REPORT

GEOTHERMAL ENERGY

Unveiling the Socioeconomic Benefits

ESMAP
Energy Sector Management Assistance Program

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

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Abbreviations

CAPEX	capital expenditure
CSR	corporate social responsibility
EDC	Energy Development Corporation
EPC	engineering, procurement, and construction
ESIA	Environmental and Social Impact Assessment
ESMAP	Energy Sector Management Assistance Program
GDC	Geothermal Development Company
GDE	Geo Dipa Energi
GDP	gross domestic product
GRÓ GTP	Centre for Capacity Development, Sustainability, and Societal Change's Geothermal Training Program
ILO	International Labour Organization
IRENA	International Renewable Energy Agency
MW	megawatt
NREL	National Renewable Energy Laboratory
O&M	operation and maintenance
RfP	request for proposals
SMEs	small and medium enterprises
STEM	science, technology, engineering, and mathematics
TVET	technical and vocational education and training
UNEP	United Nations Environment Programme
US DOE	United States Department of Energy
WING	Women in Geothermal

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Editors: Steven Spencer and Fayre Makeig
Design: Sergio Andres Moreno/World Bank

Key Findings

This report highlights the socioeconomic contributions of the geothermal sector, including the potential opportunities and benefits that can be enhanced at national and local levels throughout geothermal projects' development and operation. Key lessons and best practices are outlined in the report and showcased across 27 case studies with the intent that governments and developers alike can learn and replicate best practices to generate positive socioeconomic outcomes.

The report examines socioeconomic benefits across four categories, derived from the World Bank's Sustainable Renewables Risk Mitigation Initiative. Key findings and recommendations are:

1. Participation of domestic companies in the geothermal value chain

- There is substantial room for localization efforts particularly in the construction, and operation and maintenance (O&M) segments of the geothermal value chain. Conduct a value chain analysis to identify possible areas for domestic companies' participation.
- Tailored support programs to address specific needs and challenges faced by local companies are needed. Identify gaps and design programs to nurture the domestic and local geothermal industry's capabilities over the long term.
- Governments are using project procurement to encourage localization along the geothermal value chain. Incentives for developers to domestically source specific components and services have effectively nurtured the growth of domestic companies. However, there needs to be a balance to maintain projects' cost-effectiveness.
- Industry clusters and associations play an important role to boost the domestic industry's capacities through facilitation of training, networking opportunities, promotion of technology transfer, and collaborative research and development.
- Collaboration between government agencies and industry stakeholders are essential to align policies, initiatives, and investments with the goal of strengthening the domestic geothermal industry.

2. Geothermal employment and skill development

- Employment and skill development are vital components of the geothermal sector's growth. Regarding job creation, both construction and O&M hold substantial potential and these opportunities needs to be recognized and harnessed.
- The geothermal sector faces skill shortages with gaps prevalent among high-skilled positions and to a lesser extent among medium-skilled roles, whereas low-skilled roles face fewer recruitment challenges. Mitigating skill shortages can be possible by reskilling talent from declining industries, collaboration with educational institutions for geothermal curricula and specialized training programs, and incentivization of developers to offer on-the-job training.
- Often, developers hire individuals without prior experience in the geothermal industry and provide the necessary education and on-the-job training, through formal programs or informal peer learning. Addressing skill shortages can involve sending individuals to established geothermal markets for training.
- Expansion of the geothermal workforce requires better communication about educational opportunities through student competitions, mentorship programs, internship, and apprenticeship.
- Fostering partnership between government agencies, educational institutions, and private companies for joint investment in skill development programs is essential, and to ensure that appropriate training and education align the workforce with the industry's needs.

3. Local development and benefit sharing

- The need for community engagement goes beyond a mere formality—it is integral to the development process. Securing a social license to operate is nonnegotiable for geothermal developers.
- It is important to recognize that the investments in community engagement has long-term benefits, prevents delays and legal issues. Transparent information and comprehensive consultations are key for effective benefit sharing.

- Benefit sharing is broadly grouped into three key categories: i) Infrastructure and service enhancement directly contributing to community well-being; ii) Community skill and capability enhancement; and iii) Revenue/ownership sharing arrangements and mechanisms.
- Aligning local communities' needs with government priorities to facilitate the creation of benefit sharing programs contribute towards community and development goals.

4. Gender equality and social inclusion are addressed through an intersectional lens.

- To foster diversity and inclusion, several governments employ project procurement to incentivize the recruitment of domestic or local labor, whereas others set targets for women's workforce participation.
- Direct use projects can generate greater employment opportunities for women, youth, and marginalized groups, promoting social inclusion.
- Prioritization of gender-sensitive benefit sharing plans that respect local cultural norms and addressing potential sensitivities related to female employment are needed, including commitment to equitable benefit distribution among community members, considering factors such as age, race, and ability.

While considering the recommendations offered in this report, policy makers and practitioners would do well to keep in mind that each country has its own unique circumstances that call for customized approaches.

Executive summary

Creating Value Beyond Electricity Generation

This report highlights the socioeconomic contributions of the geothermal sector, including the potential opportunities and benefits that can be enhanced at national and local levels throughout geothermal projects' development and operation. The report was prepared using qualitative data from over 40 stakeholders in the geothermal industry, including governments, industry associations, academia, public and private sector developers, and technical experts. Quantitative data were collected from a survey of 15 geothermal developers around the world. Key lessons and best practices are outlined in the text and also showcased across 27 case studies.

This report is intended as a complement to the World Bank (2022b) handbook "A Sure Path to Sustainable Renewable Energy: Maximizing Socioeconomic Benefits Triggered by Renewables," which provides step-by-step guidance for governments on designing renewable energy programs that generate wider societal benefits beyond clean power generation. As the handbook was largely technology agnostic, this report was developed to provide further, in-depth analysis of the socioeconomic benefits that can accompany geothermal development and operation. The intent is that governments and developers alike can learn from the examples and case studies featured, and replicate best practices to generate positive socioeconomic outcomes.

The report examines benefits across four categories, derived from the World Bank's Sustainable Renewables Risk Mitigation Initiative:

- Participation of domestic companies in the geothermal value chain
- Geothermal employment and skill development
- Local development and benefit sharing
- Gender equality and social inclusion

The following section outlines key findings and best practices across these four categories. Gender equality and social inclusion are addressed through an intersectional lens. When considering the recommendations offered in this report, policy makers and practitioners would do well to keep in mind that each country has its own unique circumstances that call for customized approaches.

It is worth clarifying that this report focuses on benefits that extend beyond the risk mitigation requirements of environmental and social safeguard frameworks. The report does not explore wider sectoral advantages, such as the societal and economic benefits of greater energy security and reduced greenhouse gas emissions—important benefits across all renewable energy technologies. Instead, its examination of socioeconomic benefits centers on what can be influenced—and, importantly, enhanced—during project development and operation.

The Geothermal Value Chain: Generating Socioeconomic Benefits

Domestic companies' participation in the geothermal value chain holds significant potential for enhancing the socioeconomic benefits tied to the development and operation of geothermal projects. A comprehensive understanding of the geothermal value chain is essential in identifying areas ripe for maximizing these benefits. The availability of domestic resources in the project's host country (specifically, of goods, services, and labor) could be leveraged to localize various activities across the value chain. This will enhance value addition and boost the country's gross domestic product.

Identifying gaps in domestically accessible resources offers opportunities to design programs that nurture the domestic geothermal industry's capabilities over the long term. This strategic approach could help capture more added value. Notably, there is substantial room for localization efforts in the construction, and operation and maintenance (O&M) segments of the geothermal value chain. This remains true even when international corporations are involved, since segments of work can still be outsourced to local entities or labor forces.

While certain components such as turbines, condensers, cooling towers, and generators are specialized and unlikely to be manufactured domestically, a range of other necessary equipment (e.g., heat exchangers, pumps, valves, piping, and cladding) is commercially available and can be provided by multiple suppliers. Governments are using project procurement to encourage localization along the geothermal value chain. Incentives for developers to domestically source specific components and services have effectively nurtured the growth of domestic companies. It is imperative, however, to carefully weigh these procurement strategies so as not to jeopardize project viability or raise associated tariffs.

Clusters and industry associations play a pivotal role in boosting domestic industries' capacities. They facilitate training, encourage interactions among stakeholders from various sectors, and cultivate an environment conducive to technology transfer and research and development. Further, domestic companies looking to adapt their business activities and expand operations to partake in the geothermal value chain could be offered specialized financial products tailored to their unique needs.

Best practices to nurture a domestic geothermal industry

1. **Comprehensive understanding of the value chain.** Conduct a value chain analysis to identify possible areas for domestic companies' participation.
2. **Leveraging of domestic resources.** Capitalize on the availability of domestic resources (specifically, goods, services, and labor) to promote localization efforts. Explore ways to

maximize the use of domestically accessible resources, increasing value addition and boosting gross domestic product growth.

3. **Support programs for domestic industries.** Identify gaps in domestically accessible resources and design programs to nurture the domestic geothermal industry's capabilities over the long term. Tailor support programs to address specific needs and challenges faced by local companies.
4. **Localization in construction and O&M segments.** Recognize the substantial potential for localization efforts in the construction and O&M segments of the geothermal value chain. Encourage international corporations involved in geothermal projects to engage local entities or labor forces in various aspects of the work.
5. **Project procurement strategies.** Implement project procurement strategies that incentivize the involvement of domestic companies without compromising project viability or raising associated tariffs. Balance localization efforts with the need to maintain projects' cost-effectiveness.
6. **Support from industry clusters and associations.** Promote the formation of industry clusters and associations to boost the domestic industry's capacities. These organizations can facilitate training, create networking opportunities, promote technology transfer, and promote collaborative research and development.
7. **Specialized financial products.** Develop specialized financial products tailored to the unique needs of domestic companies participating in the geothermal value chain. These financial instruments can provide crucial support for businesses looking to adapt and expand their operations.
8. **Government and industry collaboration.** Foster collaboration between government agencies and industry stakeholders to align policies, initiatives, and investments with the goal of strengthening the domestic geothermal industry.
9. **Regular evaluation and adjustment.** Continuously monitor the effectiveness of localization efforts and support programs. Be prepared to adjust strategies based on evolving industry dynamics and economic conditions.

Expanding The Workforce With Geothermal Jobs And Skills

Employment and skill development are vital components of the geothermal sector's growth. According to the International Renewable Energy Agency, the geothermal industry provided jobs for about 196,000 individuals—a number projected to rise to 296,000 by 2030. However, the industry continues to grapple with gender disparity, with women representing only 22 percent of the overall workforce. Women tend to occupy more administrative and support positions than technical positions. Governments and companies have been trying to bridge these gaps through, for example, progressive policies, support programs, and targets to increase female employment.

Regarding job creation, both construction and O&M hold substantial potential. Construction roles, although numerous, are short term, lasting 2–3 years. Conversely, O&M positions, though fewer, are permanent, coinciding with the life span of geothermal facilities (30 years to over 50 years). In terms of person-years, O&M generates significantly more employment over the entire project cycle. Direct use projects offer notable employment opportunities, especially for women, youth, and marginalized groups.

The geothermal sector faces skill shortages. Skill gaps are prevalent among high-skilled positions and to a lesser extent among medium-skilled roles, whereas low-skilled roles face fewer recruitment challenges. Skill gaps not only hinder project advancement but also impede the establishment of government policies and institutions that foster exploration and private sector investment.

Many skills necessary in the geothermal industry can be transferred from the declining oil and gas sector. Governments and companies are actively exploring opportunities to reskill individuals from the oil and gas sector. The reskilling efforts are targeted at not only harnessing capabilities but also sustaining employment and economic prosperity. Addressing skill shortages involves developing new geothermal curricula and sending individuals to established geothermal markets like Iceland and New Zealand for training. Often, developers hire individuals without prior experience in the geothermal industry and provide the necessary education and on-the-job training, through formal programs or informal peer learning.

Since not all countries may have the required demand for geothermal-specific education, many opt for a regional approach to geothermal education and training. Expansion of the geothermal workforce requires better communication about educational opportunities through student competitions, mentorship programs, internship, and apprenticeship. Several governments employ project procurement to incentivize the recruitment of domestic or local labor, whereas others set targets for women's workforce participation. These strategies collectively strive to foster a more inclusive and skilled geothermal industry.

Best practices to expand geothermal skills and promote job creation

1. **Promote gender diversity and social inclusion.** Foster diversity by enacting inclusive policies at both government and corporate levels. Establish clear targets for boosting female representation (especially in technical roles) and facilitate mentorship and leadership programs to empower women and marginalized groups in the geothermal sector.
2. **Harness domestic job opportunities.** Recognize the domestic job creation potential of the construction and O&M segments of the geothermal value chain. Focus on promoting

local O&M jobs, since they are long term, and promoting them can provide opportunities for stable employment over the life span of geothermal facilities.

3. **Prioritize direct use projects.** Support direct use geothermal projects since they can generate greater employment opportunities for women, youth, and marginalized groups, promoting social inclusion.
4. **Address skill shortages.** Mitigate skill shortages by identifying gaps and designing specialized training programs. Consider reskilling talent from declining industries, collaborate with educational institutions for geothermal curricula, and incentivize developers to offer on-the-job training. Raise awareness of educational opportunities through initiatives like competitions, mentorship, internships, and apprenticeships.
5. **Take a regional approach to education and training.** Adopt a regional approach to geothermal education and training, fostering collaboration and resource sharing. Promote international knowledge exchange by sending individuals to established geothermal markets for training.
6. **Incentivize domestic and local labor.** Implement project procurement procedures that incentivize the recruitment of domestic or local labor, potentially promoting skill development and job creation within a region. Ensure such measures are implemented alongside appropriate capacity building initiatives.
7. **Public-private partnerships.** Foster partnership between government agencies, educational institutions, and private companies for joint investment in skill development programs, and ensure that appropriate training and education align the workforce with the industry's needs.
8. **Data collection and monitoring.** Establish a robust system for data collection and monitoring to track progress in gender and social diversity, job creation, and skill development within the geothermal sector. Regularly assess the impact of policies and programs to make data-driven adjustments and improvements.

Advancing Benefit Sharing for Sustainable Development

Geothermal development undoubtedly offers a pathway to sustainable energy solutions, although it is important to acknowledge the accompanying risks (e.g., occasional induced seismicity or release of gases), which must be meticulously managed. This underscores the paramount importance of engaging in meaningful consultations with local communities and ensuring the equitable sharing of benefits. The need for community engagement goes beyond a mere formality—it is integral to the development process, with an objective of establishing trust and credibility.

Securing a social license to operate is nonnegotiable for geothermal developers. The bedrock of this endeavor is to establish and maintain positive, enduring relationships with communities. Such relationships foster the trust and goodwill necessary for successful coexistence. Geothermal developers recognize the importance of equitable benefit distribution as a cornerstone of community collaboration.

Transparent information is key for effective benefit sharing. Comprehensive consultations ensure that communities' opinions are not only heard but also integrated into the decision-making process. Collaborative interventions that address community needs can help bridge the gap between aspirations and practical feasibility. Balancing communities' desires with realistic project outcomes is a challenge that developers must adeptly navigate.

Benefit sharing is broadly grouped into three key categories:

- **Infrastructure and service enhancement.** Geothermal projects can catalyze the improvement or introduction of critical local infrastructure and services. Schools, health centers, and other public amenities can be enhanced, directly contributing to community well-being.
- **Community skill and capability enhancement.** Empowering local communities through training in geothermal-related skills can pave the way for their integration into the geothermal workforce. This empowerment extends beyond the immediate project, since newfound skills can be used in other industries as well, strengthening the overall economic landscape.
- **Revenue/ownership sharing arrangements.** Geothermal developers recognize the value of shared prosperity. Revenue and ownership sharing mechanisms foster a sense of collective ownership and responsibility. These mechanisms could include equity stakes for a community in a project, dedicating portions of revenue to community-controlled entities like trusts, or collaborating with local governments to allocate a percentage of revenue for communal development.

In some jurisdictions, legal frameworks mandate the localized distribution of benefits, utilizing mechanisms such as royalties and production bonuses. The inclusion of benefit sharing considerations in procurement documents could help align developers' actions with communities' expectations and governments' development plans. Embracing policies that champion gender equality and social inclusion further enriches the engagement process, promoting the participation of women and marginalized groups in geothermal development.

