas industry will not be able to solve. 67 percent responded "no," with few hesitating in offering this answer. For at least one entity who expressed that they were "unsure," challenges associated with SuperHot Rock were given as an example of a potentially difficult set of challenges. Another entity agreed that currently available technologies would pose major challenges in the SuperHot context, but noted that with focused R&D, they may be overcome.

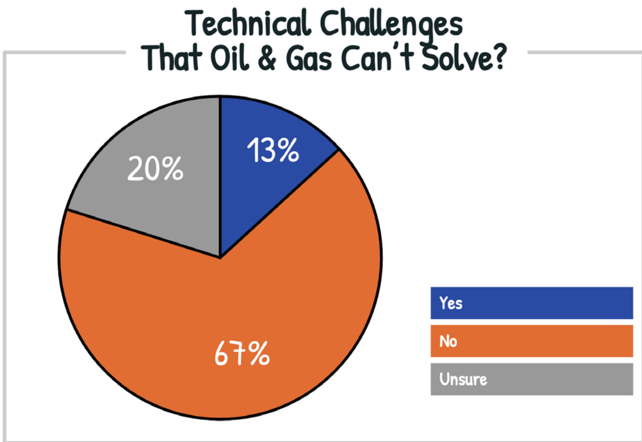

Figure 6.21. Oil and gas entity responses when asked if there were technical geothermal challenges that the oil and gas industry could not solve. *Source: Future of Geothermal Energy in Texas, 2023.*

All entities who believed that there were indeed geothermal related technical challenges that oil and gas would not be able to solve, expanded that surface equipment such as ORC turbines and other turbomachinery, are an essential component to the success of geothermal. Entities offered that current surface technologies are inefficient, that little innovation in this space is ongoing, and that this is an area that is outside of the expertise of most oil and gas entities. These entities took the position that if geothermal fails to launch, it will be the result of poor performance of equipment on the surface, and failure to innovate in this area.

In the second question, we asked entities if there were non-technical challenges associated with geothermal that the oil and gas industry will not be able to solve. Many more entities expressed that there were indeed non-technical challenges that were unsolvable by industry, as compared to unsolvable technical challenges. Non-engineering challenges of concern to entities, in order of most frequently raised, were 1) policy, regulatory, and permitting issues, 2) legal uncertainty, 3) social license issues, and 4) lack of funding for pilots and essential research.

Of the entities who answered that they were "unsure," or that there were no unsolvable non-technical challenges, they broadly acknowledged that policy, regulatory, and permitting challenges exist, particularly on Federal land in the United States, but noted that development can be pursued on state and/or private land in jurisdictions who are accustomed to working with the oil and gas industry. Texas was given by at least two entities as an example of such a jurisdiction. At least one entity noted with regard to policy, regulatory, and permitting challenges, that while there is currently no effective Federal geothermal lobby, that should not be considered a challenge that oil and gas cannot overcome – rather – the oil and gas lobby could begin to do this work on behalf of the industry for geothermal, and that State specific advocacy groups would be well positioned to tackle State level challenges.

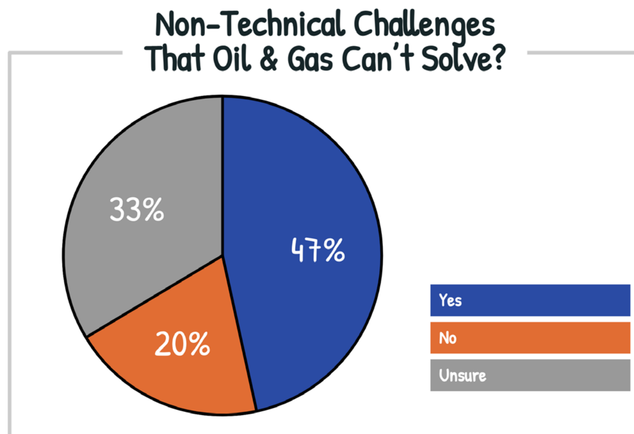

Figure 6.22. Oil and gas entity responses when asked if there were non-technical geothermal challenges that the oil and gas industry could not solve. *Source: Future of Geothermal Energy in Texas, 2023.*

With regard to the ability of industry to address social license to operate issues, one entity noted that if development in particular locations or States becomes too contentious, industry can adjust to develop in areas where communities are accustomed to working with industry in the oil and gas context. The interviewee noted that there will be no shortage of demand for small footprint, firm, green energy in the future, and that industry will simply "go where we are wanted" until the world begins to view geothermal development as a valuable and desirable community asset.

