Chapter 5

Leveraging India's Oil and Gas and Mining Industries to Advance Geothermal

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India has significant geothermal potential, and tapping into it will require new jobs and skills. Fortunately, India's large oil and gas and mining sectors have both enthusiasm for geothermal's prospects and many skills that are transferable to the emerging geothermal field. By reaching goals suggested in this report, India could create between 350,000 and 700,000 jobs.

In a country where the energy landscape is still dominated by coal and supplemented by solar and wind, geothermal can provide much needed diversification, particularly in industrial and cooling applications.[1,2,3,4]

To help tap into its geothermal potential, India can look to its oil, gas, and mining sectors. Technology and infrastructure—such as drilling rigs, seismic data systems, and heat-resistant pipelines from oil and gas operations—can be adapted for geothermal use. Inactive oil wells and mining assets can be converted into geothermal production sites, and the associated subsurface data can be very helpful for mapping out geothermal projects. By taking such steps, the nation can help lower project costs and de-risk early-stage development.[5,6]

This transition from legacy energy to geothermal also offers a powerful way to create jobs while capitalising on the country's existing oil and gas workforce. As the number of geothermal projects expands, India will face a growing demand for skilled professionals, including drilling engineers; heating, ventilation, and air-conditioning (HVAC) technicians; geoscientists; and plant operators. Many of these roles already exist in the oil, gas, and mining industries, creating a natural pathway for workers to stay employed while also developing new skills.[7]

Following a survey of professionals across various energy sectors, this chapter identifies key trends, challenges, and opportunities for geothermal energy

adoption. It also highlights ways to unlock the potential of geothermal energy by leveraging India's existing oil, gas, and mining industries. If supported with appropriate incentives, infrastructure, and increased workforce development and skills training, these industries can play a transformative role in positioning India as a global leader in geothermal innovation while creating new jobs. If the goals suggested in Chapter 8, "Policy and Regulatory Pathways to Catalyse Geothermal in India," are adopted, the country could create between 350,000 and 700,000 jobs across its various geothermal applications.

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SURVEY METHODOLOGY

For this chapter, the survey targeted professionals with expertise in energy production, policy formulation, research, and investment. The survey group included people employed in the executive, senior management, and general parts of the workforce, as well as professionals in oil and gas, mining, and related companies (e.g., Oil and Natural Gas Corporation Limited [ONGC], Oil India Limited [OIL], Cairn Oil and Gas, Essar Oil and Gas Exploration and Production Limited, Reliance, Gas Authority of India Limited [GAIL], Coal India Limited [CIL], Bharat Coking Coal Limited [BCCL], SLB, and GE Baker Hughes. Participants were asked about their experience, awareness of geothermal projects, economic outlook, and suggestions for government and academia.

The survey covered the major themes, including industry experience and role, current involvement in geothermal energy, perceived economic impact, workforce development and skill gaps, policy and regulatory challenges, and investment and market potential. It asked about geothermal energy engagement, company interest, pilot projects, research and development initiatives, collaboration, training needs, employment opportunities, and understanding of the current government policies impacting geothermal industry growth. The survey produced 76 complete responses.

Survey Respondents

The respondents were mainly from oil and gas sectors and mining sectors, as shown in **Figure 5.1**.

INDUSTRY EXPERIENCE OF SURVEY PARTICIPANTS

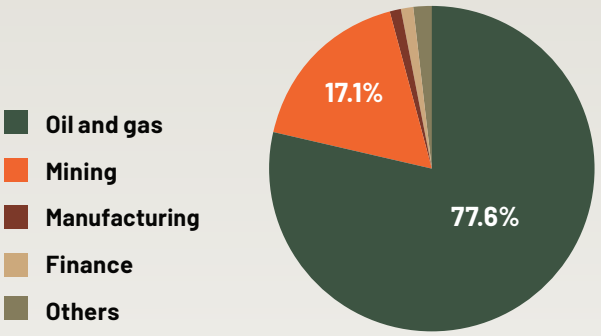

Figure 5.1: Industry experience of the survey participants. The remaining values total to less than 5%. Source: authors.