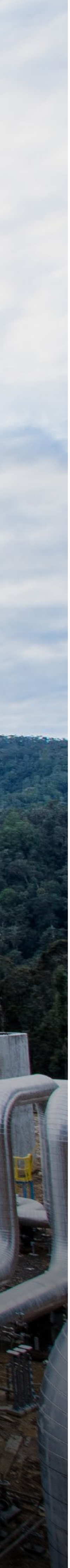
While interventions to foster community engagement and share benefits might involve financial implications, the costs are dwarfed by the value resulting from avoided delays and legal entanglements. Cultivating enduring trust and forging strong relationships with communities will require geothermal developers to form a dedicated team that mirrors the community's diversity.

Best practices for sharing benefits with local communities

1. **Understanding community needs, government priorities, and feasibility.** Align local communities' needs with government priorities to facilitate the creation of benefit sharing programs contributing to community as well as development goals. Recognize that investing in community engagement has long-term benefits, and prevents delays and legal issues.
2. **Meaningful community consultations that establish trust.** Build trust through ongoing, meaningful community consultations. Involve community input in decision-making, prioritize transparency in sharing project-related information, and maintain engagement throughout a project's life cycle.
3. **Baseline data collection and monitoring.** Collect baseline data to monitor and track the success of benefit sharing programs. Continuously assess and adjust programs based on findings to ensure they remain effective and responsive to evolving community needs.
4. **Community involvement in benefit identification.** Actively engage local communities in identifying opportunities to share benefits, ensuring that their input is integrated into project planning. Engage in scoping activities that include consultations with an array of stakeholders, reflecting the diversity of community voices.
5. **Gender-sensitive and equitable benefit sharing.** Prioritize gender-sensitive benefit sharing plans that respect local cultural norms and address potential sensitivities related to female employment. Commit to equitable benefit distribution among community members, considering factors such as age, race, and ability.
6. **Invest in local infrastructure and services for long-term gains.** Explore opportunities for improving local infrastructure and essential services, including roads, water supply, schools, and healthcare facilities.

7. **Develop the skill base within local communities, in turn building economic resilience.** Identify and facilitate skill development opportunities for community members, especially in construction and O&M roles. Consider broader skill development initiatives that empower the local workforce and contribute to economic growth.
8. **Share the financial reward of geothermal projects.** Explore revenue and ownership sharing arrangements, including equity stakes, community trusts, and other revenue sharing models.
9. **Learn from best practices.** Document and learn from experiences in other successful geothermal projects. Share knowledge and insights with local communities. Improve community engagement by collaborating with successful examples from other countries and replicate successful benefit sharing models.
10. **Enhance legal frameworks for benefit sharing.** Examine legal frameworks that extend beyond mere compensation for adverse effects and incorporate comprehensive benefit sharing strategies. Evaluate the feasibility of the mandatory integration of benefit sharing plans in geothermal project development so that community interests are represented effectively. Further, include benefit sharing provisions in procurement documents to align project actions with communities' expectations and governments' development objectives.

ONE.
HARNESSING EARTH HEAT



As the climate crisis and global energy challenges continue, there is a growing need to utilize renewable energy sources. Geothermal energy is heat generated deep inside the Earth's core. This energy can be harnessed from geothermal reservoirs found in many places across the world. Along with other renewable energy technologies, geothermal presents an excellent solution to sustainably meeting energy needs for the countries that can access it. Considering that geothermal presents a reliable and constantly available power source regardless of season, climate, or weather conditions, it also offers certain unique advantages over other energy sources. As a baseload energy source, geothermal will play a critical role in the energy transition and as a complement to other renewable energy sources. Unlike fossil fuel sources of baseload power, geothermal-based energy is produced at the extraction point. Whether used for a power generation facility or for direct application, geothermal-based energy improves energy security since it is derived from a local resource, meaning less reliance on ongoing fuel imports to support generation.

The term *geothermal* means "earth heat." This heat may be used in many applications, including the ones described below:

1. **Electricity generation:** Medium- to high-temperature/high-enthalpy[1] resources are used to generate electricity using a flash or binary technology. Such projects tend to be large so as to achieve economies of scale. However, smaller-scale electricity generation projects do exist.
2. **Direct use:** Low- to high-temperature/high-enthalpy resources may provide heat directly or via heat exchangers. Geothermal energy has many direct use applications, for example, in tourism (e.g., thermal baths and therapeutic balneology), agriculture (e.g., greenhouses, food drying, soil warming), and space heating. The applications could be of a very small scale (e.g., household heat pumps), to very large applications (e.g., communitywide district heating systems). Direct use projects may be developed independently or in cogeneration with electricity generation projects. Multiple users may share the same source in cascading systems as the geothermal effluent is utilized downstream.

This report provides examples for direct use as well as electricity generation. It does not, however, address small-scale household applications.

The installed geothermal capacity remains nominal in comparison with other renewable energy technologies, despite the widescale potential for geothermal energy and the benefits that it can bring. A total of 7,468,058 gigawatt-hours (GWh) of renewable energy was produced globally in 2020; geothermal had a 1.27 percent share in this total production (IRENA 2022b). Although the overall production appears small, geothermal energy plays a critical role in the energy mix of a handful of countries. For example, geothermal energy accounts for 66 percent of the primary energy use in Iceland, where geothermal power

1. Enthalpy is a property of a thermodynamic system. It is defined as the sum of the system's internal energy and the product of its pressure and volume. These qualities define the quality of a geothermal resource.

plants generate 25 percent of the total electricity (Orkustofnun n.d.). The contribution of geothermal energy is significant in Kenya as well. In 2021, Kenya had an installed geothermal capacity of 863 megawatts (MW), and geothermal energy production accounted for 48 percent of all electricity generation (Richter 2022). Also, geothermal is far more efficient than other renewables. In Türkiye, for example, 1,608 MW of geothermal capacity generated 3 percent of the country's total electricity supply, whereas 9,000 MW of solar contributed only 2 percent (World Bank market sounding 2022). Governments are increasingly recognizing the potential for developing geothermal resources to mitigate carbon emissions and improve energy security. In the United States, geothermal energy represents less than 1 percent of overall energy generation, although in 2022, the government committed $165 million for research and development in new geothermal development (Hampton 2022).

Although geothermal development has thus far centered on electricity generation, there is significant potential for—and growing recognition surrounding—the socioeconomic benefits of direct use applications, for example, in space heating and cooling, agriculture and agro-industries, and industrial uses, as well as in recreation and tourism. In 2019, the estimated installed thermal power for direct utilization was 107,727 megawatts thermal (MWth) (Lund and Toth 2020).

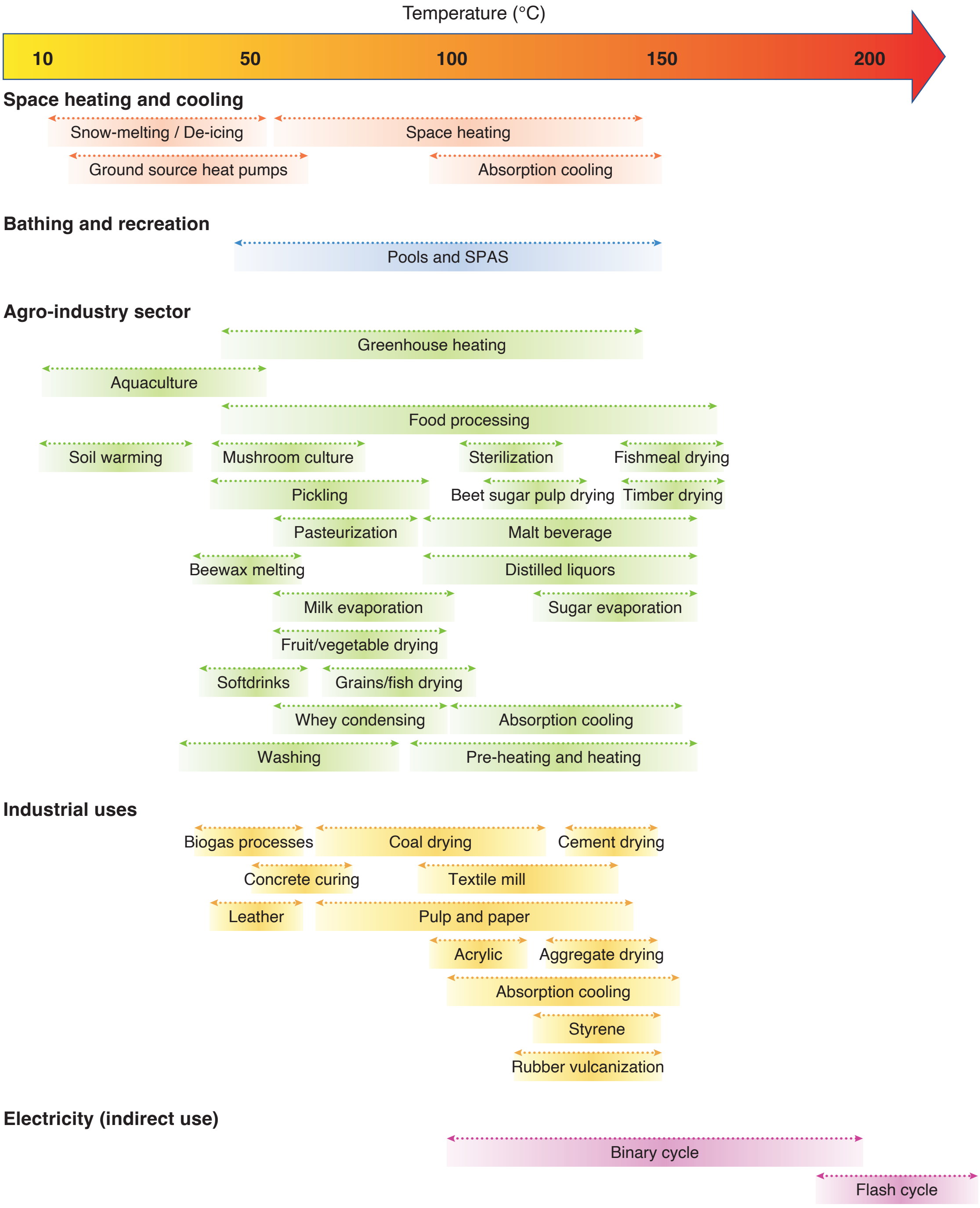
In regions such as Europe and Asia, geothermal heating has become cost competitive with fossil fuel alternatives. This led to a 52 percent growth in geothermal energy for heating applications over 2015–20 (IRENA 2022a). Geothermal heating finds application mainly in three sectors—industry (4 percent), agriculture (16 percent), and residential and commercial buildings (80 percent) (Lund and Toth 2020; IRENA, IEA and REN21 2020).

There is also enormous potential to create symbiotic systems that integrate geothermal electricity generation and direct use applications. After geothermal resources have been utilized to generate electricity, the geothermal effluent still contains heat. This heat can be utilized for other applications that require lower temperatures (see figure 1.1). In a highly efficient system, this chain can continue, with the effluent continuing to pass to lower-temperature applications. This would reduce waste heat and contribute to more economic activities—in what is known as a cascading system. Such systems can be developed at a large scale, for example, within an industrial park, or at a smaller scale, to bring additional benefits to communities surrounding such projects (e.g., a geothermal food drying system or greenhouse agriculture).

The Geothermal Resource Park in Reykjanes, Iceland, for example, has two geothermal power plants (with total installed capacity of 174 megawatts electrical and 150 MWth) for district heating. It also hosts many companies that benefit from the shared infrastructure costs and high-quality electricity and heat supply. The companies utilize steam, at varying temperatures, and other products, such as brine (heat), carbon dioxide, silica, and hydrogen sulfide, in their production (IRENA 2020; World Bank market sounding 2022). Box 1.1 details other ways in which Iceland has created value through direct use projects.

FIGURE 1.1

Examples of direct uses of geothermal energy



Source: World Bank 2022a.

BOX 1.1

ICELAND: CREATING VALUE BEYOND ELECTRICITY GENERATION

When high-enthalpy resources are used for power generation, the benefits need not stop at clean electricity. Iceland, among other countries, has demonstrated the immense potential and socioeconomic impact of promoting cascading uses of geothermal heat. Iceland's geothermal sector successfully repurposes geothermal effluent after it has been used to generate electricity. The repurposing enables using this effluent, which would otherwise be wasted, while it is still hot and makes it viable for other applications. Examples of repurposing include the Blue Lagoon, world renowned for its balneotherapy, and Reykjavík's extensive district heating systems. Further, geothermal low- to medium-enthalpy resources are used directly for district heating (Fludir) and in geothermal heated greenhouses (e.g., Friðheimar) that allow farmers to grow produce year-round in a northern climate.

Often, the availability of lower-cost heating makes these industrial activities extremely cost competitive. Business growth is benefited enormously in turn. The development of tourism, agriculture, and other industrial applications symbiotically with geothermal electricity generation can be significant to the creation of new economic opportunities.

The successful case of the Blue Lagoon highlights the potential for socioeconomic benefits extending beyond those created by power production. In 2019, the company posted gross profits of €22 million, employed 809 people, and paid €5.8 million in taxes to the Icelandic government.

Source: World Bank market sounding 2022; Zhao et al. 2019; Blue Lagoon 2019a, 2019b.

Many countries are developing regulatory frameworks to support more direct use projects, which are developed either in conjunction with geothermal electricity generation or as standalone projects that can tap into more widely available lower-enthalpy heat sources (as detailed in box 1.2). While this report does not delve into the details of designing and implementing an enabling environment for the development of geothermal resources, the Energy Sector Management Assistance Program (ESMAP) offers a series of other resources that do so. Two important guides include the Geothermal Handbook: Planning and Financing Power Generation (World Bank 2012) and Direct Utilization of Geothermal Resources (World Bank 2022a). Annex 1 of the present report provides a useful overview of the important role played by the public and private sectors in geothermal resources' development, and in enhancing socioeconomic outcomes at the national and local level.

Photo: Workers at a fish drying facitlity in Iceland which utilizes geothermal heat.

BOX 1.2

GLOBAL: A TRANSPARENT REGULATORY FRAMEWORK CAN ATTRACT INVESTMENT AND MAXIMIZE BENEFITS

The nature of geothermal energy renders the development and implementation of regulations potentially complex. Depending upon the country context, geothermal development may be regulated by a variety of government entities, including those overseeing mineral extraction, those controlling the use of land and water resources, or those overseeing energy production. Meanwhile, having a clear and straightforward regulatory framework has proven to facilitate a greater influx of private investment into the sector. Geothermal companies and developers need a clear view on what they can and cannot do, and the process and timeline to obtain the required approvals.

Many countries are beginning to implement regulations with a specific focus on geothermal energy. They recognize that the nature of geothermal energy means it needs unique regulations, which differ from those for other renewable energy technologies. The vast majority, however, have focused solely on electricity generation. This has limited the immense potential for direct use applications of geothermal energy, and the significant socioeconomic benefits potentially accompanying these projects.

Indonesia, a country with an existing geothermal law for electricity generation, is now developing specific legislation to guide the development of direct use projects. The government has recognized an untapped potential for utilizing geothermal heat, with applications ranging from those in tourism to agriculture, and the widespread socioeconomic benefits associated with these projects. While the new legislation is being created, the government is actively attempting to facilitate direct use projects by providing technical guidance sessions on the process for obtaining business permits under the existing legislation.

BBA Legal,* a corporate law firm, offers a useful database, which outlines applicable geothermal rules and regulations to explore, exploit, or produce electricity in 16 countries, including Canada, Chile, Ethiopia, France, Germany, Iceland, Indonesia, Italy, Japan, Kenya, Mexico, New Zealand, the Philippines, Türkiye, the United States, and Vietnam. Private investors can utilize this database to better understand the regulatory approval process for a project, or it can be used by countries looking to develop their own unique geothermal regulatory frameworks.

Source: World Bank market sounding 2022; BBA Legal (http://www.geothermal.bba.is).

* More information on BBA Legal is available at https://www.bbafjeldco.is/about.

Understanding the Socioeconomic Benefits of Geothermal Project Development

Geothermal energy projects present an opportunity for national as well as local socioeconomic development. One measurable economic gain is new employment opportunities. Each megawatt installed translates into an estimated 34 jobs—much higher than the 19 jobs created for wind power and 12 jobs created for solar photovoltaics (Enel 2023). These direct jobs are created during the design, construction, and operation of a geothermal electricity project.

