



Introduction

Geothermal and the Lone Star State

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Texas is hot, and it's not just the climate. It's hot under our feet as well. The core of the Earth is 6,000 °C (10,832 °F), the same temperature as the surface of the sun. The Earth's crust is an excellent insulator, shielding the surface from the enormous amount of heat that lies below. One needs only to stand near an erupting geyser, or visit a volcano to experience the immense power of this energy resource. And it is everywhere - ubiquitous. At any point on Earth, if you drill deep enough, you reach temperatures sufficient to produce electricity. Geothermal is an untapped subsurface energy giant.

The Union of Concerned Scientists estimates that the amount of available geothermal energy beneath our feet is 50,000 times more than the global total of oil and gas resources combined (UCS, 2014). Put another way, the oil and gas industry has powered the world through the industrial revolution and into modern times on the much smaller of our two subsurface resources - hydrocarbons and heat.

Texas geologies, including geothermal resources in the State's sedimentary basins, along with the State's status as the epicenter of the oil and gas industry, present a large and promising opportunity to develop geothermal resources in the State.

But why geothermal in Texas now? Over the past two decades within the oil and gas industry, there have been significant and enabling technological advances as a result of deepwater oil and gas exploration, and the invention of directional drilling technologies and hydraulic fracturing techniques - the enabling features of the 'shale boom.' New technologies and methodologies emerging from and perfected by the oil and gas industry over the past twenty years, such as horizontal drilling, multi-stage fracturing, and managed pressure drilling, have proven so disruptive that over the past decade they have rearranged global geopolitics and propelled the United States into energy independence (Olien, 2022). But these disruptive technologies and ways of working in oil and gas have just barely begun to be applied in the geothermal context, and when these technologies are transferred through oil and gas industry engagement in geothermal, we should expect, and even plan for, breakthrough impact, and fast, exponential leaps in capabilities and performance in the years to come. You'll see examples of these leaps in the pages of this Report.

Curiously however, most, if not all geothermal focused vision statements and analyses over the years have failed to take into account the swift and dramatic impact oil and gas industry engagement would have in

<https://doi.org/10.15781/8c5z-fs65>



geothermal development and scale over the coming decades. As a result of either underestimation, or failure to acknowledge the impact of technology transfer, fast innovation, and engagement at scale by the oil and gas industry, geothermal growth lingers consistently in single or low double digit growth over the coming decades in energy transition reports and models (EIA, 2022). These numbers have failed to motivate entrepreneurs, funders, governments, and even industry to acknowledge the sleeping clean energy giant beneath our feet as a potentially significant player in the energy transition. This failure of enthusiasm isn't particularly surprising, as imagining the limits of what is possible is where innovators and entrepreneurs find inspiration.

Much like the rise of unconventional, whose meteoric ascent largely took the world by surprise, geothermal is poised for similar, exponential growth should technology development and transfer follow the footsteps of the shale boom. Given increasing oil and gas industry engagement in this space, which is explored in depth in the pages of this Report, this is a possibility that should no longer be

overlooked as the world searches for energy transition strategies. Globally scalable geothermal development looks increasingly approachable to oil and gas entities if the past several decades of expertise are fully leveraged and optimized for geothermal development, and you'll see data in support of this in the coming Chapters. Further, geothermal entrepreneurship has entered a period of renaissance, with more geothermal startups launching over the past two years than in the past ten years combined, many buoyed by oil and gas investments, and a majority being led by lifelong oil and gas industry veterans. Several of these companies are planning or currently executing pilot projects and demonstrations in Texas.