Figure 5.2 breaks down the participants' experience levels. Overall, participants mostly came from the oil and gas professions, and the number of respondents from each age category is balanced.

EXPERIENCE LEVEL OF RESPONDENTS

Experience Level	Percentage (%)
15+ years	22.4
10-15 years	28.9
5-10 years	22.4
<5 years	26.3

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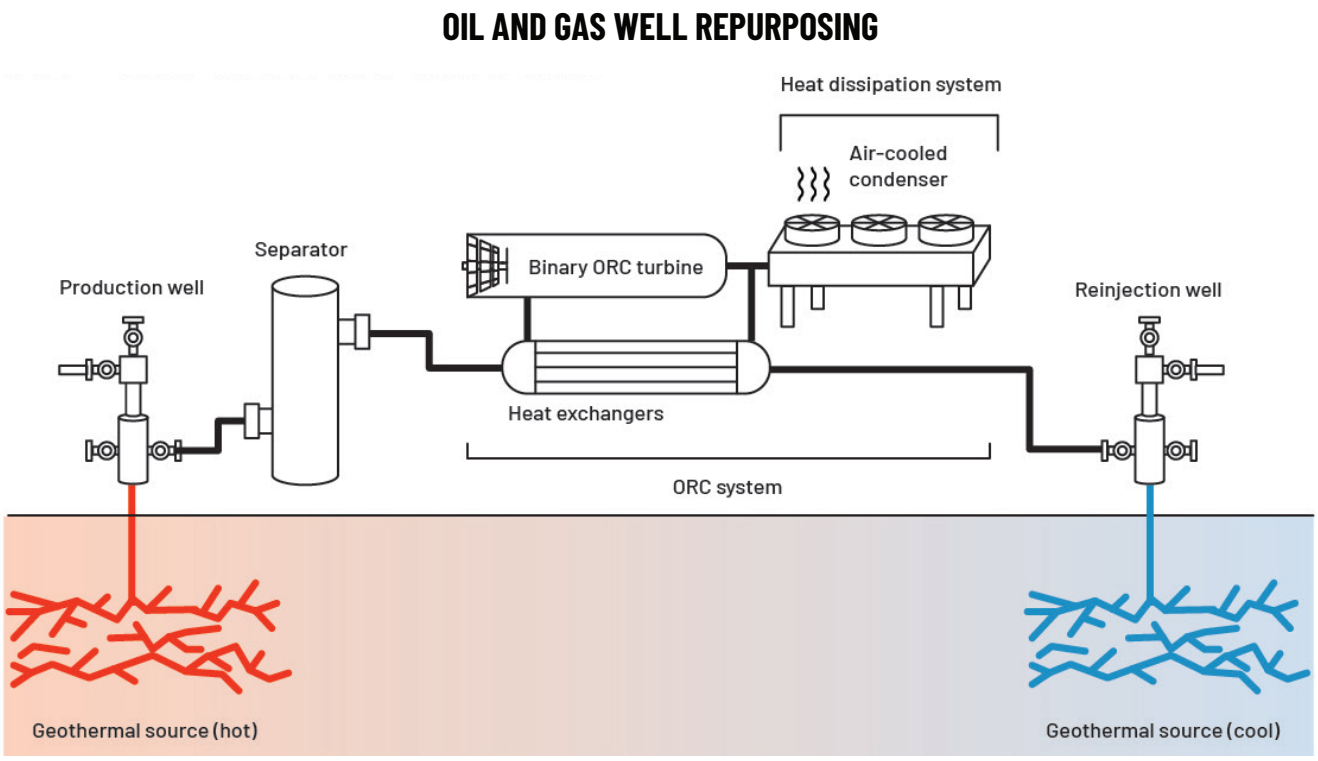

Figure 5.3: Typical geothermal setup for oil and gas repurposing. Source: Project InnerSpace.