Finally, with regard to concern for lack of funding for essential R&D and pilot projects as raised by at least two entities, these are challenges that both industry and startup teams are facing, and are considered in further detail below, and in Chapter 9, The Texas Startup and Innovation Ecosystem.

E. Pilots and R&D

Entities were asked the hypothetical question of how they would spend a budget of $100 million to have the greatest impact and near term benefit for the growth of geothermal. 87 percent percent of entities chose to spend more than 80 percent of their $100 million on pilots and field deployments. This reflects a consistent theme that was repeated by entities many times during the interview process, that field deployment and iterative learning is essential, was the foundational principle that enabled the shale boom, and that for geothermal to succeed, teams must have sufficient funds to try new things (and sometimes fail) in the field, iterate, and try again.

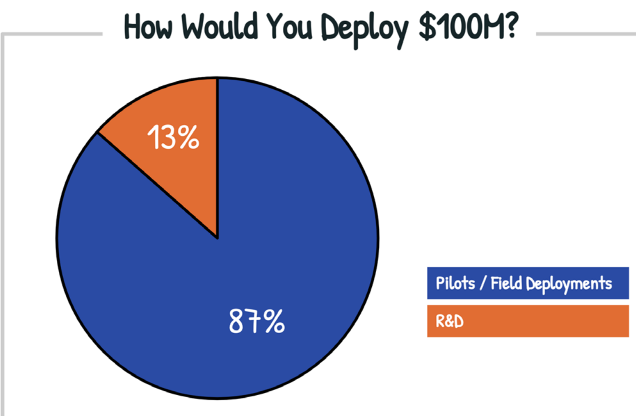

Figure 6.23. Oil and gas entity responses when asked how they would deploy $100 million dollars in funding for geothermal. *Source: Future of Geothermal Energy in Texas, 2023.*

Of teams who chose to spend a majority of their funding on pilots and field deployments:

- Three would pursue a sedimentary geothermal pilot;
- Two would pursue a combined heat and power pilot;
- Two would pursue a blind hydrothermal pilot;
- Two would pursue a geothermal + CCUS hybrid system pilot;
- One would pursue a coal plant conversion pilot;
- One would pursue a SuperHot pilot;
- One would pursue an offshore geothermal pilot; and
- One would pursue a hydrothermal revitalization pilot.

Teams generally expressed the desire to fund a series of iterative wells within one technology type, and in one location, as opposed to pursuing multiple unrelated pilots.

Entities who expressed an interest in funding R&D stated the desire to put more than 80 percent of their funds toward 1) high-temperature electronics, including sensor technologies, and 2) next generation drilling technologies.

100 percent of entities acknowledged that at least some R&D will be needed to address technical challenges. Several noted that oil and gas entities are already working on the R&D challenges that they believe are key to growing geothermal, including high-temperature completions technologies, like cements and fluids. Two areas of R&D were raised consistently by entities as areas of research that may be outside of the areas of expertise of their entities, or that no one entity may be incentivized to invest heavily in. These include surface technologies like ORCs, turbomachinery driven directly by sCO2 or engineered Working Fluids, and/or thermoelectric generation ("TEGs"), and materials science research into high-temperature materials such as elastomers, coatings, insulators, electronics and sensor technologies.

We next asked entities if they believe that materials R&D is essential to addressing challenges associated with the growth and development of geothermal. Entities were split approximately 50/50 on this topic between "yes" and 'unsure.'