Geothermal projects also create indirect jobs in upstream industries providing supplies and services to the geothermal industry (e.g., those in equipment manufacturing). In addition, a vast number of induced jobs are created due to spending by those who are directly and indirectly employed in the geothermal industry. For example, during construction, workers will necessarily spend a portion of their income within the project community. This will result in more jobs at restaurants and shops, in transportation, and in hospitality.

Research suggests that local job creation impacts are further amplified among direct use projects (creating direct, indirect, and induced jobs), and that these projects, in particular, could create a greater number of quality jobs for women (World Bank 2022a). Several of the case studies in chapters 3 and 4 exemplify the job creation potential of direct use projects.

New employment opportunities, particularly in rural and low-income communities, can have an immense social impact. These impacts are diverse and complex but could lead to a reduction of domestic violence, improve social protection, and prolong education for children as they do not need to work to support the family (World Bank 2020; ILO 2022a; UN 2021).

There will also be fiscal benefits to governments, not only due to income taxes on those employed directly or indirectly in the geothermal sector, but also from taxes on businesses, taxes on goods and services, royalties for resource use, and land leasing agreements.

The availability of reliable, stable, and affordable energy (both heat and electricity) may have a more far-reaching economic impact as it could help attract industrial players in establishing local operations and contribute to the growth of small and medium enterprises (see box 1.3). Although it is more challenging to quantify this on a project-specific basis, energy access may also result in many more "productive use" jobs and better job quality, with improved working conditions, higher wages, and more formal employment.

While both social and economic benefits are significant, economic benefits tend to be more easily quantified than social benefits. Social benefits may include new education opportunities and attainment, skill development, and skill diversification.

BOX 1.3

KENYA: ECONOMIC GROWTH AND DIVERSIFICATION RESULTING FROM A GEOTHERMAL PARK

Oserian began in 1969 as a small vegetable farm in Nakuru County, Kenya, with just eight employees. In the 1980s, Oserian ventured into rose cultivation and began selling long-stem roses to the commercial market. In 2000, Oserian approached KenGen, the government entity charged with electricity generation. KenGen had drilled an exploratory well on Oserian property. While the well was suitable for large-scale power generation, it was left unutilized, even though it could provide heat for other uses. Oserian recognized this potential to provide heating (and later electricity) for its greenhouses.

Tapping into geothermal heat enabled Oserian to expand rapidly. Temperature control of its greenhouses would otherwise have been cost prohibitive, but with geothermal heat, Oserian could create optimal conditions to maximize its rose production. By increasing the greenhouses' temperature, Oserian could lower the humidity and, consequently, reduce fungal growth on rose leaves. In 2004, Oserian went on to develop the first wellhead plant in the country and developed a second wellhead plant in 2007. The two wellhead plants have a combined capacity of 3.2 megawatts (MW). In 2018, the company also added 1 MW of solar to its mini grid.

In 2021, Oserian sold its rose operations, which covered over 100 hectares of greenhouse space. At the time of the sale, Oserian had 3,000 people employed in the greenhouses and 25 employed in plant operation and maintenance. The company's business model has since evolved, and it now operates as a utility, providing heat, power, and water to industrial customers.

BOX. 1.3 *(CONTINUED)*

Oserian is spearheading the development of a renewable energy industrial park and marketing the opportunity for industrial players to take advantage of the affordable, reliable, and clean power and heat it is producing. Oserian's current customers include Bohemian (the new owners of the rose company), a fish farm, a factory producing animal feed, a company raising insects for biological pest control, and several others. This industrial hub has created a variety of direct and indirect employment opportunities and is contributing significantly to the region's economic growth and diversification.

At the project site and community level, improvements and additions to infrastructure can have far-reaching socioeconomic impacts, from improved mobility to better health care and education, to improved income generation prospects and expanded small business opportunities. Infrastructure projects, both related and unrelated to geothermal projects, are commonplace within project communities. Because geothermal projects are often located in remote areas, developers will construct roads for site access and build water supply systems. These can sometimes be shared with the local community. Further, to gain community acceptance and a "social license to operate," developers often dedicate funds for infrastructure development, which will benefit communities (e.g., new schools and clinics).

What is perhaps unique about geothermal energy, compared with other renewable energy technologies, is that local communities can utilize heat (direct use) downstream from power generation, or standalone projects could supply this heat. The development of direct use projects in agriculture has been shown to have significant socioeconomic benefits, including better food security. For example, geothermal heat can be used to create optimal conditions for growing crops in greenhouses. This in turn mitigates the adverse impacts of pests and fungal growth and improves crop yield. Geothermal heat can also be utilized for postharvest preservation to dry, dehydrate, and store food, and in turn minimize spoilage (IRENA 2022a). Geothermal food drying alone represents an opportunity to increase the global availability of food by an estimated 20 percent if the technology is widely deployed and scaled up (IRENA 2022a).

Figure 1.2 highlights certain socioeconomic benefits that may be realized through the development and operation of geothermal projects. Although listed separately, for the reader's ease, these factors are intrinsically linked. For example, lucrative employment will result in better outcomes in health and education, among others.

Again, this report focuses on socioeconomic benefits that extend beyond the risk mitigation requirements of environmental and social safeguard frameworks—and that can be actively influenced, and notably improved, during project development and operation. It does not, however, delve into the broader sectoral advantages, such as the significant societal and economic benefits due to greater energy security and reduced greenhouse gas emissions—a common outcome across all renewable energy technologies.

FIGURE 1.2

Economic and social benefits to be expected from geothermal projects

Government	• Domestic economic growth • Private sector investments in geothermal markets • Revenue generation from taxes • Cost savings on fossil fuels • Improved legislation • Infrastructure expansion
Developers	• Decreased risks • Investments incentives • Skill development and diversification • Community acceptance/social license to operate
Communities	• Stabilization of electricity supply, resulting in business growth and increased industrial activity • Local employment opportunities; skill development and diversification • Infrastructure improvements (e.g. roads, schools, health clinics, and water supply) • Improved economic outcomes in agriculture through reduced spoilage and improved crop yield • Income gender equality • Security in communities, social cohesion • Greater awareness and understanding around geothermal energy

Source: Derived from World Bank market sounding (2022).

For the purpose of this report, the socioeconomic benefits explored have been grouped into four categories, as illustrated in figure 1.3. These categories are derived from the World Bank's Sustainable Renewables Risk Mitigation Initiative:

1. **Participation of domestic companies in the geothermal value chain.** The development and operation of geothermal projects (for direct use and electricity generation) will create a host of new opportunities for domestic companies to provide goods and services. Contracts can vary greatly in size, for example, from a large-scale contract for civil works to a small-scale contract to provide employees' uniforms.

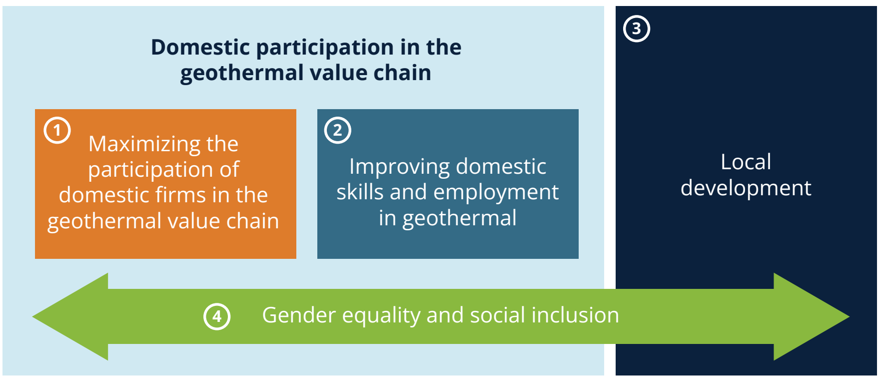
Regardless of size, contracts will have a positive economic impact on the countries where geothermal projects are being developed. The projects will contribute to governments' fiscal revenues, the gross domestic product, and job growth.

2. **Geothermal employment and skill development.** The development and operation of geothermal projects will create new direct, indirect, and induced jobs. On-the-job learning and formal education opportunities will result in new skills and greater skill diversity in the national workforce. They will also generate more domestic employment.
3. **Local development/benefit sharing.** Developers will work with local communities to assess how they can bring lasting benefits and gain community members' acceptance of nearby projects. Approaches vary greatly depending on developers' and communities' needs but may include the addition of new (or upgraded) infrastructure, skill development programs, or mechanisms to share project revenue. Local communities can benefit from gaining access to electricity as well as heat.
4. **Gender equality and social inclusion.** When designed carefully, geothermal projects can improve gender equality and the social inclusion of those disadvantaged based on their social identity (ethnicity, age, class, disability, and gender). The benefits and outcomes in this regard include access to job opportunities, education and training, business opportunities, and local development initiatives.

This report covers the first three categories in the sequence shown in figure 1.3. The fourth category, gender equality and social inclusion, is addressed through an intersectional lens across the report, recognizing the interconnectedness of social identity and the way identities interact to reinforce inequalities or can be leveraged to achieve equity.

The information for the four socioeconomic categories was derived from extensive literature reviews, consultations, and data received from stakeholders (see annex 2 for methodology).

FIGURE 1.3
Socioeconomic categories



Source: Adapted from World Bank (2022b).
Note: RE = renewable energy.

TWO.
THE GEOTHERMAL VALUE CHAIN

The geothermal value chain is the sequence of business activities and processes involved in harnessing geothermal power to generate electricity or geothermal heat. In this report, the value chain of the geothermal industry is broken down into its segments. In a detailed value chain analysis, all the inputs required to progress from one segment to the next, including the necessary goods (raw materials, equipment, etc.), services, and labor are documented.

Mapping and utilizing the geothermal value chain can help to:

- Identify opportunities to maximize the socioeconomic benefits of developing and operating geothermal projects, and improve outcomes;
- Understand the inputs required to achieve the end product of geothermal power and/or heat;
- Assess the goods, services, and labor that can be provided domestically, creating added value and contributing to the gross domestic product of the country where a project is being developed;
- Identify gaps in domestic skills, materials, and so on, and assess what labor, goods, and services will need to be brought in as imports in the short to long term;
- Assess what support programs may be required to address gaps and steadily increase the provision of domestic goods, services, and labor to the geothermal value chain.

Figure 2.1 depicts the geothermal value chain for both electricity generation and direct use, from the early planning phase to the point of heat or electricity production.

It should be noted that for direct use projects, the activities along the value chain include the planning, construction, and operation and maintenance (O&M) of only the geothermal-specific components of a project. For example, for a geothermal-heated greenhouse, the activities captured in the value chain would include the geothermal well, heat centrals, and piping network. It would not consider the greenhouse infrastructure itself.

Domestic Participation In The Geothermal Value Chain

Each segment and subsegment of the geothermal value chain has a unique market structure, ranging from highly concentrated, as in the case of the manufacture and supply of geothermal turbines and generators, to highly competitive, as in the case of power plant construction and installation, including steam-gathering systems.

Contributions to gross domestic product will come from the goods, services, and labor in each segment that can be provided domestically, or "localized." Relevant ministries, utilities, and government agencies can choose to aid in localizing value chain segments through supportive programs and enabling policies.

FIGURE 2.1

The geothermal value chain and its life-cycle costs, by segment share

Source: World Bank 2022b and World Bank market sounding 2022.

Note: Figure assumes a 25-year project life cycle.

* Manufacturing sits outside the value chain, since many components will be manufactured outside project countries. Geothermal turbines, condensers, cooling towers, and generators are highly specialized pieces of equipment, which are manufactured in only a handful of countries. Some components such as heat exchangers, pumps, valves, piping, and cladding may be manufactured domestically.

Parts of the value chain that are more competitive, with more players providing the same goods/services, tend to be easier to localize as they are less specialized. For example, it may be relatively easy to localize the construction of the infrastructure required to access and utilize geothermal sites (such as roads, labor housing, and water supply networks). Some activities that require highly specialized expertise and large investments (such as the case for the manufacturing of steam turbines) are very unlikely to be localized (see box 2.1). The potential for localization will also be greatly influenced by a country's existing resources, the availability of companies that can provide goods and services, and the existing skill base of the domestic workforce (World Bank 2022b).

Other activities may become feasible over time as a market develops or as skills are built. Iceland, for example, has been able to develop the capacity necessary to maintain most of the geothermal equipment within the country (see box 2.2).

BOX 2.1

LOCATING THE MANUFACTURE OF GEOTHERMAL EQUIPMENT

The manufacturing of geothermal turbines, condensers, cooling towers, and generators has been illustrated as an input to the geothermal value chain rather than a part of the value chain. Manufacturing is considered upstream because it is usually conducted in a different location than the investment. In addition, the market is highly concentrated, with only a limited number of companies supplying geothermal turbines, condensers, cooling towers, and generator units (World Bank 2012; NREL 2018).

Binary-cycle turboexpanders are manufactured in Israel, the United States, Italy, and Germany, with Israel accounting for 74 percent of the market (NREL 2018). Flash cycle geothermal steam turbines are manufactured in Japan, Italy, the United States, France, Mexico, the Russian Federation, India, and China, with Japan accounting for 82 percent of the market (NREL 2018).

All turbines, condensers, cooling towers, and generators are produced in factories that require high capital expenditure, significant research and development, and protected intellectual property and patents. Given the high capital expenditure required for factories and the market concentration, generally it is not advisable that countries spend their resources in localizing the manufacture of these types of equipment.

Much of the other equipment required for a geothermal power plant or direct use facility, however, are off-the-shelf products, provided by multiple suppliers (e.g., heat exchangers, pumps, valves, piping, cladding). The manufacturing of these components can be more easily localized.

Source: NREL 2018; World Bank market sounding 2022.

BOX 2.2

ICELAND: DEVELOPING DOMESTIC MAINTENANCE CAPACITY

In most countries, the maintenance of geothermal turbines, gensets, and other specialized equipment is outsourced to equipment manufacturers. This is considerably expensive, not only because of the cost of shipping the equipment, but because of the periods of downtime incurred. There is also a great deal of risk associated with shipping bulky and heavy items overseas.

Iceland is one country that has succeeded in localizing the majority of its equipment maintenance. The initial impetus to do so was necessity. The 2008 financial collapse in Iceland left geothermal power producers in dire straits. The Icelandic currency depreciated rapidly, making loan repayment extremely challenging. This required a new approach to business and an extreme tightening of fiscal expenditures, including on operation and maintenance.

One power producer, Orka Nátturunnar (a subsidiary of Reykjavik Energy), responded by investing in the capacity necessary to service equipment locally. It established a partnership with a forward-thinking local business that was prepared to provide the maintenance services, as well as a US-based firm that would support capacity building.

Orka Nátturunnar knew there were educated people who could do the job in the country—they simply needed to be taught how. Jointly with a private company, called Deilir Technical Services, the producer invested in human capacity, and in the necessary machinery and tools to make repairs and produce spare parts in a domestic workshop.

While this was a substantial initial investment, it paid for itself almost immediately. The first repair completed on a turbine rotor cost only one-third of what it typically would to send the part abroad.

BOX. 2.2 *(CONTINUED)*

Beyond the immense cost savings, efforts to localize equipment maintenance produced many other unforeseen benefits:

- With staff trained to better understand the equipment and identify issues in a timely manner, the equipment's life spans have been extended.
- Replacement parts have been customized to the unique location and type of steam, meaning they can reduce future maintenance needs.
- Sites have 100 percent maintenance coverage, and the operational downtime of projects has been drastically reduced.

Source: World Bank market sounding 2022.

Photo: Geothermal equipment maintenance workshop in Iceland.

Table 2.1 provides a broad overview of experiences captured through interviews and a survey (see annex 2 for a list of stakeholders supplying information). However, it should be noted that each country will have a unique level of domestic capacity in the geothermal value chain, which strongly depends on their market maturity, availability of skilled labor, policies and regulations, and experience in other adjacent industries.

Each country should therefore conduct its own value chain analysis, which will involve documenting all raw material, equipment, companies, and available labor that can be fed into the geothermal value chain. Through this analysis, it may become apparent that comparative advantages exist in specific segments of the value chain. In other words, it may be easier for some countries to localize geothermal value chain activities in a manner that is quality- and cost-competitive with the global market. Indonesia, for example, has a comparative advantage in geothermal drilling because of its well-developed oil and gas sector.