OIL, GAS, AND MINING IN INDIA

India has a long and complex history of oil, gas, and mineral resource development. Mining activities in India date back thousands of years, with ancient civilisations extracting gold, copper, and iron for tools and trade. Modern mining took shape under British rule, particularly in coal-rich regions like Jharkhand, West Bengal, and Odisha, which supplied fuel for colonial railways and industries. The discovery of oil in Assam in 1889 marked the beginning of India's petroleum industry, with the Digboi oil field as the site of Asia's first commercial oil well.

After gaining independence, India nationalised much of its oil, gas, and mining industry to secure energy sovereignty and industrial growth through the establishment of such major public sector institutions as ONGC and CIL. In the 1990s, economic liberalisation opened the energy sector to private and foreign investment, leading to technological upgrades and increased production, particularly in offshore oil and gas blocks. Today, India remains one of the world's largest producers of coal and continues to invest in domestic oil and gas exploration, even as the country begins transitioning toward cleaner energy alternatives.

Existing Subsurface Assets and Geothermal Potential

As India charts a path to a low-carbon future, the legacy infrastructure and knowledge base of its oil and gas industry—particularly in mature energy-producing states—provide a valuable foundation for geothermal development.The greatest advantage of India's energy-producing states lies not only in their physical infrastructure but also in the extensive subsurface data and deep geological understanding that decades of hydrocarbon exploration have generated.

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The Cambay basin of Gujarat, for instance, is one of India's most studied sedimentary basins, with rich geological,

thermal, and structural data from oil and gas operations that can inform geothermal resource assessment. Such data offer an unparalleled head start for identifying viable geothermal sites with reduced exploration uncertainty.[8]

Other states—including Maharashtra, Andhra Pradesh, Madhya Pradesh, Rajasthan, Chhattisgarh, Jharkhand, Telangana, and Odisha—similarly possess both subsurface data and technical expertise stemming from decades of oil, gas, and mining activity. These regions could use existing geological surveys and drilling records to assess geothermal potential and target development zones, but current NDR rules restrict data to oil and gas. As noted in Chapter 8, "Policy and Regulatory Pathways to Catalyse Geothermal in India," allowing geothermal access would reduce risk and speed deployment.[9,10]

Globally, several pilot projects have shown how existing subsurface knowledge from oil and gas fields can accelerate geothermal development, including initiatives by GreenFire Energy in the United States (2020), MS Energy Solutions in Hungary (2021), and CeraPhi in the United Kingdom (2023).[11] While some of these projects also involved repurposing wells, success hinged on leveraging preexisting geological understanding and operational data.

India's oil and gas sector also brings essential technical capabilities such as directional drilling, well logging, and reservoir modelling that can enhance the precision and efficiency of geothermal projects. Advanced monitoring tools—including fiber optic temperature sensing and subsurface imaging, already used in India's mature basins—can be directly applied to geothermal resource assessment and management.

By capitalising on this wealth of subsurface knowledge and expertise, India can de-risk early-stage geothermal exploration and accelerate deployment, particularly in industrial regions where geological data and technical capacity are already concentrated.

Sharing Technology Across Industries

Over the past two decades, technological advancements in oil and gas, particularly in unconventional drilling, have opened up new frontiers with strong relevance to geothermal development in India. Techniques such as directional drilling, advanced casing, use of polycrystalline diamond compact bits, and reservoir stimulation—widely used in shale plays like the Permian Basin in the United States—can be adapted for India's deeper and more complex geothermal reservoirs, especially in regions such as Ladakh, Himachal Pradesh, and Gujarat. Recent engineered geothermal system pilot projects globally (including in Utah, in the United States) have demonstrated how hydraulic stimulation and real-time monitoring tools like seismometers, distributed acoustic sensing, and tracer diagnostics can help map subsurface heat flows and optimise well performance. Leveraging these capabilities through cross-sector collaboration can reduce exploration risk, lower costs, and speed up the commercialisation of geothermal energy in India, especially in industrial zones where heat demand is high and existing energy infrastructure can be repurposed.

One thing to note is that oil and gas firms have a higher level of direct engagement in geothermal energy than the mining industry. However, there is no significant difference in exploratory or collaborative efforts between the two sectors. Increased knowledge-sharing initiatives between both sectors may accelerate geothermal adoption.