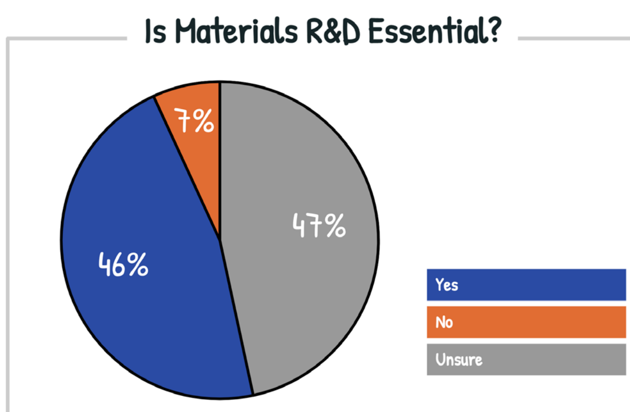

Figure 6.24. Oil and gas entity responses when asked if materials research and development is essential to addressing geothermal challenges. *Source: Future of Geothermal Energy in Texas, 2023.*

Entities who answered "yes" most frequently referred to SuperHot Rock challenges as likely to require significant

R&D dollars in materials, with entities raising the issues of corrosion, scaling, and a host of unknowns that will arise when working with supercritical fluids. Entities noted that supercritical water and/or brines are likely to pose a different set of technology challenges compared with sCO2 and engineered Working Fluids, but a majority of interviewees agreed that the higher the temperature, the greater the set of unknowns in terms of technology solutions and needs, and the more likely that materials R&D will be needed. One entity noted that drilling and exploration at the temperatures associated with SuperHot projects are not entirely unknown to oil and gas, offering deepwater offshore exploration wells as an example of projects that exceeded 300 °C (572 °F). The interviewee continued by noting that these deepwater wells were among the most complex and expensive ever drilled, and had the prize of decades of oil and gas production behind them to justify the investment. Thus, he noted, while industry could technically drill SuperHot projects today, the end does not currently justify the means in terms of cost. The interviewee noted that this is where materials R&D may become relevant, in reducing the cost of drilling these complex wells.

"Unsure" entities generally did not disagree that materials R&D was needed and would be helpful in growth geothermal, but instead took the position that there may be other ways to achieve the same result using more incremental approaches, existing technology adaptations, and innovative methods to achieve a similar result without the need to develop new materials. One example that was raised by an entity that might, for example, negate the need for the temperature hardening of all tools downhole is to increase the pumping capabilities of rigs to achieve increased circulation, utilize technologies that allow for continuous circulation, and aggressively cool, or even refrigerate fluids at the surface. These methods, he noted, may keep the tools cool enough to reliably drill deeper and hotter projects with conventional oil and gas technologies.

To a majority of entities who were "unsure," they generally agreed that before significant dollars are invested in materials science, much of which could take a decade or more before becoming commercially viable, there needs to be a cost/benefits analysis of other ways to achieve a similar result with adaptations to existing tools, technologies and techniques.

100 percent of interviewees who answered "no" on this question felt certain that adaptation of existing technologies would be sufficient to overcome challenges without significant materials R&D investment.

F. Industry Collaboration and Consortia

The last set of questions focused on the idea, often originating from governments and funding entities, that some form of organized industry collaboration, or a consortium model, may be a key avenue to enabling accelerated progress of the industry as a whole in addressing geothermal challenges. Data collected from responses suggests that while the idea sounds good on paper, the devil lies in the details.

93 percent of interviewed entities expressed support for the idea that combined industry effort in the form of cross-entity collaboration would be helpful in addressing geothermal challenges. However, when we asked follow up questions about what that collaboration might look like, responses got more nuanced.