TABLE 2.1
Localization potential for services along the geothermal value chain

VALUE CHAIN SEGMENT	SUBSEGMENT
Planning and legislation	Resource mapping
	Geothermal planning
	Stakeholder consultation
	Policy and regulation development
Enabling infrastructure investments	Preliminary Environmental and Social Impact Assessment (ESIA) for exploration and permitting
	Infrastructure development
	Power contracting
	Exploration drilling
Feasibility and financing	Environmental and Social Impact Assessment for the project
	Community engagement
	Test drilling
	Financial modeling and feasibility
Project design and procurement	Plant and steam field design
	Well drilling
	Procurement of material and equipment inputs
Construction and commissioning	Power plant construction
	Steam field development
	Transmission line installation
Operation and maintenance	Equipment repair, minor and major overhauls, makeup wells and training*
Decommissioning	Disassembly of equipment and facilities, reconstruction on land

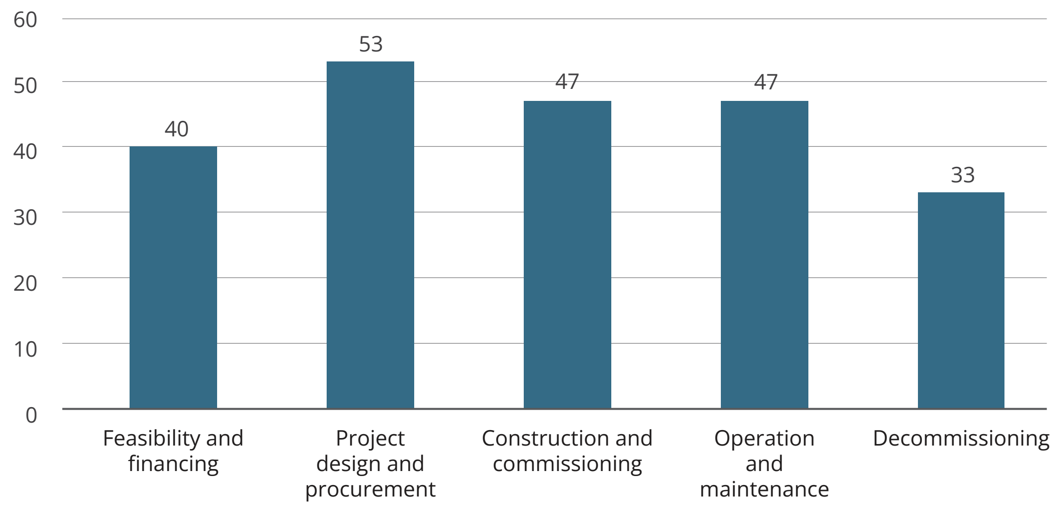
Note: Localized potential:
green = high, yellow = medium, and red = low.
* Routine maintenance and monitoring can be localized with ease, although drilling of makeup wells and maintenance of specialized equipment (e.g., rotors) is often outsourced to international companies.

Open dialogue among governments, developers, and suppliers, as well as carefully designed incentivizing policies, can lead to opportunities to localize segments of the geothermal value chain. Box 2.4 (at the end of this chapter) shares some relevant examples in this context. A well-designed policy will consider the suppliers' and developers' perspectives. From the suppliers' perspective, it is important to understand the interest of companies in supplying goods and services, their ability to do so, and any barriers that they may face. From the developers' perspective, it is important to understand the challenges or implications that might be faced as a result of procuring goods and services domestically. Figure 2.2 captures the experiences of 15 developers worldwide in procuring goods and services from the countries where they have developed and are operating geothermal projects. As with all new policy introductions, clear communication and transparency are essential, as is allowing sufficient lead time for developers and suppliers to respond adequately.

For governments, the breakdown of investment in geothermal development and the job creation potential may be deciding factors in where to focus support for the industry's development. Figure 2.1 breaks down the percentages of capital expenditure required to develop a geothermal project, for both electrical generation and direct use applications. The total cost of a geothermal project includes exploration and resource assessment, drilling works, field facilities, a power plant, gathering systems and other superficial installations, power lines, and disposal systems, among others.

FIGURE 2.2

Share of developers finding it difficult to procure domestic goods/services, by value chain segment



Source: Based on the results of a 2022/23 World Bank survey of 15 developers across the world.
Note: Challenges include increased lead time, increased price compared with the international market, or lower quality than what can be sourced from the international market.

Figure 2.1 shows that construction and commissioning constitute the largest share of the total cost, followed by project design, procurement, and operation and maintenance. These areas of the value chain represent a substantial opportunity for domestic value creation if some activities can be localized in a cost-competitive manner. This trend applies to projects managed by the public and private sectors, for both direct use and electricity generation. However, it is important to clarify that the potential for localization can vary significantly from one project to another, depending on the geothermal resource, location, country policies and regulations, and the planned use.

To mitigate uncertainties and risks, especially during the initial stages of project development, planning and relevant legislation require significant attention and support from the government. Such measures are also pivotal in determining the feasibility of resource utilization options, and encouraging private sector investment, thus enabling industries to integrate geothermal resources into their operations. By doing so, these industries can reduce CO_2 emissions, while also reaping economic benefits for domestic companies and the local communities in close proximity to geothermal projects.

Where the public sector shoulders the early burden of risk mitigation before engaging with private entities, it can also expect to incur high costs during the initial phases of the development process.

An Enabling Environment for the Geothermal Value Chain

Creating an enabling environment for the geothermal value chain is the responsibility of the government and will help advance domestic participation in providing services and goods. First, it is necessary to identify the different kinds of services, skills, equipment, and technologies to be fostered, and in what geographic locations. The next step is to help ensure that local firms and labor have the resources they need to compete (technology, equipment, and skills). Governments can help establish channels of communication and trade groups so opportunities are known, and business relationships can be built, and set up financial tools so companies can become operational.

While domestic companies may be eager to engage in the geothermal value chain, barriers to their full participation are common. One hurdle is a simple lack of awareness about opportunities. This may be due to the absence of a convening body highlighting the opportunities for companies to engage in the geothermal value chain or the lack of a central location to view requests for proposals (RfPs) from the industry.

In some countries, a lack of access to the relevant technologies can be a challenge, particularly among small and medium enterprises (SMEs). In Ethiopia, for example, one developer noted that some domestic companies were not using email—the method typically used by the developer to circulate RfPs (World Bank 2022b). In Indonesia, another developer reported that small enterprises struggled to respond to RfPs published in English (World Bank market sounding 2022). Such challenges can be addressed by using alternate modes of communication, for example, by publishing opportunities in a local language in local and regional newspapers. Common demand- and supply-side challenges and barriers for both developers and local businesses are summarized as follows:

- Lack of knowledge about, and access to, the domestic geothermal value chain
- Lack of clarity regarding, or confidence in, the country's project pipeline
- Lack of relationship between domestic firms and geothermal developers
- Gap between domestic firms' capabilities and industry expectations
- The speed with which developers seek to secure new suppliers
- Cultural and social barriers faced by businesses owned or led by women and disadvantaged individuals

Support programs targeting domestic industry players can help to address these challenges and maximize the added value that geothermal development can bring to a country—particularly in value chain segments with high localization potential (e.g., construction and O&M). Procuring goods and services from domestic companies while maintaining a low cost of electricity generation will increase geothermal development's contribution to gross domestic product.

Renewable energy associations and clusters

Renewable energy associations and industry clusters can play a crucial role in the development of a domestic geothermal industry by bringing together industry players, facilitating synergies, and spurring innovation and knowledge sharing. Even though they may currently focus on other types of renewable energy, they can expand to include geothermal energy.

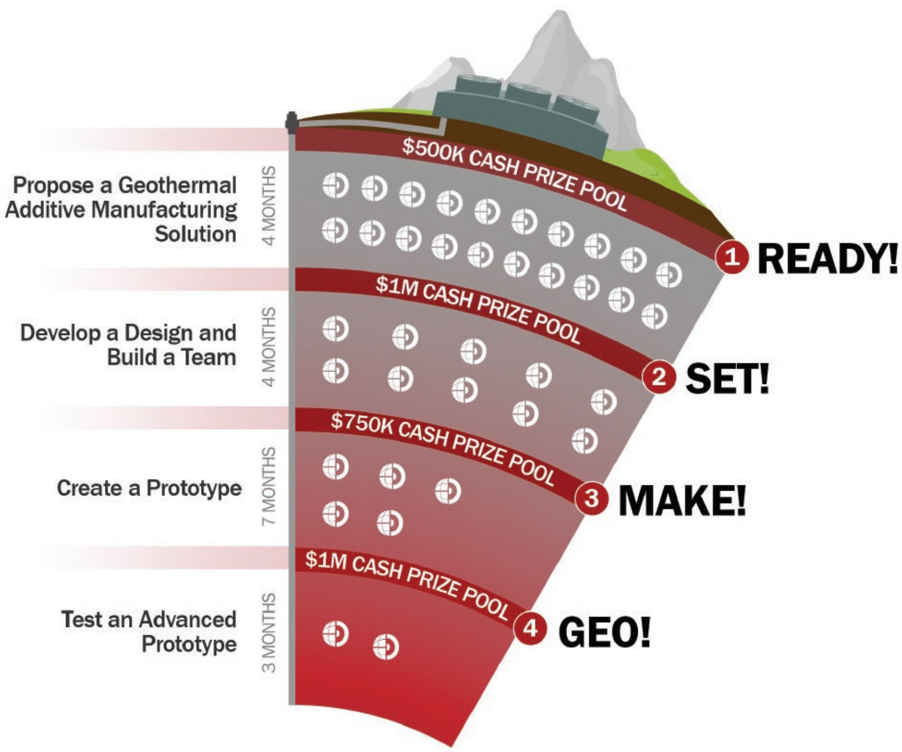
Clusters and industry associations help to build awareness about the domestic industry among companies seeking opportunities. They also often play a role in facilitating connections between developers and domestic players that can provide the required goods and services. For example, an industry association or cluster may maintain an online directory of domestic companies involved in the geothermal value chain. They also play an important role in building the capacity of domestic companies. They may offer training programs, for example, to help improve companies' ability to respond to RfPs and may facilitate peer-to-peer learning experiences.

Organizations that connect institutions, researchers, and enterprises may support industrial development and help companies become more competitive by stimulating technology transfer. For example, Iceland's Renewable Energy Cluster (https://energycluster.is/) is a nonprofit organization that has brought together 34 members from across the country, including educational and research organizations, energy companies, engineering and consultancy companies, and start-ups, to create a platform supporting entrepreneurship and the export of geothermal knowledge and technology.

Facilitating funding and financing to support start-ups and scale up domestic capacity

Funding to support start-ups and research and innovation may be particularly impactful. Funding may be administered through government programs or may be directed via industry associations and clusters. For example, in the United States, the American-Made program and the US Department of Energy run a competition called the Geothermal Prize, which awards funding for innovation in addressing challenges fundamental to operating in harsh geothermal environments. The prize has a four-stage process (illustrated in figure 2.3), whereby innovators and entrepreneurs bring a proposed manufacturing solution from conceptual design to an advanced prototype over the course of 18 months (US DOE 2022a).

FIGURE 2.3
Structure of the geothermal prize of the US Department of Energy



Source: US DOE 2022a.

Financing is also critical for companies looking to scale their operations in the geothermal sector. Companies need access to financing to win contracts but also to deliver promised goods/services. For example, they may need to access capital to expand their labor force; ramp up production; or secure material, equipment, and product stock. Support to domestic banks, either from the government or development finance institutions, can facilitate the creation of tailored financing tools for companies to participate in the geothermal sector. Box 2.3 describes how financing schemes have supported geothermal-heated greenhouses and cascading socioeconomic benefits, such as rural job creation, in Türkiye.

BOX 2.3

TÜRKIYE: FINANCING THE GROWTH OF GEOTHERMAL GREENHOUSES

Türkiye's geothermal electricity generation ranks fourth in the world, with 1.64 gigawatts (GW) of installed capacity. The country has also emerged as a global leader in the direct use of geothermal resources. When excluding heat pumps, Türkiye ranks second globally in its use of geothermal heat. Installed direct use applications have a thermal capacity of 5.1 gigawatts thermal (GWt), equaling 8.5 percent of the country's 60 GWt theoretical geothermal potential.

Approximately 25 percent of direct use applications are in heated greenhouses. Their growth has been remarkable over the past two decades, with total surface area expanding 400 percent since 2002. There have been multiple drivers of this growth:

BOX. 2.3 *(CONTINUED)*

- There is a strong correlation between temperature-controlled greenhouses and crop yield.
- Greenhouse heating is a simple application of geothermal's direct use, requiring only a low-enthalpy source.
- Geothermal is more economical than other sources of heat; this greatly reduces the operating expenses of a greenhouse.
- The Turkish government has implemented programs to attract private investment in geothermal greenhouse development.

The Turkish Ministry of Agriculture and Forestry's guidelines for potential investors in the agricultural industry recommend (and incentivize) a greater focus on geothermal greenhouses. Meanwhile, Ziraat Bank and the Agricultural Credit Cooperative offer low-interest investment and working capital loans that provide greater flexibility than traditional financing; such flexibility includes, for instance, a principal grace period of up to two years. Investors are also eligible to access grants from the Ministry of Agriculture and Forestry and a national program supporting rural development.

Such government support is yielding significant socioeconomic benefits. For example, a 71.7-hectare project in Aydin is producing 20,000 tons of tomatoes annually and employing 750 people. Another greenhouse in Kütahya is producing 35,000 tons of tomatoes and employing 1,100 people.

Sources: IRENA 2022a; World Bank market sounding 2022.

Photo: Geothermal greenhouses in the Dikili geothermal field, Türkiye.

Encouraging procurement from companies in project countries

Some governments have encouraged geothermal developers to work with domestic companies by utilizing their project procurement process. In a competitive bidding process, a government may create incentives for private developers (and their subcontractors) to purchase goods and services from domestic companies. These would typically be communicated with potential bidders early on (prebidding) to seek their feedback on the procurement design and allow the companies time to develop partnerships with domestic firms. They would then be featured in the procurement documents, including the request for qualification and the RfP (illustrated in figure 2.4), possibly adding preferential points to the strength of the proposal. Where a competitive bidding process is not pursued, it is possible to discuss and decide upon these elements in project negotiations.

Once a developer is selected, the commitments made to purchase goods and services from domestic companies would then become elements of contractual documents between the government and the developer, such as the power purchase agreement. Table 2.2 outlines several approaches that governments have taken to encourage domestic players in geothermal development. Before implementing related policies, governments should be mindful of the market's readiness to provide the required goods and services, since premature implementation may lead to unwanted market distortions (e.g., increased tariffs), or stalled progress if certain requirements cannot be met.

Box 2.4 shares the experiences of Türkiye and Indonesia in leveraging geothermal procurement to bolster their domestic industry.

FIGURE 2.4

Competitive bidding process and key documents

Source: Adapted from World Bank (2022).

TABLE 2.2

Ways to encourage domestic participation in the geothermal value chain

GOVERNMENT STRATEGY	DESCRIPTION
Request developers to produce a plan for how they will work with domestic companies	Requesting such a plan can ensure that developers have investigated areas along the geothermal value chain where domestic companies can participate. It will increase the likelihood that a developer has identified potential firms that can provide the required goods and services and is set to engage these companies.
Require that one project partner must be a domestic company	Requiring international developers and/or engineering, procurement, and construction companies to partner with domestic developers can help to build up domestic knowledge in project development. It can also help domestic developers and contractors establish a track record. The domestic partner can be a sleeping partner, or a financial or technical partner.
Incentivize developers to direct a percentage of total procurement spending to domestic companies	Governments may set incentives for developers that can commit to procuring a certain percentage of goods and services from a project country (see box 2.4). These targets may then become contractual obligations, for example, in the power purchase agreement. Such incentives may be set to encourage procurement from companies owned/led by women and socially disadvantaged groups.

Source: Based on World Bank (2022).

BOX 2.4

TÜRKIYE AND INDONESIA: ENCOURAGING DOMESTIC PROCUREMENT

Renewable electricity generation in Türkiye is supported through a feed-in tariff program. The Turkish Renewable Energy Law sets the tariff to be paid out to generators, which varies by technology. The law also stipulates that power producers can benefit from a support scheme, called the Renewable Energy Resources Support Mechanism, if domestic mechanical and/or electromechanical components are used for generation. The support scheme acts as a top-up to the established tariff, providing power producers with an incentive to procure domestic components where possible.