Existing Workforce and Skills

India's oil, gas, and mining industries represent a significant portion of the national workforce. The oil and gas sector alone employs more than 2.5 million people directly and indirectly—including those working for both Indian and international companies operating in the country—while the mining sector accounts for more than 1.2 million direct jobs and supports several million more through related industries and services. Many of these roles—such as drilling crews; transport workers; Engineering, Procurement, and Construction (EPC) contractors; and maintenance technicians—possess skill sets that align closely with the needs of the geothermal sector.

However, even with this significant overlap, there are still knowledge gaps between these established industries and geothermal. While technical expertise from these sectors can be transferred to geothermal projects, workers will need to develop specialised knowledge in geothermal exploration, drilling, and resource management. Vocational institutes and academic programs can bridge these gaps by updating curricula, developing new training programs,

TRANSFERABLE SKILL SETS FROM THE OIL AND GAS INDUSTRY

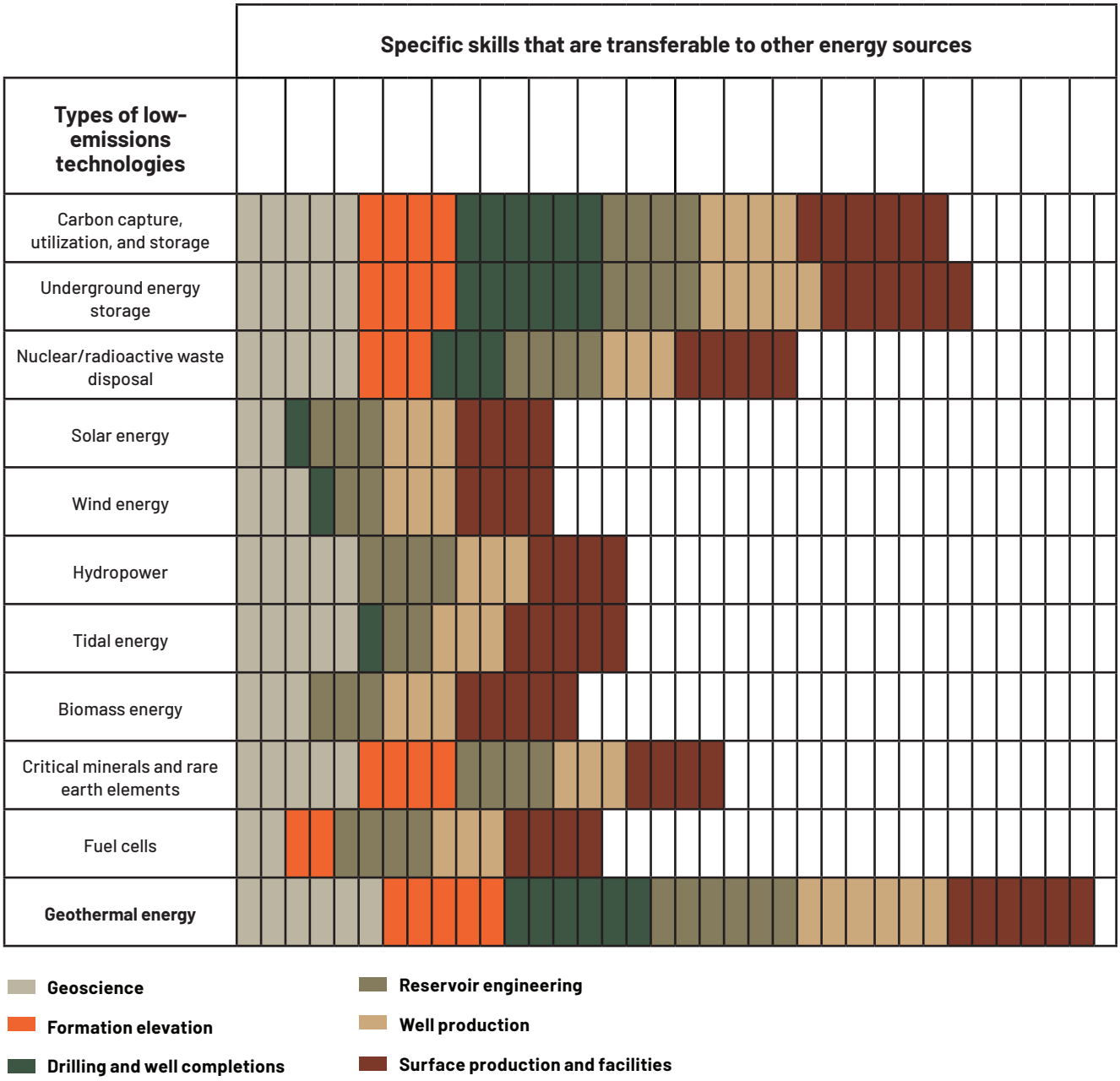

Figure 5.4: Geothermal ranks highest when considering the potential impact of transferring oil and gas skills into other energy transition and low-carbon technologies. Source: Tayyib, D., Ekeoma, P. I., Offor, C. P., Adetula, O., Okoroafor, J., Egbe, T. I., & Okoroafor, E. R. (2023). *Oil and gas skills for low-carbon energy technologies.* Society of Petroleum Engineers Annual Technical Conference and Exhibition.

collaborating with other academic institutions, and supporting industry-led initiatives. Since such efforts will require funding, government support and financial incentives can jump-start efforts while also stimulating investment. (See Chapter 8, "Policy and Regulatory Pathways to Catalyse Geothermal in India.") Successful geothermal markets such as Indonesia and Kenya demonstrate that strong public–private partnerships and favourable regulatory environments are critical for attracting additional investment. Adopting similar strategies would put India in a position to unlock the full potential of its geothermal resources.