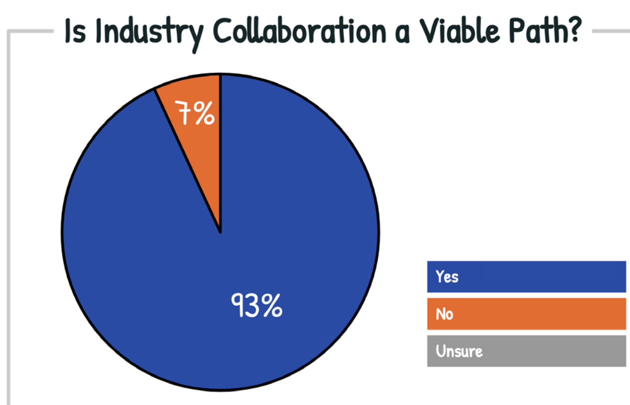

Figure 6.25. Oil and gas entity responses when asked if industry collaboration is a viable path to address geothermal challenges. *Source: Future of Geothermal Energy in Texas, 2023.*

When asked what types of information entities would find most helpful to share amongst a consortium of entities, there was a fair deal of disagreement, with some saying that only data that would help with industry-wide standardization would be acceptable, while others expressed interest in limited data sharing of the outcomes of consortium member pilots. Others expressed that the purpose of such an effort should be shared R&D, with the group benefitting from advancements as a whole, but entities disagreed about how intellectual property would be handled in such an arrangement, and several entities expressed that intellectual property was a sticking point for their entities in entering and considering such arrangements. Though all entities were asked, few were able to offer concrete examples of R&D focused industry consortia that they believe were highly effective at achieving the goals they set out to achieve.

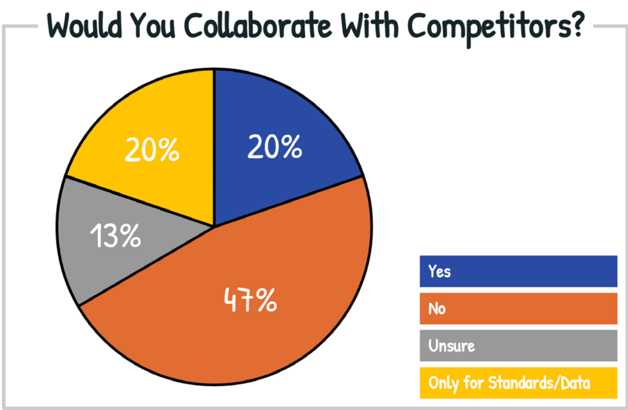

Figure 6.26. Oil and gas entity responses when asked if entities would be willing to collaborate with competitors in an industry consortium. *Source: Future of Geothermal Energy in Texas, 2023.*

Generally, responses to this question were consistent based on industry entity type. For instance, operators generally agreed that R&D focused consortia arrangements can be successful, even when the consortia includes competitors. One entity stated "operators are just better at this." Other entity types, including oil field service, drilling contractors, and suppliers were much more hesitant generally to consider a consortium model that would include competitors. In fact, those entities were much more likely to take the position that a small group of existing and complementary partners, including trusted and existing customer/service provider relationships, was a much more effective strategy for collaboration, or that it is best to let entities compete than to try to collaborate with competitors.

An example of this complementary partnership approach to collaboration is the recently launched "Wells2Watts" consortium, which is a partnership between Baker Hughes, Continental Resources, INPEX, and Chesapeake Energy. A first of its kind amongst oil and gas industry entities for geothermal, the goal of the partnership is to progress technologies that will support oil and gas Well Reuse, as well as non-productive geothermal well revitalization. The consortium will work with geothermal startup Greenfire Energy on the use of AGS/Closed Loop Geothermal Systems in the Well Reuse context (Baker Hughes, 2022).

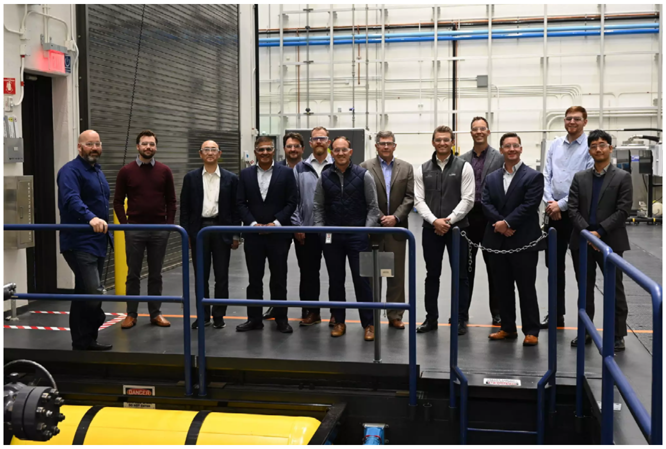

Figure 6.27. The Wells2Watts consortium team at their laboratory test well at the Oklahoma State University Hamm Institute of American Energy in Oklahoma City, Oklahoma. *Source: Baker Hughes, 2022.*