It's not just industry and startups who are eyeing geothermal as an option for Texas' energy future. Recent polling data shows that geothermal is a uniquely bipartisan technology that Republicans, Democrats, and Independents wish to see greater emphasis on (CTEI, 2021). In a September 2022 survey of Texas voters, the second highest policy concern, behind immigration, was

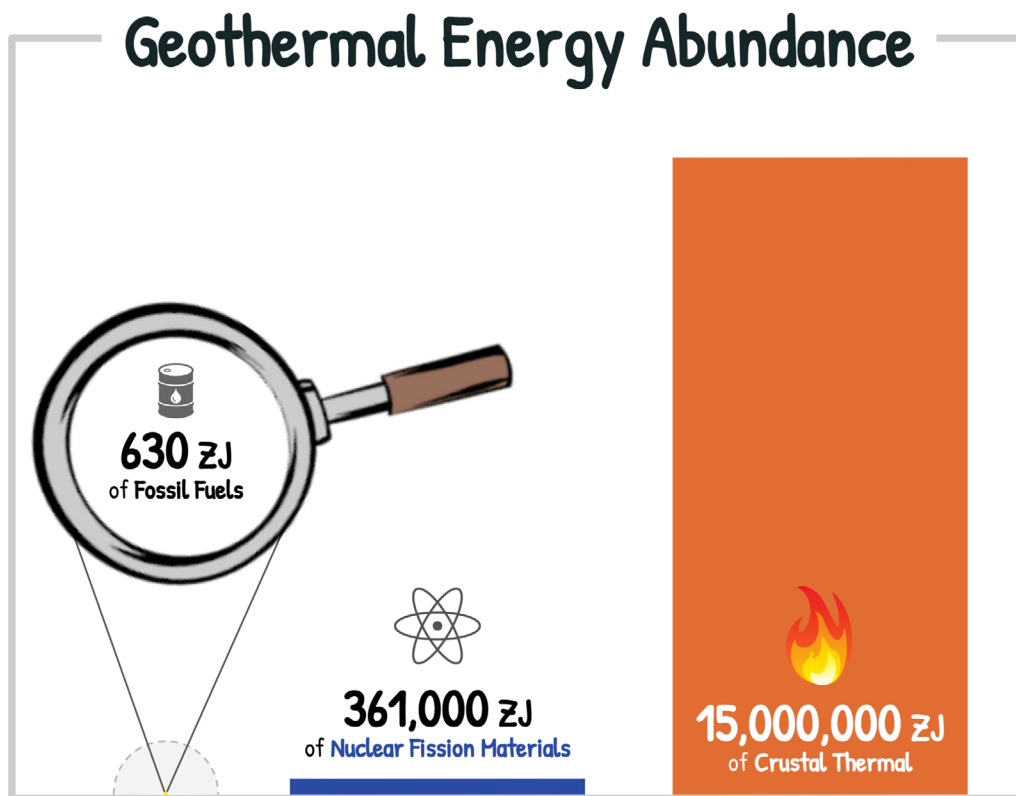


Figure. 0.1. Comparison of total heat energy in Earth's crust, compared to fissionable materials, and fossil fuels. Note that total fossil fuels, when compared with crustal thermal energy, is the equivalent of less than one pixel at the bottom of the graphic. Source: Adapted from Dourado, 2021