WORKFORCE AND JOB CREATION BENEFITS OF GEOTHERMAL

India's oil and gas sector can be organized into five verticals that are relevant to the geothermal industry: exploration and production, refining, marketing, pipelines, and research and development. Companies across these verticals employ workers in executive, supervisory, clerical, and general roles. According to the Ministry of Petroleum and Natural Gas database, there are an estimated 86,000 employees at Indian companies (e.g., ONGC, OIL, GAIL, Indian Oil Corporation Limited, Bharat Petroleum Corporation Limited, and Hindustan Petroleum Corporation Limited; see **Figure 5.5**).[12,13] Contracts with auxiliary companies allow these companies to fill an additional 430,000 manufacturing and service roles, among others.

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COMPANIES OPERATING IN INDIA'S OIL, GAS, AND MINING SECTORS

Operator Companies	Service Companies
Oil and Natural Gas Corporation Limited (ONGC)	Schlumberger (SLB)
Oil India Limited (OIL)	Baker Hughes
Coal India Limited (CIL)	Halliburton
GAIL (India) Limited	Seros
Bharat Coking Coal Limited (BCCL)	Revata Engineering
Indian Oil Corporation Limited (IOCL)	Global Drilling Fluids and Chemicals Limited
Bharat Petroleum Corporation Limited (BPCL)	Catalyst Drilling Fluids
Hindustan Petroleum Corporation Limited (HPCL)	Lotus Tricone Drill Bits
Cairn Oil & Gas (Vedanta Limited)	Gpak Offshore Services Private Limited
Reliance Industries Limited	Bergzest Energy Private Limited
Essar Oil and Gas Exploration and Production Limited	Interface Gas Consultants Private Limited
Shell	Stratom Energy Solutions
ExxonMobil	Encode Net Ventures Private Limited
Chevron	Petrosh Energia
BP	SAZ Oil

Figure 5.5: Operator and oil field service companies in India's oil, gas, and mining sectors. Source: Raj Kiran, Subsurface Energy and Storage Systems Lab, Department of Petroleum Engineering, Indian Institute of Technology (Indian School of Mines), Dhanbad.

maintenance, and more. The increase in geothermal direct-use applications for residential and industrial cooling is also expected to benefit the HVAC and maintenance workforce.