IV. Conclusion

Over the past few years, largely behind the scenes, oil and gas entities have been building visions, ideating, planning investments and pilots, funding R&D, building teams and strategies, and otherwise entertaining their level of engagement in building the future of geothermal. This behind the scenes activity has begun to show up publicly in occasional press releases and headlines, and in industry panels at the PIVOT - From Hydrocarbons to Heat conference, but these public glimpses of industry activity only scratch the surface of industry engagement (PIVOT, 2022c; 2022d). If we look closely at the data reported by industry about their areas of interest in geothermal, we can see clear trends. One is belief across entities that application of modern technologies from industry to geothermal will have a substantive and positive impact on project outcomes. Another is a forward looking view of what concepts might bear fruit for industry, including "bold" concepts that have failed to get traction within traditional geothermal and government spaces, like AGS/ Closed Loop, and SuperHot Rock.

Finally, the view of nearly 70 percent of interviewed entities that there is not a single technical challenge associated with geothermal that industry cannot solve is headline worthy. Rarely in such a conservative industry, in response to a speculative question, do we see such a consensus. That traction and consensus is what can propel Texas into a global leadership role in geothermal, led by its oil and gas industry.

Conflict of Interest Disclosure

Jamie Beard serves as Executive Director of Project InnerSpace, a 501(c)(3) organization that works on issues within the subject matter of this manuscript, and is compensated for this work. She further serves in a non-compensated role as a founding member of the board of the Texas Geothermal Industry Alliance. Outside of these roles, Jamie Beard certifies that she has no affiliations, including but not limited to board memberships, stock ownership and/or equity interest, in any organization or entity with a financial interest in the contents of this manuscript, and has no personal or familial relationship with anyone having such an affiliation or financial interest.

Ken Wisian serves as an Associate Director of The Bureau of Economic Geology, Jackson School of Geoscience at the University of Texas at Austin, and is compensated for this work. His main area of research for 30 plus years in geothermal systems. Outside of this role, Ken Wisian certifies that he has no affiliations, including board memberships, stock ownership and/or equity interest, in any organization or entity with a financial interest in the contents of this manuscript, and has no personal or familial relationship with anyone having such an affiliation or financial interest.

Silviu Livescu serves as a faculty member in the Petroleum and Geosystems Engineering Department and a co-principal investigator for the HotRock Industry Affiliates Program, both at the University of Texas at Austin, and is compensated for this work. He is also a co-founder of Bedrock Energy, a geothermal heating and cooling startup, and the editor-in-chief of Elsevier's Geoenergy Science and Engineering. Outside of these roles, Silviu Livescu certifies that he has no affiliations, including board memberships, stock ownership and/or equity interest, in any organization or entity with a financial interest in the contents of this manuscript, and has no personal or familial relationship with anyone having such an affiliation or financial interest.

Bryant Jones serves as the Head of Education and Policy at Project InnerSpace, a 501(c)(3) organization that works on issues within the subject matter of this manuscript, and is compensated for this work. He is also a full-time Ph.D. candidate at Boise State University where he researches at the nexus of policy studies, science and technology studies, and energy transition studies. Outside of this role, Bryant Jones certifies that he has no affiliations, including board memberships, stock ownership and/or equity interest, in any organization or entity with a financial interest in the contents of this manuscript, and has no personal or familial relationship with anyone having such an affiliation or final or financial interest.

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Chapter 6 Appendix A

The authors of the Future of Geothermal Energy in Texas report are grateful for the participation and insight provided by the following individuals. Thank you for taking the time to share your knowledge and experiences about the oil and gas industry engagement in the geothermal industry in Texas and from around the globe. Data collected from all participants has been aggregated and anonymized to capture and disseminate trends, views, and perspectives.

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