Indonesia has also seen success in incubating local manufacturing capacity, but through a less flexible approach. Geothermal developers are required to procure a set percentage of components and services domestically, as detailed in table B2.4.1. This percentage depends on the size of the project. While this measure has been successful, developers have noted that it limits flexibility and motivation to go above and beyond the established requirement.

TABLE B2.4.1

Local content requirements for geothermal projects in Indonesia

GEOTHERMAL PROJECT CAPACITY	LOCAL CONTENT REQUIREMENT
Up to 5 megawatts (MW)	3 percent for goods, 89 percent for services, 42 percent for goods and services combined
>5 MW–10 MW	2 percent for goods, 82 percent for services, 40 percent for goods and services combined
>10 MW–60 MW	16 percent for goods, 74 percent for services, 33 percent for goods and services combined
>60 MW–110 MW	16 percent for goods, 60 percent for services, 29 percent for goods and services combined
Above 110 MW	15 percent for goods, 58 percent for services, 29 percent for goods and services combined

Source: IRENA 2022c; World Bank market sounding 2022.

Some governments have tailored such requirements to favor women and disadvantaged groups. The Government of Kenya provides an excellent example. In 2005, the government implemented a new regulation requiring all government entities to procure at least 25 percent of goods and services from SMEs, seen as a critical step toward addressing unemployment in the country. However, they soon realized that some groups of people were being left behind. In 2013, the government introduced new legislation requiring all government and publicly owned entities to procure 30 percent of all goods and services from SMEs owned by youth, women, and disabled individuals (Mohammed 2019). This regulation applies to the geothermal entities owned by the Government of Kenya, including the Geothermal Development Company, as well as the majority state-owned power utility KenGen.

Such policies are not without challenges and must be carefully designed and implemented. In Kenya, procuring from many small SMEs, rather than evaluating just a few bids from large, formal companies, means additional expenses are incurred. On the other hand, SMEs have reported challenges related to the up-front costs required to provide goods and services and slow payments disrupting cashflow needs (Omariba 2020). Such challenges can be addressed with forethought and the implementation of clear and user-friendly systems. Simplifying the process by compiling a directory of qualified SMEs available to provide needed goods and services may also help.


5,8 m
5,5 m

THREE.

GEOTHERMAL JOBS AND SKILLS

Geothermal energy brings a multitude of socioeconomic benefits—and far more than conventional energy technologies. In particular, it creates more jobs than natural gas and other utility-scale electricity generation technologies on a per megawatt basis at a comparable cost of electricity. Not only are geothermal jobs more numerous but they are also of better quality and longer duration (US DOE 2019; IRENA and ILO 2022).

The International Renewable Energy Agency's Annual Jobs Review (IRENA AND ILO 2022) reported 196,000 jobs in the geothermal sector worldwide in 2021. This is an increase of over 100 percent from 2020 (IRENA and ILO 2021). China represents the largest share, with 78,000 jobs. The European Union ranks second, with 60,000 geothermal jobs, followed by the United States with an estimated 8,000 direct jobs (IRENA and ILO 2022).

In terms of gender equality, there is progress to be made. While women's participation in the renewable energy sector is higher than in the mining and fossil fuel sectors (at 32 percent versus 25 percent, on average, respectively), women remain underrepresented (ESMAP 2019). Men still compose a large majority of the geothermal workforce; women held only 22 percent of geothermal jobs in 2020. Even greater discrepancies exist in the types of roles held by men and women in the sector. A study on gender equality in the geothermal industry in New Zealand and Iceland showed that although women held 14 percent and 23 percent of jobs overall, respectively, these shared dropped precipitously—to 8 and 10 percent—when looking at only jobs in operations. Meanwhile, women filled 28 percent and 62 percent of support roles (Calibugan et al. 2021).

Over the past four decades, the percentage of women in the geothermal workforce has indeed risen. In 1980, it was only 10 percent. However, this figure also suggests that without intervention, the geothermal sector will not achieve gender equality until 2100.

Organizations such as Women in Geothermal (WING) and forward-thinking governments and companies are trying to change these trends. Proactive programs and policies to bring more women into STEM (science, technology, engineering, and mathematics) education, recruit and retain female talent, narrow the gender pay gap, and showcase female leaders are making concrete differences. Box 3.1 introduces a WING-initiated program to give men the knowledge and tools to better support and empower their female colleagues.

BOX 3.1

TÜRKIYE: GETTING MEN ON BOARD TO ADVOCATE FOR GENDER EQUALITY

Women in Geothermal (WING) is a global network empowering, connecting, and lifting up women in the field of geothermal energy. The network aims to leverage professional development and education to break down gender barriers and advance gender equality in all roles within the industry.

While WING programming focuses primarily on women, the organization acknowledges that gender inequality is not a “women’s problem” but a societal problem that everyone needs to work toward resolving. WING recognizes the need to educate and provide the required tools for men to advocate for gender equality. Men hold 78 percent of jobs and the vast majority of leadership roles in the geothermal industry. For meaningful change to occur, men need to be engaged in the conversation on diversity and inclusion. Over 30 percent of WING members are men.

The WINGman Special Taskforce, a platform created for WING by the New Zealand firm Upflow (www.upflow.nz), endeavors to eliminate gender stereotypes and encourage men to be role models, champions, and advocates of gender equality. This platform engages men in the conversation on gender equality and gives them the tools to act to make meaningful change. Offerings include information on the effects of unconscious bias, insights into current thinking around diversity, and tools and advice on how to better support female colleagues. The ultimate aim is to achieve an industrywide culture and environment of fairness where women can realize their full potential.

After several successful pilots between 2017 and 2019, the program was launched for the broader geothermal community. A four-day intensive “Train the Trainers” program now provides a male and female representative from an organization with the material, support,

BOX. 3.1 *(CONTINUED)*

and guidance to deliver WINGmen Special Taskforce training to men within their home organizations. The trainers commit to delivering a 1.5-hour workshop every month for 8–10 months starting within 3 months of the "Train the Trainers" program.

This model has had widespread impact; real cultural change has been demonstrated post-training. With each organization having dedicated staff championing gender empowerment, and providing the required education and guidance to gain support for gender equality, meaningful change is happening within the geothermal industry.

Source: Blair et al. 2021; Blair 2021; WING n.d.

Photo: Geothermal facility tour convened by Turkish chapter of WING.

IRENA's World Energy Transitions Outlook provides a road map to limit global temperature increase to 1.5° Celsius. The report suggests that to achieve this pathway, the share of geothermal capacity will increase to 8 percent in 2030, pushing the number of global geothermal jobs up to 296,000 the same year (IRENA 2021). These jobs will be spread across the geothermal value chain and will require varying levels of expertise, from high-skilled roles to unskilled labor.

Figure 3.1 highlights important geothermal professions by skill level. A high-skilled role can be defined as one that would require a higher education degree (bachelor's or above). A medium-skilled role would require a vocational degree, apprenticeship, or significant on-the-job training and experience. A low-skilled role would require only basic education, and at times no formal schooling.

Figure 3.2 illustrates the share of employment opportunities across the geothermal value chain. Construction and O&M represent the greatest opportunities for job creation. A 50 MW geothermal project would create an estimated 155 person-years[2] of jobs during the construction phase (ESMAP 2019). Although construction creates more jobs than O&M, these jobs will last only during the construction phase, which typically spans three years (World Bank 2022b). In a well-developed market with a strong pipeline of projects and a mobile workforce, the labor involved may transition to future geothermal developments, or may return to construction work in other, adjacent industries.

2 The exact definition of a person-year may vary depending on circumstances. Person-years are computed by dividing the sum of the hours all employees work on a project by the number of hours typically worked in a year.

FIGURE 3.1

Geothermal jobs along the value chain by skill level

Skill Level	HIGH	MEDIUM	LOW
Legislation and planning	• Policy makers • Energy sector planners • Energy modelers • Energy regulation experts • Environment, social, and gender experts • Legal experts		
Enabling infrastructure investments	• Environmental scientists • Reservoir modelers, and reservoir and drilling engineers • Geologists, geophysicists, and geochemists • Hydrologists • Wildlife biologists • Environmental engineers • Community engagement specialists • Gender and social specialists	• Derrik operators • Rotary drill operators • Roustabouts	• Drivers
Feasibility, financing, and project tendering	• Environmental scientists • Reservoir modelers, and reservoir and drilling engineers • Geologists, geophysicists and geochemists • Hydrologists • Wildlife biologists • Civil, mechanical and environmental engineers • Community engagement specialists • Gender and social specialists	• Derrik operators • Rotary drill operators • Roustabouts • Construction equipment operators • Construction managers	• Drivers • Construction laborers
Project design and procurement of inputs	• Reservoir modelers, and reservoir and drilling engineers • Geologists, geophysicists and geochemists • Hydrologists • Wildlife biologists • Civil, mechanical, electrical and environmental engineers • Financial advisors • Transaction advisors • Logistics experts • Community engagement specialists • Gender and social specialists	• Derrik operators • Rotary drill operators • Roustabouts • Drilling managers	• Drivers
Construction, transport, and commissioning	• Civil, mechanical, electrical and environmental engineers • Community engagement specialists • Gender and social specialists • Reservoir modelers, and reservoir and drilling engineers • Geologists, geophysicists and geochemists	• Carpenters • Construction equipment operators • Construction managers • Electricians • Plumbers • Pipefitters • Steamfitters • Health and safety experts	• Drivers • Construction laborers • Security guards
Operation and maintenance	• Electronics, electrical, and environmental engineers • Reservoir modelers, and reservoir and drilling engineers • Geologists, geophysicists and geochemists • Community engagement specialists • Gender and social specialists	• Electricians • Plumbers • Pipefitters • Steamfitters • Plant operators • Steam field and plant managers	• Security guards • Cleaners
Decommissioning and recycling	• Environmental, civil, mechanical, and electrical engineers • Community engagement specialists • Gender and social specialists	• Construction equipment operators • Construction managers	• Drivers • Construction laborers • Security guards

Source: Original compilation.

FIGURE 3.2

Share of jobs created along the geothermal value chain, by segment (%)

Legislation and planning	Enabling infrastructure investments	Feasibility, financing, and project tendering	Project design and procure-ment of inputs	Construction, transport, and commissioning	Operation and maintenance	Decommissioning and recycling
0–1%	0–1%	0–1%	0–5%	50–60%	20–30%	10–20%

Percentage of jobs created

Source: Based on a 2022/23 World Bank survey of geothermal developers.

In contrast, O&M creates long-term job opportunities, which will continue for a plant's life. During operation, a 50 MW geothermal project would support about 35–60 permanent jobs over a period of 30–50 years, the equivalent of up to 3,000 person-years (ESMAP 2019).

In addition to the direct jobs outlined above (those created in project design, construction, and O&M), geothermal projects will also create indirect and induced jobs. Table 3.1 details job categories and examples for both electricity generation projects and direct use. For direct use, direct jobs are only those related to a project's geothermal-specific equipment, such as the heat exchanger and the piping network. For example, in a geothermal greenhouse project, a maintenance technician for the heating system would be in a direct job, but a tomato harvester working within the greenhouse would be in an induced (productive use) job.

TABLE 3.1

Job categories created through geothermal project development and operation

JOB CATEGORY	DESCRIPTION	EXAMPLES
Direct jobs	Jobs created as a result of the design, development, management, construction, and operation and maintenance of a geothermal project. For direct use projects, direct jobs are only those related to the design, construction, and operation and maintenance of the geothermal heat delivery of a project.	Electricity generation: A reservoir engineer required for project design, construction, and operation is a direct job. Direct use: A maintenance technician for a district heating system is a direct job.
Indirect jobs	Jobs created as a result of the demand for material inputs in project development, including building material and equipment.	A factory worker in a plant producing steam turbines is an indirect job.
Induced jobs	Jobs that result from the spending of those directly and indirectly employed in geothermal projects. "Productive use" jobs are considered a type of induced job and result from the increased use of energy amid improved quality and quantity of supply.	A restaurant server in a project community or a lifeguard at a geothermal spa facility is an induced job.

Labor requirements along the geothermal value chain

The sections below outline the types of roles that will be required within each segment of the geothermal value chain.

Legislation and planning

The planning and legislation phase is primarily led by governments, and it requires predominantly high-skilled individuals with a higher education degree. These jobs are not project specific and are therefore typically long term in nature. Some individuals may have broader roles extending beyond the geothermal industry, for example, covering several renewable energy technologies.

Geoscientists, engineers, and mathematicians will play an important role in assessing a country's geothermal resources and estimating the viability of developing such resources. Energy sector planners will assess the capacity of grid infrastructure to support new geothermal developments. They will also model and assess the demand for energy. This work will inform targets for geothermal capacity. Experts will be required to design supportive policies that bolster the geothermal sector and domestic industry to achieve such targets, and integrate them in the regulatory and legislative framework.

Procurement specialists, along with lawyers, will support the project procurement process and devise any requirements to be set for developers within contractual agreements. Communications personnel will help to raise awareness about project tender opportunities and government programs that are supporting the growth of the geothermal industry.

Social and gender experts will play a critical role in engaging stakeholders from an early stage, ensuring there is support for geothermal development and that projects will have positive impacts on the communities where they are located. They may also advise on the development of policies that contribute to equality and economic development in project-affected communities, and provide insights into how the procurement process might achieve the desired outcomes of the government and community stakeholders.

Enabling infrastructure investments

The permitting process for geothermal development will require professionals from both the government and developer sides. Wildlife biologists, socioeconomic specialists, hydrologists, and archeologists are needed to support the environmental and social impact assessment and help obtain the required permits. Once permits are obtained, construction workers and managers need to build the necessary infrastructure to access and utilize sites during project development, including roads and water supply networks.

Power marketers and lawyers will play a central role in negotiating and finalizing power purchase agreements—an important precursor to feasibility and financing. Exploration drilling will also begin at this stage, requiring a variety of skilled professionals, including engineers, geologists, welders, tool pushers, cementing personnel, drilling fluids personnel, safety managers, and site managers. Some roles will be performed by the in-house team of the drilling company, while others will be subcontracted out.

Feasibility, financing, and project tendering

The professionals required for the project-specific environmental and social impact assessment will be similar to those required for the preparation of such an assessment for exploration and for supporting infrastructure. More in-depth community engagement will begin at this stage. This will require individuals with expertise in community consultation, as well as knowledge of the local culture and customs. Likewise, test drilling may be required, demanding similar skills on site to those needed for exploration drilling.

Financial experts will be needed to model projects and determine whether they are bankable given the expected expenditures and revenue forecasts.

Project design and procurement of inputs

Once a developer has confirmed that a site is feasible for geothermal development, it will typically enter an engineering, procurement, and construction contract. The contractor will utilize its own team of workers but will also subcontract out elements of work. During the design phase of a 50 MW power plant, 40–50 people are usually employed (GEA 2010).

Engineers from different disciplines and with different skills and expertise will be required (civil, mechanical, electrical, electronic, environmental, reservoir, etc.) to model and monitor the reservoir, design the plant facility, mitigate risks to the natural environment, specify plants' electrical components, develop electronic systems to operate the plants, and design mechanical systems and foundations, among other important tasks.

Procurement specialists will be needed to procure all required building materials and equipment, and logistics experts and drivers will be needed to arrange delivery to sites. Drilling personnel, such as drill operators, derrick operators, and roustabouts, are needed to drill production wells. Geological experts will also be required to study the topography and geological makeup of a geothermal site and use their knowledge of rock types to make recommendations on the most cost-effective areas to drill.

Construction, transport, and commissioning

The number of jobs increases during the construction phase. Plant construction will typically last for two to three years, and the number of employees required over this period will vary. For a 50 MW power plant, there may be up to 40 project overhead staff, as well as up to 400 subcontractors and craftspeople at the project peak (GEA 2010). The number of people required decreases in the case of constructing a smaller geothermal plant or direct use geothermal facility, although not proportionally. For example, the number of people required for a 25 MW plant decreases only 25 percent when compared with that for a 50 MW plant (GEA 2010).