According to multiple studies, for each megawatt of installed capacity in geothermal, at least 5 to 10 employees are needed along the entire value chain from research and development, education and training, administration and authorities, production of surface and underground technology, plant construction, and pipeline construction to operation and maintenance and services.[14]

As mentioned in the executive summary and other chapters, India could create 10 gigawatts of power, 10 gigawatts of cooling, and 50 gigawatts of industrial direct-use geothermal by 2050.

Creating these 70 megawatts could, in turn, generate between 350,000 and 700,000 jobs across various geothermal applications.

The recent growth of solar power in the energy sector provides a useful analog for comparison. In 2024, the Ministry of New and Renewable Energy reported that 9.7 gigawatts of grid-connected solar photovoltaic were installed in 2023. These efforts created 17,000 jobs related to both solar heating and cooling. Geothermal heating and cooling are similarly manpower-intensive.

Wages

Sixty percent of survey respondents said they anticipate wage increases in skilled geothermal professions, owing to the demand for specialised knowledge in geothermal engineering and resource management. Eighty-five percent agree that geothermal energy will contribute to regional economic growth by providing stable, renewable energy sources and reducing reliance on fossil fuels.

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EXPECTED ECONOMIC AND WORKFORCE IMPACT

Impact area	Positive response
Job creation	75%
Wage growth	60%
Economic Boost	85%

Figure 5.6: Survey results on expected economic and workforce impacts. Source: authors.

According to AmbitionBox,[15] a career advisory company in India, average annual salaries in the energy sectors are as follows:

1. Oil and gas
   a. Executive salaries for roles such as chief general manager and other high-level positions range from INR 24.0 lakhs to 97.8 lakhs.
   b. Supervisory staff and engineering salaries range from INR 3.2 lakhs to 27.5 lakhs.

2. Coal mining
   a. Executive salaries range from INR 38.1 lakhs to 54 lakhs.
   b. Managerial salaries (such as deputy general managers and management trainees) range from INR 9.0 lakhs to 17.9 lakhs.

Given the close technical and operational similarities between these industries and geothermal energy, these ranges provide a useful benchmark for the emerging geothermal sector. Geothermal jobs in India could aim to align with comparable compensation levels to attract and retain skilled professionals transitioning from other energy sectors.

While geothermal energy is still an emerging field in India, the significant skill overlap with oil and gas suggests that employees who transition into geothermal roles could expect competitive wages. The survey conducted for this report also supports this expectation.

Roughly 50% of respondents noted their companies are planning to leverage existing infrastructure to develop geothermal, suggesting a clear pathway to scale this sector in India.

IMPACTS AND PLANS

When respondents from companies with a geothermal focus (see **Figure 5.7**) were asked about both current impacts and future plans, their answers reflected optimism about geothermal energy's economic potential and industry outlook. Their responses, however, also reveal lackluster sentiments about the lack of ongoing activities and the participants' involvement in the geothermal projects. Most of the respondents with less enthusiastic responses work at companies with no ongoing geothermal activities.

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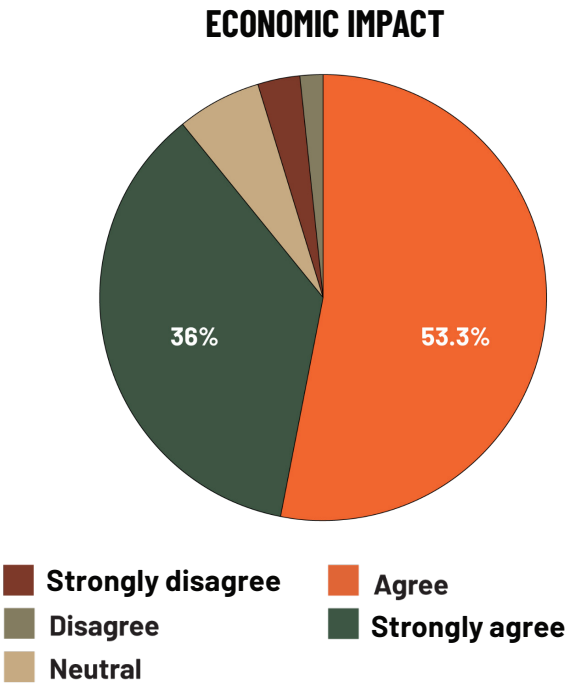

Figure 5.8: Percentage of respondents with each response to the question "Will there be a positive impact on the Indian economy due to increased geothermal activity?" Source: authors.