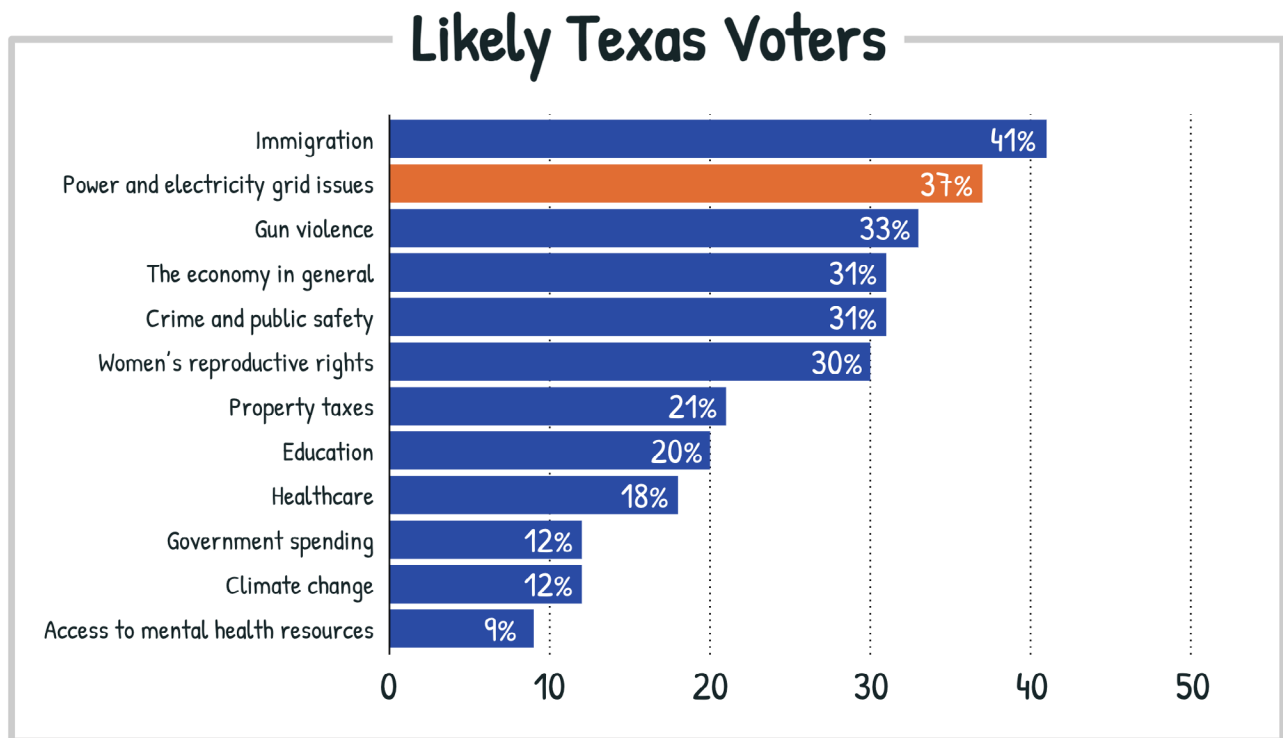


Figure 0.2. Top policy concerns for Texas voters during the 2022 midterm elections. Concerns about the electrical grid in Texas are second only to immigration as top of mind for Texas voters. *Source: Adapted from DFP, 2022.*

power and electricity grid issues. 73 percent of Texas voters support investments into new energy technologies that will alleviate periods of high stress on the electric grid in Texas (DFP, 2022). Additionally, geothermal energy has the lowest unfavorable ratings compared to all energy sources among Texas voters (DFP, 2022). Texas voters who are knowledgeable about geothermal express high levels of favorability toward the energy source, though data suggests we have a long way to go in familiarizing the public with geothermal, particularly in States like Texas where the resource has no surface manifestations, and is effectively invisible. Nevertheless, Republicans, Democrats, and Independents all support a greater emphasis on geothermal energy technologies, and view geothermal as a part of the future energy mix in the State of Texas (DFP, 2022; CTEI, 2021).

Through an exploration of a variety of topics relevant to the growth of this resilient, secure, baseload, clean energy source in Texas, this Report aims to reframe the conversation about geothermal to the upper limits of possibility, placing the technical, regulatory, legal, educational, and scaling barriers of geothermal into the backdrop of the Lone Star State, where ‘everything

is bigger’ - and asking the question - how would the millions of innovators, regulators, entrepreneurs, oil and gas workforce, academics, and industry entities in the State nurture and grow this resource, as they did oil and gas over the past century. Many authors of this Report, including myself, were inspired to study or pursue careers in geothermal by what remains the most visionary, comprehensive, and forward-looking work in this field, *The Future of Geothermal Energy*, published by the Massachusetts Institute of Technology Energy Initiative in 2006 (Tester, et al., 2006). At the risk of understatement, a significant amount of extremely consequential, breakthrough innovation in drilling and subsurface engineering, led by the oil and gas industry, has happened since that time. So it’s time for an update, taking the technology advancements of the past two decades, oil and gas industry capabilities, and synergistic assets present in Texas into account in exploring the Future of Geothermal in Texas. We hope that the next generation of geothermal innovators, entrepreneurs, pioneers, and advocates will find inspiration here the way we did years ago. Enjoy the ride, and since a geothermal pun seems like the best way to kick off this Report, *Full Steam Ahead.* 🔥



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. 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 have 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.



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