Again, a variety of skilled engineers will be required during this phase, including civil, electrical, electronic, and mechanical engineers. They will supervise and ensure that construction adheres to design plans, oversee the installation of critical components, and conduct tests and inspections to commission plants.

Construction laborers, equipment operators, and construction managers will carry out the construction of the plant facility. Specialized tradespeople, such as electricians, plumbers, and carpenters, will install components, pipe systems, and build fixtures according to plant design plans.

Operation and maintenance

Once a geothermal power plant is operational and producing power, the owner and operator will employ a range of professionals for the facility's O&M. Typically, 10–25 O&M personnel, including plant managers, engineers, maintenance technicians, and site operators, would be required for a 50 MW plant (GEA 2010).

In addition to O&M personnel, support and repair services will also be required to ensure a plant operates efficiently. The supplier of the turbine used in a plant, for example, may need to provide repair services.

Photo: Welders working on a geothermal project in Kenya

The steam gathering system and geothermal reservoirs will also require maintenance. Wells may need to be reworked over time to ensure adequate fluid and steam flow and injection. The piping of the steam gathering system must be maintained, and parts will need to be replaced periodically due to normal wear and tear.

Local employment created by geothermal direct use projects

Direct use of geothermal heat holds immense potential for local job creation (World Bank 2022a). Direct use projects may be developed as stand-alone projects, or to accompany power generation projects, utilizing the excess heat in the geothermal effluent. The types of jobs created will depend on the end use of the geothermal heat, and may include direct, indirect, and induced jobs in agriculture, services, tourism, and industry.

In Poland, a study documented the impacts of geothermal exploitation on employment structures across 10 municipalities between 2005 and 2018 (Kurek et al. 2021). The results from a comparison of the study's findings with a control group of municipalities illustrate a strong shift to the trade and service sectors, with overall employment in municipalities with geothermal projects outperforming the reference group. The results show a strong correlation between employment creation and the development of geothermal spas and recreational centers in the studied municipalities. The industrial use of geothermal resources, for example, for district heating, resulted in only minor changes to the municipalities' economic and employment structure; however, such projects may significantly improve residents' quality of life residents and reduce energy expenses. In this study, particularly strong impacts were observed in smaller municipalities versus larger municipalities, illustrating the potential for geothermal spas to serve as a catalyst for rural tourism and fuel rural economic growth. In another example (captured in box 1.3, chapter 1), Kenya's Oserian geothermal park is changing the economic and employment structure in Nakuru County.

Enormous potential exists for geothermal applications in agriculture (e.g., in geothermal-heated greenhouses and for food drying), although such applications have thus far been underexploited. The agricultural sector is the largest employer in developing countries and supports the largest portion of rural livelihoods in the world today (IRENA 2022a). Not only can geothermal applications in agriculture help to boost production and reduce food wastage, but can also create a variety of new skilled and unskilled jobs.

Photo: Dried fruit processing center in Mexico.

Especially in developing countries, geothermal direct use projects in agriculture have an opportunity to contribute to equity and equality for women, youth, and disadvantaged groups. Women play a central role in the food systems of developing countries—producing an estimated three-quarters of the total production (IRENA 2022a). Improving production through geothermal direct use applications will therefore impact women positively. Overall, opportunities for women in geothermal direct use projects are considered to be greater than those in power production due to the vast variety of jobs that can be created (World Bank 2022a). Table 3.2 considers women's employment in three direct use projects.

TABLE 3.2

Women's share of workforce in select direct use projects

DIRECT USE APPLICATION	EXAMPLE	DIRECT JOBS CREATED—FTE	PERCENTAGE OF JOBS HELD BY WOMEN (%)
Spa/tourism/beauty products	Blue Lagoon, Iceland	809	58
Food drying	Deshidratador Geotermico de Alimentos de Nayarit, Mexico	60	80
Greenhouse	Caldiran Geothermal, Türkiye	40	75

Source: IRENA 2022a; World Bank 2022a.

Note: FTE = full-time equivalent.

Skill gaps in the geothermal sector

Although geothermal resources have been used for electricity production for more than a century, many countries still lack the necessary human resource capacity to support the industry's growth. This is especially true in countries that do not yet have an established geothermal industry, or do not have an oil and gas industry from which to draw talent (World Bank market sounding 2022). Box 3.2 sheds light on the current situation in East Africa.

BOX 3.2

EAST AFRICA: SKILL SHORTAGES FOR GEOTHERMAL DEVELOPMENT

According to a 2015 analysis undertaken by the United Nations Environment Programme, East African countries would need to train and recruit an additional 12,000 skilled people in the scientific and engineering disciplines by 2030 to fulfill their geothermal energy ambitions.

The study, which focused on the 13 countries of the East African Rift System (Burundi, Comoros, the Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, and Zambia), highlighted a troubling shortage of skilled personnel to fill roles across the entire value chain. In particular, there is a dire shortage of geoscientists, reservoir engineers, drilling engineers, and plant engineers, with only 41 percent, 3 percent, 3 percent, and 6 percent, respectively, of the required manpower currently available for planned development to 2030 (UNEP 2015).

Another study on geothermal energy in East Africa, conducted by the International Renewable Energy Agency, documented that all countries in this region, except Kenya, face a shortage of trained and qualified labor. This not only impacts domestic hiring by the companies engaged in the geothermal value chain, but also has government-level impacts in the design and implementation of a sustainable geothermal program. Without adequate capacity in the public domain, a lack of supportive policies and institutions will eventually limit exploration activity. The study documented a shortage of technical expertise to complete geoscientific studies; execute negotiations regarding power purchase agreements with private developers; develop a dedicated regulatory framework; supervise drilling, prevention, and control of well scaling; and manage and implement projects (IRENA 2020).

Source: UNEP 2015; IRENA 2020.

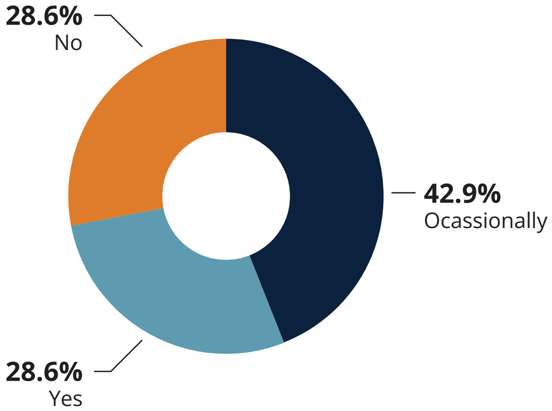
For this report, 15 developers operating in Nicaragua, Panama, Peru, the Dominican Republic, Canada, Sweden, Israel, Pakistan, Kenya, Mexico, the Philippines, Türkiye, El Salvador, Switzerland, Costa Rica, and Indonesia were surveyed. The developers were asked to provide their input on the challenges to recruiting domestic talent for high-, medium-, and low-skilled roles.

The survey findings suggest that the greatest challenges are faced in recruiting highly skilled individuals. Seventy-two percent of the developers reported challenges to recruiting high-skilled labor domestically (29 percent report this challenge often and 43 percent report this challenge occasionally, as shown in figure 3.3). The challenges included longer lead times to fill roles, reduced talent pool from which to select individuals, or resorting to hiring from the international market. The roles that were continuously highlighted as the most challenging to fill include geoscientists (such as geologists, geophysicists, and geochemists), geothermal modelers, production and reservoir engineers, drilling specialists, and plant engineers. When high-skilled roles can be filled by hiring from within the domestic market, these individuals tend to come from larger urban centers rather than from project communities.

Medium-skilled roles appear to pose less of a challenge, with 43 percent of the developers facing only occasional challenges to sourcing skills domestically. Low-skilled roles are the easiest to fill, with 93 percent of respondents finding no difficulty hiring members of neighboring communities who could be upskilled on the job. For example, Indonesia-based Supreme Energy offers a geothermal development program for community members to train and become plant operators, mechanical and electrical technicians, field chemists, and well testing officers (box 3.3).

FIGURE 3.3

Share of surveyed developers that have found it difficult to recruit highly skilled talent in project countries (%)



Source: Original compilation from survey results.

INDONESIA: INVESTING IN HUMAN RESOURCE DEVELOPMENT

Supreme Energy, founded in 2007, is an Indonesia-based independent power producer. The company has two operational plants, with a total of 170 megawatts of installed capacity, and another site in development. It employs 187 staff; of these, 117 work at the two operational geothermal plants.

The team at Supreme Energy has had a strong focus on acquiring and retaining quality talent, and the company has grown quickly over the past 15 years. Although Indonesia's geothermal industry benefits greatly from the wealth of expertise in the country's well-developed domestic oil and gas industry, there are still skills unique to the geothermal industry that require time and effort to develop.

Early in their operations, companies working in geothermal energy struggled to retain experts in the geosciences field, such as geologists, geoscientists, and geophysicists. Given the limited number of qualified subsurface specialists, and the high demand for their skills, employees were often recruited by other companies. High turnover rates presented a business challenge.

Rather than recruit talent from abroad, as many companies do when talent is not easily available domestically, Supreme Energy's human resources team devised a strategy to grow talent in house. They decided to hire a cohort of 10 new graduates with geoscience backgrounds and put into action a plan to provide on-the-job learning and an array of professional development opportunities. Most of the new recruits were given the opportunity to study abroad, either in New Zealand or Iceland, to further develop their specialized knowledge. The strategy proved successful, and the company now has a competent geoscience team.

BOX. 3.3 *(CONTINUED)*

The company has also recognized the opportunity to recruit experienced staff from the oil and gas sector—including electrical and mechanical engineers, environmental engineers, biodiversity specialists, health and safety experts—who can then receive specialized geothermal knowledge once they step into their new roles. The company's induction training program complements classroom learning and on-the-job training with job shadowing, whereby a new hire conducts day-to-day work with an experienced peer in a similar role.

At the power plant level, it has also been a top priority for Supreme Energy to hire members of the local community. Since the specific skills required are not always easily available within the communities surrounding project sites, the company launched a geothermal development program for outstanding associate's and bachelor's degree holders from surrounding communities. Those selected enter a yearlong program, which includes four months of in-class learning, conducted in cooperation with a local university. They then transition to eight months of on-the-job training, after which the trainees are assigned to various roles, including power plant operator, mechanical and electrical technician, field chemist, and well testing officer.

Source: World Bank market sounding 2022.

Photo: New personnel training at Supreme Energy facility in Cepu, Indonesia

Similarly, PT Geo Dipa Energy in Indonesia has delivered welding-related training, in response to a request from the heads of surrounding villages. Forty trainees from four different villages received theory and work safety classes, followed by welding practice over a five-day training period. Certification for welding competency was also provided to the participants.

The supply of skilled labor can hinder geothermal project development—and its associated socioeconomic benefits—if not addressed in a timely manner. Growing a sustainable geothermal industry will increase the demand for sector-specific skills, and it will be up to both governments and private sector players to respond through education programs to fill gaps that may exist in geothermal skills and professions.

Female participation in the geothermal workforce

Female employment remains low despite 84 percent of the surveyed companies reporting a policy in place to improve workforce diversity. Apart from one outlier nearing gender equality, 14 developers reported having between 4 percent and 30 percent female employees. The gender disparity is even more pronounced when looking at on-site roles (including those in construction and O&M), with female participation ranging from zero to 20 percent at the high end. These roles have traditionally been male dominated because they either require technical STEM education, in which women have historically been underrepresented, or because of cultural norms and stereotypes about what are appropriate roles for women. Even where female employment percentages are improving, other challenges persist. Women continue to be underpaid when compared with their male counterparts, despite having the same level of skills and responsibility.

Companies and governments are making headway in addressing these gaps (see boxes 3.4 and 3.5). For example, in 2019, the Kenyan Department of Energy implemented a gender policy, which provides a framework for mainstreaming gender balance in senior positions. This was done to promote women and girls' participation in STEM education, and gender-responsive planning in budgeting and policy design. This was a landmark and a first on the African continent.

Other countries have responded at an even higher level, creating national mandates for gender equality that have led to greater gender equality in the geothermal industry, and beyond. In Iceland, for example, the Act on Equal Status and Equal Rights of Women and Men mandates any public and private company board or government council or committee to have a minimum of 40 percent representation of either sex. The act also stipulates that any private company with more than 25 employees must have a formal gender equality program in place. Beyond this, Iceland has one of the best maternity and paternity policies in the world, making it easier for new mothers (and fathers) to continue to pursue their careers.

Photo: WING gathering in El Salvador.

BOX 3.4

EL SALVADOR: LAGEO—TAKING ACTION TO IMPROVE THE SHARE OF FEMALE EMPLOYMENT

LaGEO is a government-owned entity charged with the development of geothermal resources in El Salvador. LaGEO has two geothermal plants: the first was commissioned in 1975 in Ahuachapán and has an installed capacity of 95 megawatts (MW) and the second was inaugurated in 1992 in Berlin and has an installed capacity of 109.4 MW.

Twenty-five percent of the staff at LaGEO, across both administrative and technical roles, are female. LaGEO is taking concerted efforts to improve this ratio by adapting its policies and facilities as needed, and has committed to achieving the goal of gender equality.

Table B3.4.1 Number of staff by employee level and gender at LaGEO, 2022

GENDER	DIRECTOR	MANAGER	MIDDLE MANAGER	TECHNICAL STAFF	OPERATIONAL STAFF	TOTAL
Women	50	23	13	36	10	132
Men	50	77	87	64	90	368

Source: World Bank market sounding 2022.

Some of the actions taken by LaGEO include implementing flexible working hours and remote working options, creating female-friendly spaces (e.g., a dedicated nursing room for new mothers), and collaborating closely with Women in Geothermal (WING) and partaking in the WINGmen Special Taskforce.

BOX. 3.4 *(CONTINUED)*

A key focus has been on improving female participation in technical roles that have traditionally been male dominated. Every year, major maintenance is carried out on the geothermal generation units at the Berlin and Ahuachapán power plants. For these short-term roles, men were predominantly hired for electrical and mechanical works, and for cleaning parts and equipment. By prioritizing women for these roles, LaGEO has achieved a 30 percent increase in female participation in maintenance roles, from 22 women in 2016 to 83 in 2022.

Photo: LaGEO female employees carrying out maintenance work.

Source: World Bank market sounding 2022.

BOX 3.5

NEW ZEALAND AND ICELAND: SPOTLIGHT ON THE GENDER PAY GAP

While women are underrepresented in the geothermal sector in terms of workforce participation, they also face inequality in terms of pay. Several geothermal companies worldwide have made significant strides in reducing, and even eliminating, this gap.

Contact Energy, a New Zealand–based company, has taken action by disclosing its pay equity statistics on a platform called Mind the Gap. The company has committed to monitoring and reporting pay by gender for roles that require a similar level of skills, knowledge, and accountability. As of June 2021, Contact Energy's statistics indicated that women make 97.6 percent of what their male counterparts earn.

Contact Energy also reports on the median pay by gender across the company; this helps to illustrate the composition of the workforce. As of June 2021, the pay gap across the company was 49 percent. The company attributes this to the fact that women are overrepresented in customer contact roles and many more men working at the power station sites.

Monitoring and acknowledging the gender pay gap is the first and most critical step to address this inequality. Contact Energy has committed to eliminating their gender pay gap and attracting and cultivating female talent in technical roles.

Iceland-based Reykjavik Energy documented a gender pay gap of 8.4 percent in 2008, meaning that women were earning only 91.6 percent of what their male counterparts were earning.

BOX. 3.5 *(CONTINUED)*

Unexplained gender-based pay gap at Reykjavik Energy (percent by year)

In 2017, Reykjavik Energy worked with researchers to design a model that allows pay to be calculated without gender bias. Using the model, the company took swift action to adjust the current employees' pay to achieve gender pay equality and implemented the tool to be used by human resources for every new hire. The company has statistically eliminated its gender pay gap ever since it adopted the model for use.

Source: Mind the Gap n.d.; Contact Energy 2022; Reykjavík Energy 2021.

Assessing and responding to skill needs

Modeling the potential employment creation from geothermal development can help to plan the number of jobs that will be needed in the geothermal sector and their type. It will also improve the way education and training are provided to address gaps.