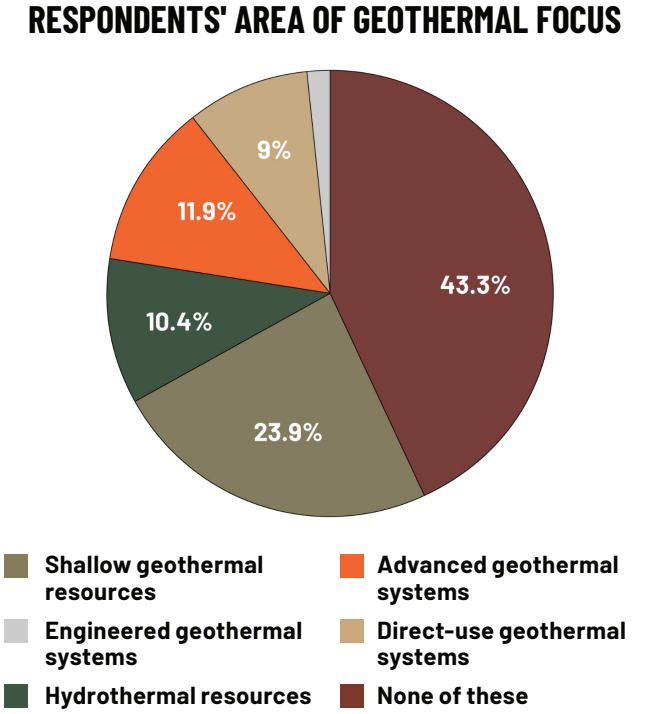

Figure 5.7: Respondents' areas of geothermal focus. Source: authors.

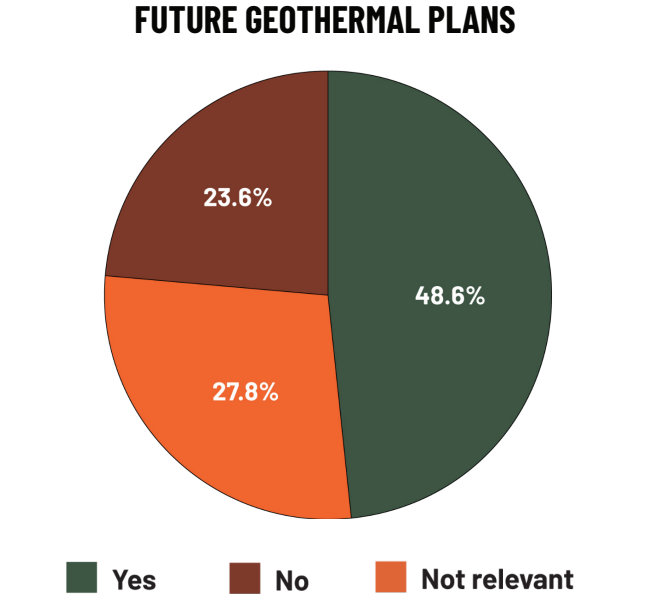

Figure 5.9: Percentage of respondents with each response to the question "Is your company planning to leverage existing infrastructure to develop geothermal resources?" Source: authors.

OVERALL FINDINGS

The statistical results of the survey undertaken to assess the oil and gas industry and perceptions of geothermal highlight a positive and consistent perception of geothermal energy's potential impact, competitiveness in wages, and industry interest. Eight-five percent of respondents agree that geothermal energy will contribute to regional economic growth by providing stable, renewable energy sources and reducing reliance on fossil fuels. Such findings are encouraging for policymakers and investors, as they suggest a readiness within related energy sectors to support geothermal development and workforce integration.

Eight-five percent of respondents agree that geothermal energy will contribute to regional economic growth by providing stable, renewable energy sources and reducing reliance on fossil fuels.

Overall, the responses were largely neutral to positive when it comes to the economic benefits of enhanced geothermal activities. The industry professionals are optimistic about the geothermal opportunities in India, though some participants expressed concerns regarding the trajectory of geothermal sector developments. Pilot projects in potential areas could enhance the participation of various stakeholders and demonstrate the viability of geothermal energy in India.

The survey results indicate that while geothermal energy is gaining recognition, direct involvement remains limited. About 70% of respondents reported that they had not previously worked on geothermal projects, though 80% belonged to companies operating in oil, gas, or mining. These findings suggest that while technical expertise exists, its application to geothermal energy is still in a nascent stage. The response pool consisted of a large number of managers, indicating that most participants have strategic decision-making capabilities in their respective organizations. A small portion of professionals were actively engaged in exploration and drilling operations, which are key areas for geothermal project execution.

Respondents also expressed concerns over regulatory hurdles and financial viability. While 75% expected geothermal development to create jobs, 60% worried about the existing workforce's skill gap. Overall, while industry experience in geothermal projects is currently limited, there is a growing interest in leveraging existing technical skills for geothermal energy expansion. With the right policies (as outlined in Chapter 8, "Policy and Regulatory Pathways to Catalyse Geothermal in India"), training, and investments, geothermal energy has the potential to become a significant contributor to India's renewable energy mix.

CONCLUSION AND FUTURE RECOMMENDATIONS

Interest in geothermal energy is gaining traction among academics, policymakers, and industry professionals across India, as evident with the release of the Ministry of New and Renewable Energy's 2025 National Policy on Geothermal Energy.

The development of a skilled workforce is essential for unlocking the full potential of geothermal energy in India, and the country has a big head start on the path to achieving this potential with its experienced oil and gas industry. For India to become a leader in geothermal power, the country should consider taking the following steps:

- Leverage expertise from the oil, gas, and mining sectors to support geothermal exploration and drilling advancements.
- Make strategic investments in education, training, and specialised courses to accelerate workforce development and bridge the workforce skills gap.
- Form collaborations between private enterprises and government entities to bolster research and infrastructure development.
- Encourage companies to undertake small-scale geothermal pilot projects to help establish feasibility and build confidence in long-term investment.
- Expanding NDR rules to allow for geothermal use of oil and gas data will reduce exploration risk and accelerate geothermal's development.

Taking such actions will allow India to create a robust geothermal workforce—one that will increase employment and wages while helping the country achieve a more resilient and sustainable energy industry.

APPENDIX: DATA COLLECTION, SAMPLING, AND METHODOLOGY

Oil and gas industry data were collated from various sources, including Ministry of Petroleum and Natural Gas and the annual reports of different companies available in the public domain.

We used a combination of random and stratified sampling methods to ensure a balanced representation of industry stakeholders. The survey remained open for responses for eight weeks, during which we sent reminders to maximise participation. We collected data anonymously to ensure confidentiality and encourage honest responses.

We conducted the study based on data analysis that included general patterns, exploratory data analysis, statistical analysis, and sentiment analysis. The survey questionnaire contained Likert-scale questions on various industry aspects, such as geothermal job impact, wage comparisons, and company interests. To perform statistical tests, we converted text-based Likert-scale responses into numerical values:

- Strongly disagree = 1
- Disagree = 2
- Neutral = 3
- Agree = 4
- Strongly agree = 5

For categorical variables, we applied appropriate numerical encoding based on the number of categories present. We either removed or imputed missing values to maintain data integrity. First, we employed principal component analysis (PCA) to identify the most influential factors in the survey responses.[16] The PCA included four steps: (i) standardisation of data sets to ensure equal weights for all variables, (ii) eigenvalues and eigenvector computation to determine the principal components, (iii) selection of components to explain the majority of variance, and (iv) a scree plot to visualise the importance of each component.

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