It is possible to estimate the direct, indirect, and induced job impacts of an established geothermal capacity target using different economic modeling tools. The World Bank (2022b) handbook *A Sure Path to Sustainable Renewable Energy: Maximizing Socioeconomic Benefits Triggered by Renewables* offers an overview of such economic modeling tools, and under what circumstances they are best applied to model job creation. The International Labour Organization (ILO) also offers several guidebooks on the process to estimate green jobs, such as *Assessing Green Job Potential in Developing Countries: A Practitioner's Guide* (ILO 2011).

The following three methods are commonly used to measure renewable energy jobs, and can be applied within the context of the geothermal sector:

- **Business surveys** seek real-life, on-the-ground employment numbers from specific companies and their projects in development/operation.
- **Employment factors** estimate jobs by multiplying the number of jobs created for a specific unit (e.g., MW) by the expected unit size of a geothermal project or program. Jobs are expressed as full-time equivalents, which equate to a person working full time for one year. Employment factors can be found in existing literature and are estimated based on data collected from companies and governments.
- **Input/output tables** utilize a statistical method to quantify employment, while taking into account the interdependencies of economic sectors. Box 3.6 presents an input-output model produced by the US-based National Renewable Energy Laboratory to estimate the employment impacts of geothermal capacity expansion.

For macroeconomic parameters beyond employment (including GDP, fiscal revenues, and trade balance), input-output tables and computable general equilibrium models can be used. Results will depend upon the quality of input data and the model's level of detail (World Bank 2022b).

In addition to quantifying jobs, it can be important to consider other dimensions, such as formal vs. informal employment, and gross employment vs. net employment. Formal employees are employed under contract, earn a salary, and contribute to the national social security system (ILO 2011). Informal employees earn income working in a specific job, but do not have a contractual agreement with the employer in charge. It is often difficult to quantify informal employment because many companies choose not to report it, and hence, their data will not be accounted for in government employment statistics.

Gross employment is the number of jobs created by a project. Net employment is the number of jobs created minus those displaced as a result of a technology's expansion or introduction. When forecasting the effects of a planned geothermal program, net employment may be important to estimate; the introduction of new geothermal capacity creates jobs yet also results in job losses in other industries (such as in fossil fuels) (ILO 2011).

BOX 3.6

THE GEOTHERMAL JOBS AND ECONOMIC DEVELOPMENT IMPACT MODEL

The Geothermal Jobs and Economic Development Impact (JEDI) model is a user-friendly tool that can estimate the economic impacts of constructing and operating a geothermal power generation plant. The Excel-based model is available for free and can be downloaded from the National Renewable Energy Laboratory's website.

The data used for the model were gathered from geothermal projects, a literature review, conversations with industry professionals, and an existing model called the Geothermal Electricity Technology Evaluation Model.

The model uses default values intended to be representative of a typical geothermal project, and to facilitate a generic impact analysis. The default values are based on reasonable expenditure patterns for constructing and operating geothermal projects in the United States. Model users are encouraged to input as much project-specific data as possible, since resource characteristics, location, financing arrangements, and other factors will influence the actual construction and operating costs.

While the JEDI model is customized to estimate the impacts of electricity capacity expansion, the National Renewable Energy Laboratory has developed another model, called the Economic Impact Analysis for Planning model, to estimate impacts from direct use development.

Source: NREL 2019.

> "Strategic human resources planning must be integrated with the assessment of geothermal resource potential, harmonizing the collective vision of government entities, developers, industry, research institutes, universities, and other stakeholders in each country."

Heber Didier Diez Leon,
President, Mexican Geothermal Association

In certain countries for which data exist, a comparison of job projections with labor statistics and data on existing education and training programs (and their graduation rates) can help assess whether the available labor will meet current and future demand from the geothermal sector (World Bank 2022b). Skill sets that can be transferred from other industries can also be considered. For example, there are many skill synergies between the fossil fuel and geothermal sectors (see box 3.7). Again, the World Bank and ILO offer several useful guidebooks and toolkits that outline this process. These include:

- *A Sure Path to Sustainable Renewable Energy: Maximizing the Socioeconomic Benefits Triggered by Renewables* (World Bank 2022b)
- *Anticipating Skill Needs for Green Jobs: A Practical Guide* (ILO 2015)
- *Greening TVET and Skills Development: A Practical Guidance Tool* (ILO 2022b)

An ILO survey of 32 countries, conducted in 2011 and again in 2019, indicates that most countries lack comprehensive information on skill gaps and skills shortages with respect to green jobs (ILO 2019). While skill needs have been identified and anticipated better since 2011, institutionalized mechanisms for skill anticipation, with private sector involvement, remain exceedingly rare; only a handful of countries actively monitor and evaluate labor and supply and demand in renewables. This makes it difficult to develop specific skill policies and design responsive and effective education and training to meet the current and future demand.

This challenge is compounded by the weak links that persist between renewable energy policies and skill and training levels. Ministries dealing with education and training and employment are poorly represented in policy making on climate change and renewable energy. Where coordination does exist, it tends to be ad hoc, with a lack of monitoring and evaluation. The ILO highlights the importance of improved interministerial coordination to actively assess and respond to labor and skill needs (2019).

BOX 3.7

SKILL SYNERGIES BETWEEN THE GEOTHERMAL AND OIL AND GAS SECTORS

The geothermal and oil and gas sectors have many skill overlaps between skilled and unskilled roles. While drilling jobs are certainly a priority for the geothermal sector, other skills, from design, manufacturing, and installation, to operation, are also valuable. Countries can leverage this skill overlap in labor between the geothermal and the oil and gas sector (and, to a lesser extent, the coal sector).

Project planning. Both geothermal and oil and gas require surface studies, test well drilling, and reservoir models during project planning to evaluate underground resources. Geothermal relies on a wide range of skills, including different geoscience disciplines (e.g., geophysics, geochemistry, and geology), as well as expertise in environmental and social evaluation. Even though many aspects of these energy sectors are the same, an understanding of the unique conditions is essential (Umam et al. 2018). Reskilling of labor from the oil and gas sector toward geothermal will thus focus on specific conditions in the geothermal sector such as rock type, chemistry, pressure, and temperature, and interpretation of information.

Design and manufacturing. The most important difference between geothermal power generation and conventional power plants is the gathering system (steam and brine). Specific knowledge is required to optimize the geothermal energy produced and to prevent scaling and erosion by identifying material (the chemical composition in geothermal fluid) and operational practices. Another specific design condition in geothermal is the noncondensable gas content in the steam that has to be released. Because the steam is saturated, it can degrade turbines, pipes, and other equipment. Mechanical systems for geothermal energy must therefore be manufactured and designed following specific protocols to combat scaling and erosion. Reskilling will be required especially for design teams.

Installation and operation and maintenance require similar shares of skilled and unskilled workers, regardless of the technology. Sector-specific knowledge is required in the environmental, health, and safety aspects unique to a resource. Also essential is specific know-how for operating geothermal fluid-gathering systems and geothermal flash turbines. However, engineers, mechanics, and electricians need not undergo extensive reskilling.

Source: Extracted from World Bank (2022).

Geothermal education and training

To date, the public and private sectors have both played an important role in providing geothermal education and training—the public sector through formal educational institutions such as universities and TVET institutes and the private sector through scholarship programs for staff, in-house training programs, and on-the-job learning. The private sector's involvement has been necessitated by the immaturity of the geothermal market, but also due to the need for geothermal workers to obtain hands-on, field-based, learning experience.

Nevertheless, relatively few formal educational institutions offer specialized geothermal instruction, and they tend to be concentrated in a few developed geothermal markets, for example, Iceland and New Zealand. The International Geothermal Association (IGA) maintains a useful database, which lists a collection of these programs across all continents.

Many programs worldwide, however, cover the base skills required to enter the geothermal industry (e.g., typical degrees in electrical, mechanical, civil, and environmental engineering). The same is true of vocational training programs, such as those designed for welders and electricians.

Programs that were once targeted at the oil and gas sector—for example, degrees in reservoir management—are also increasingly expanding their scope to offer geothermal-specific instruction. Many governments are also considering the potential to reskill individuals from declining industries such as oil and gas to leverage capabilities but also preserve jobs and economic prosperity.

Many skills, especially for low- and medium-skilled roles, could be taught on the job—as evidenced by an Indonesian developer that offers structured on-the-job training (see box 3.3). Of the 15 developers surveyed for this report, 86 percent reported having an established geothermal training program for newly recruited staff.

> "Geothermal uses many of the same services, technologies and personnel as the oil and gas sector. There is a unique opportunity to quickly leverage oil and gas capabilities and technologies into the geothermal sector while preserving jobs and regional economic viability and ensuring US energy sector vitality."

Douglas Hollett, *Former Principal Deputy Assistant Secretary, United States Office of Fossil Energy*

Source: ThinkGeoEnergy.

In many countries, there will likely not be sufficient demand to justify the creation of dedicated and specialized geothermal programs until multiple projects have been established. To avoid the pitfalls of training without employment prospects, some countries developing their renewable energy skill base have chosen to focus on medium-skilled roles, particularly in the trades, for example, welders and electricians. These roles tend to be easily transferrable between sectors and can help to ensure that individuals are trained to be employable in the long run, not for unsustainable labor niches.

In countries where geothermal development is in its initial stages, interested students often pursue educational opportunities abroad (often with the financial support of a geothermal developer). Some countries are choosing to develop training programs at a regional level, to achieve economies of scale (World Bank 2022b). Box 3.8 outlines a World Bank initiative to scale up regional vocational education and training for the geothermal industry.

When developers provide financial support for their employees to study abroad, they often do so with the condition of an employment bond. For example, an employee receiving a company's financial support to study abroad for four years must return to that company as an employee for at least four years. Otherwise, they are required to compensate the company for their educational expenses. Measures such as these limit "brain drain" and poaching by other companies.

For many years, the Geothermal Training Program (GTP) program of the Centre for Capacity Development, Sustainability, and Societal Change (GRÓ) has filled a critical gap in geothermal education for developing countries. However, countries such as Kenya and El Salvador are increasingly being viewed as regional hubs for geothermal education and training (see box 3.9).

"Training is a big investment, but it prevents big and expensive mistakes.

Cyrus Karingithi,
Asset Manager, KenGen, Kenya

BOX 3.8

EAST AFRICA: A REGIONAL APPROACH TO TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING

Technical and vocational education and training (TVET) programs have traditionally been aimed at local and national markets and have been challenging to scale up. But as the demand for technical skills grows across Africa, and employers face challenges to recruiting individuals with specialized technical skills, there is an urgent need to strengthen and integrate the provision of TVET programs in the region. While it may be challenging for individual countries to produce all the necessary skills domestically, a regional approach could achieve economies of scale, while also facilitating the regional mobility of qualified workers.

The East African Skills for Transformation and Regional Integration Project (EASTRIP) is a World Bank–financed five-year project to improve access to TVET programs and their quality. It is a World Bank initiative in partnership with the governments of Ethiopia, Kenya, and Tanzania. The project has created a common framework, which will allow the transfer of qualifications between countries. EASTRIP is currently supporting 16 TVET institutes, including the KenGen Geothermal Training Centre, which will focus on developing specialized technical skills required by the rapidly growing East African geothermal industry.

The regional TVET institutes have been supported to create industry advisory committees, conduct market surveys on skill needs, and pursue industry certification in addition to regulatory approval. The institutes have benefited from peer learning among countries; World Bank training on management, financial management, competitive bidding, and establishing risk mitigation measures, and technical assistance provided by bilateral partners in China and the Republic of Korea to upskill faculty.

Attracting female students and tracking graduates' and employers' satisfaction have been central components of the project. The initial three rounds of verification show that the project could substantially expand access and improve the programs' quality, and boost graduates' employment rates. The most recent results show that:

- Enrollment has increased from the baseline of 6,971 students to 30,776;
- Enrollment of female students has increased from the baseline of 741 students to 5,230 students; and
- The number of graduates employed within six months has increased from 47 percent to 69 percent.

Source: EASTRIP 2022a, 2022b, 2022c.

BOX 3.9

ICELAND: THE GEOTHERMAL TRAINING PROGRAM—BUILDING EXPERTISE IN DEVELOPING COUNTRIES

The Geothermal Training Program (GTP) currently under the Centre for Capacity Development, Sustainability, and Societal Change (GRÓ) was launched in Iceland in 1979 with the central purpose to:

- Strengthen geothermal expertise in developing countries,
- Provide intensive hands-on training to university graduates engaged in geothermal work,
- Enhance skills by allowing fellows to work alongside geothermal professionals in Iceland, and
- Provide tailor-made training based on specific institutions' and specific countries' needs.

For many decades, the GRÓ GTP has filled a critical gap for countries with no or limited geothermal-specific education programs. While these countries require skilled personnel, they may not necessarily have the demand to warrant the creation of geothermal-specific programs. The GRÓ GTP is also unique in its focus on developing expertise through hands-on learning experiences. The program takes fellows out of the classroom, to learn from site visits, practitioners, and field experts, and build connections with a diverse cohort from different parts of the world.

The core activity of the GRÓ GTP has been a six-month training program, which is delivered in Iceland. As of 2022, 766 fellows from 65 countries had graduated from this program. The GRÓ GTP also allows fellows with outstanding performance in the six-month program to advance their studies and complete a master's or doctorate degree. Since 1998, 81 students in the six-month program have completed their Master of Science studies and five have completed their PhD studies. The GRÓ GTP also offers short courses on location and recently began offering online courses. These having jointly benefited about 3,000 participants.

BOX. 3.9 *(CONTINUED)*

Through four decades in operation, about 25 percent of fellows have been female. This ratio continues to improve year on year, and the number of male and female participants was nearly equal in 2021. The GRÓ GTP now actively promotes female participation through gender-balanced candidate selection and targets gender equality across all its programs.

The GRÓ GTP has played an important advisory role in the design and implementation of geothermal diploma programs in emerging geothermal markets. A partnership among the GRÓ GTP, LaGeo, and the University of El Salvador has resulted in the creation of a new five-month geothermal diploma program in El Salvador, which in 2022 attracted 29 students from Colombia, Mexico, Nicaragua, the Dominican Republic, Honduras, Plurinational State of Bolivia, Argentina, and El Salvador. The program has a key focus on gender equality; 44 percent of the students in the most recent cohort were female.

This program is increasing opportunities in Latin America for individuals to receive geothermal training in their native language and has positioned El Salvador as a growing hub for geothermal education.

Source: World Bank market sounding 2022; Axelsson et al. 2022.

Photo: A group of GRÓ GTP six-month trainees on a field activity

Governments often seek funding from international institutions and other governments (e.g., Iceland, Japan, New Zealand) to support geothermal development by building the capacity of their entities engaged in the sector. Grants available through the World Bank, the United Nations Development Programme, and the United Nations Environment Programme have long been a major source of technical assistance for geothermal energy. This technical assistance can vary in scope, which includes, for example, specific project preparation work to high-level policy advice to governments, regulators, and utilities. Developing governments require technical assistance especially to support :

- The design of policy instruments to support geothermal energy;
- Pricing and cost recovery mechanisms for countries where geothermal energy is not the least-cost option;
- The application of available climate finance instruments to monetize greenhouse gas reductions;
- The design and implementation of risk-mitigation instruments;
- The design or improvement of the tendering process and tender documents;
- Private sector participation and public-private partnership models for geothermal investment; and
- The scoping of opportunities to develop local manufacturing.

Photo: An ESMAP direct use study tour of an Iceland-based geothermal fish drying facility, 2022

> “Government commitment to geothermal targets is key to spurring education.”
>
> **Professor Gioia Falcone,**
> *University of Glasgow, United Kingdom*

Communicating the opportunities in the geothermal sector will be crucial in creating demand for geothermal education and training. Individuals will invest in geothermal education when a viable career path is clear to them; this will require governments to commit themselves to geothermal development.

Encouraging the development of a skilled geothermal workforce must begin with students. Giving both high school and university students a window into the geothermal sector could help to increase awareness and enthusiasm about the career opportunities within this field. Boxes 3.10 and 3.11 describe two initiatives, in New Zealand and the United States, respectively, which seek to introduce students to the geothermal industry. Programs and initiatives such as these present a unique opportunity to engage women and disadvantaged groups in the geothermal industry from an early age, creating greater opportunities for mentorship and career progression.

BOX 3.10

NEW ZEALAND: ENCOURAGING MĀORI YOUTH TO PURSUE CAREERS IN GEOTHERMAL ENERGY

The Toi Kai Rawa Trust is a New-Zealand-based Māori economic development agency that serves to improve Māori prosperity, including wealth and well-being, and cultivate young leaders.

A key goal of the Toi Kai Rawa is to support the Māori in the region to exceed the national average income levels by 2030. For this, Toi Kai Rawa has developed a range of partnerships to position Māori for high-value jobs. One key focus has been on developing the geothermal workforce of the future.

The Māori STEAM Strategy seeks to improve Māori's participation in science, technology, engineering, and mathematics by encouraging more students to pursue education and careers in these fields. The strategy includes workshops, discovery tours, youth summits, a mentorship program, and internships with a goal to educate more Māori youth in the field and expose them to different career paths.

Source: Toi Kai Rawa 2020.

BOX 3.11

UNITED STATES OF AMERICA: ENCOURAGING STUDENTS TO ENTER THE GEOTHERMAL SECTOR

The US Department of Energy's Geothermal Technologies Office runs an annual student competition, called the Geothermal Collegiate Competition (US DOE 2022b), which engages students from across the country in solving real-world problems. The competition serves a dual purpose:

- To inspire a new generation of geothermal scientists and stakeholders and give them an opportunity to engage with industry experts as well as their communities, and
- To contribute to research and innovation for the expansion of geothermal energy.

The competition runs for an entire academic year, with the theme shifting from year to year. In 2022, the competition focused on planning a direct use project, which would require teams to follow the processes of site identification, resource assessment, demand assessment, conceptual design, and stakeholder engagement.

The winning team of the 2022 competition, from the University of Oklahoma, was awarded $10,000 for designing a system to repurpose six abandoned oil and gas wells to provide geothermal energy for more than 730,000 square feet of educational and municipal buildings, including buildings owned and operated by the area's indigenous communities, the Absentee Shawnee Tribe, and Citizen Potawatomi Nation. All the students of this team were enrolled in the oil and gas program of the University of Oklahoma, but several of them chose to pursue their master's and doctorate studies with a focus on geothermal, having had such an in-depth exposure to the geothermal industry. The team is also hopeful to turn their project into a reality.

Source: NREL 2022; US DOE website.

Photo: Geothermal Collegiate Competition Award.

Encouraging the private sector to create domestic employment opportunities

Jobs created at the local level, within the communities surrounding geothermal project sites, can have far-reaching socioeconomic benefits and can contribute significantly to projects gaining social acceptance (as detailed in chapter 4). Roles that can easily be filled by local community members include construction laborers, drivers, security personnel, cooks, cleaners, community engagement liaisons, and administrative staff. With some training, it is also possible to hire individuals for field and pipeline maintenance, and for plant technician and operator roles.

Table 3.3 presents several approaches taken by governments to encourage developers, and their subcontractors, to hire from project countries and contribute to workforce development.

TABLE 3.3

Encouraging the private sector to upskill and employ the domestic workforce

STRATEGY	DESCRIPTION
Request developers to produce a plan for how they will employ domestic (and local) workers	Requesting such a plan will ensure that developers have designed a strategy for recruiting domestic staff. It will also encourage their subcontractors to hire domestic staff. Such a plan would also outline the types of roles that could be fulfilled by the local population and may potentially include plans for training the local workforce to upskill individuals to a level that they are employable.
Incentives to have a percentage of employees that are citizens of the project country	Developers can be incentivized to commit to prespecified targets for local/domestic employment (e.g., additional points awarded in the proposal evaluation stage). These requirements may then become contractual obligations, for example, in the power purchase agreement. Such incentives may be broken down further to encourage the hiring of women and/or socially disadvantaged groups.
Requirement to implement/fund education, apprenticeships, and training programs	Developers may be required or incentivized to provide education and training to the domestic workforce, or incorporate apprenticeships into the construction phase. Developers may contribute to the establishment of higher education programs; support existing, or develop new, vocational training programs in welding, electrical work, plumbing, and masonry; offer apprenticeships or on-the-job training; or a combination of all. Having developers provide training can help to ensure those being trained receive practical and hands-on training specific to the geothermal industry and that they receive employment post training. Such incentives and requirements may be broken down further to encourage training and education programs targeting women and/or socially disadvantaged groups.

Source: Based on findings from World Bank market sounding (2022).

FOUR.

ENSURING THAT GEOTHERMAL PROJECTS' SOCIOECONOMIC BENEFITS ARE FELT BY LOCAL COMMUNITIES

Each phase of geothermal development—from the initial scientific assessment(s) and exploration drilling to operations—has an impact on the communities where projects are located. Impacts could range from increased noise and traffic, to the possibility of induced seismicity. All geothermal developers must therefore have community buy-in—a "social license to operate," which is an "implied consent, independent from legal or statutory requirements" (CROWDTHERMAL n.d.). In this context, developers engage in timely conversations with the communities near project sites. These interactions help developers to understand and mitigate the risks involved, besides addressing community members' expectations by adopting relevant project design, creating local employment opportunities, and establishing community-based projects and programs, which typically become part of a corporate social responsibility strategy.

Utility-scale geothermal projects have a lengthy lead time of 5–10 years (World Bank 2012; Gudmundsson 2016). Often, communities are displeased if no tangible benefits materialize within this time frame. However, investors may not be ready to invest heavily in communities without guarantees that a project is viable and until operations generate cashflow (World Bank market sounding 2022). These issues require attention, especially in remote, impoverished, and marginalized communities, which have little infrastructure, low literacy rates, and little understanding of geothermal energy.

Developers, therefore, must find a careful balance between communities' wants and needs and what they can realistically deliver before and after a project becomes operational. From developers' perspective, they cannot be substitutes for governments, which are expected to provide communities with the infrastructure and programs they need. Yet developers also require community consent and buy-in. To gain this social license to operate, it is critical that a trusting relationship be established—one that benefits all parties, minimizes drastic changes to existing conditions, and leaves lasting benefits within communities (Karytsas et al. 2019). It is worth remembering that a social license to operate is not granted just once; it is an ongoing process of acceptance and approval through the entire life cycle of a geothermal plant and its operation.

> "You can have a very good project, but without a social license, you cannot develop. The community will either celebrate with you or be up in arms with you—it's a choice."
>
> **Cyrus Karingithi,**
> *Asset Manager, KenGen, Kenya*

Close communication and transparent messaging allow developers to build trust and relationships at the early stages of project feasibility, exploration, and drilling (more details in section 4.1.3). This is especially critical when a geothermal project may be sited on or near areas of historical and/or cultural importance (see box 4.1).

The CROWDTHERMAL project, funded by the European Commission, developed a conceptual framework for the social license to operate. The framework aims to reduce the risks associated with social conflict and improve transparency in geothermal development (see figure 4.1 and box 4.8). The framework provides measurable indicators at four levels, from low to high, depending on the relationships between communities and developers.

BOX 4.1

NEW ZEALAND: THE NEED TO RESPECT AND UNDERSTAND LOCAL CULTURES, RELIGIOUS BELIEFS, AND PRACTICES

Geothermal resources have been used by civilizations for millennia, for recreation, bathing, and healing. In some contexts, these resources were also regarded as more than natural features. The Earth's heat was often viewed as a divine gift or to even possess divine powers itself. In many cultures today, across all continents, geothermal energy continues to play an important role in spiritual and religious belief and rituals.

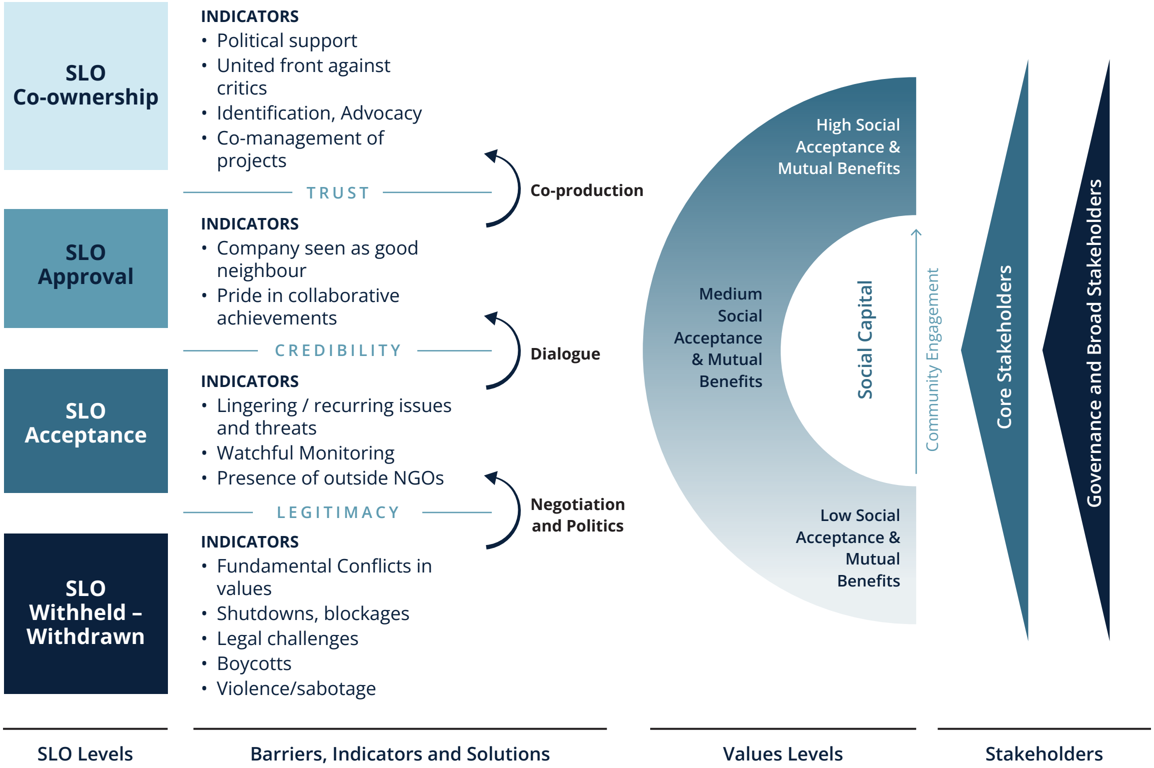
Some locations with large geothermal energy development potential are, therefore, also sacred sites. Understanding the spiritual importance of geothermal resources can be an essential first step in gaining social acceptance for a proposed project. In countries such as Indonesia, Kenya, the United States, and Chile, opposition tied to spiritual and religious beliefs has delayed or even halted projects.

New Zealand has served as an interesting example of a country that has positively managed both societal priorities and project development. New Zealand's Māori tribes consider geothermal resources sacred, and these resources hold a critical importance in the Māori tribes' religious ceremonies. New Zealand's energy utilities, independent power producers, and Māori tribes have worked together collaboratively to ensure that the rights and customs of Māori communities are protected, while the country also meets its energy needs.

Source: World Bank market sounding 2022; Jackson, Addison, and Arbury 2021; Luketina and Parson 2019.

FIGURE 4.1

Developing geothermal energy: A model for the social license to operate (SLO)



Source: CROWDTHERMAL n.d.

Note: NGO = nongovernmental organization; SLO = social license to operate.

Besides the social license to operate, there are other motivations for developers to share benefits with communities. In some contexts, they may need to commit to providing certain community benefits to demonstrate compliance with government regulations and obtain operational permits. In other instances, their efforts may be to comply with lenders' requirements, for example, those outlined by development finance institutions. For publicly listed companies, a CSR strategy may be critical to environmental, social, and governance (ESG) ratings and the ability to attract investments from retail and institutional investors. Others may be driven by their public image more broadly, wanting to be viewed as sustainable companies in all respects, beyond the green energy being produced. On all occasions, there is mutual gain to be found. Box 4.2 points to one example in Japan, where a developer worked closely with community members to help revive onsens, traditional Japanese thermal baths. The developer was able to capitalize on a new source of geothermal heat to be harnessed for power production, and small business owners became more financially sustainable by accessing a new stream of revenue.

BOX 4.2

JAPAN: CREATING NEW REVENUE STREAMS FOR RURAL COMMUNITIES

Baseload Capital saw an opportunity to partner with rural communities in Japan to not only operate its business but also contribute to these communities' economic resilience. Japan has a long history and tradition of *onsens*, which are natural hot springs, often accompanied by an inn called a *ryokan*. Small rural businesses continuing this tradition have struggled financially in recent years, with many having to close their doors to tourists.

Baseload Capital created its first small-scale pilot project by working with local business owners eager to continue their tradition from one generation to the next. The pilot project is designed to utilize heat from the hot springs to produce power. The hot water is first used to generate electricity. Then the hot water is supplied to the *onsens* via pipes at a temperature suitable for bathing. The plant not only provides a stable supply of clean electricity and hot water, it has also created a new source of long-term revenue for the *onsen* owners. Baseload Capital and community members hope that this model of pairing rural tourism and electricity generation can be replicated elsewhere.

Photo: One of Baseload's power plants in Japan.

Source: World Bank market sounding 2022; Baseload Power n.d.; Richter 2020.

In the context of this report, benefit sharing goes beyond compensation for adverse environmental and social impacts (such as compensation when relocation is a requirement for project development). Whereas compensation is quite commonplace in the geothermal sector and mandated by law through countries' social and environmental safeguard frameworks, benefit sharing remains primarily voluntary. Some examples where benefit sharing has become mandatory due to regulation are outlined in section 4.2.

Various mechanisms and models for benefit sharing exist. Benefit sharing can be in the form of direct monetary provisions or nonmonetary provisions, whereby support is provided indirectly through different local development projects and programs (World Bank 2022b). Examples of direct monetary benefit sharing include revenue or equity sharing, or the creation of community-led development funds. Examples of nonmonetary benefit sharing include improvements to infrastructure, support for health and education programs, better environmental remediation and protection programs, and local employment opportunities. Section 4.3 expands on these mechanisms, as categorized below:

1. Improvement of or new additions to services and local infrastructure such as roads and wells;
2. Community-level skill and capability enhancement (including skills related to the geothermal project); and
3. Revenue-/ownership-sharing arrangements.

Photo: Environmental conservation program funded by LaGeo in El Salvador

Lessons in benefit sharing

Geothermal projects around the world offer many lessons that showcase how both governments and developers have worked alongside communities to plan and implement benefit sharing mechanisms. In the interviews conducted for this report, it was quite a common observation that developers invested in communities, above and beyond what is required by law for compensation. Another observation was that developers share a common approach to identifying, prioritizing, and implementing projects that benefit communities. Figure 4.2 summarizes the engagement process, and the following subsections outline it in greater detail, from generating socioeconomic evidence and conducting early engagement, to the design of a community engagement plan and the implementation of benefit sharing projects and programs.

Policy and regulatory design to boost benefit sharing

Policies and regulations can be crucial in ensuring local communities receive socioeconomic benefits, especially in cases where community involvement in energy development projects has been lacking. Unfortunately, the vast majority of countries do not have specific geothermal-related socioeconomic policies and regulations. Below are several examples of where they exist:

- **Indonesia**[3] has a regulation mandating all investors to implement corporate social responsibility (CSR) arrangements. For the geothermal sector, regulations mandate CSR for electricity generation, requiring all geothermal business permit holders to arrange local community development and empowerment programs through the regional government, with costs allocated in the permit holders' annual work program and budget (Purwanto et al. 2021).
- **Kenya**[4] has proposed two clauses for sharing benefits from the exploitation of energy resources. The first clause states that the "revenue raised nationally shall be shared equitably among various levels of government." The second clause requires that investments in property shall benefit local communities and their economies. These benefits include profits, training, employment, technology transfer, and CSR programs. However, a clear framework for benefit sharing mechanisms remains a challenge (Ministry of Energy 2018). Both KenGen and the Geothermal Development Company (see box 4.3 and also box 4.7), both active in geothermal generation, have multiple programs benefiting communities.

3 Article 15 of Investment Law No. 25 of 2007 mandates all investors to implement corporate social responsibility (CSR). For the geothermal sector, CSR is mandated by Geothermal Law No. 21 of 2014 and Article 97 of Government Regulation No. 7 of 2017.

4 Under Kenya's National Energy Policy, 2018, to fulfill Constitutional rights, two clauses are proposed for sharing benefits. The first clause is to fulfill Article 202(1) of the Constitution, which states that "revenue raised nationally shall be shared equitably among various levels of government." The second clause is to fulfill Article 66(2), which requires that investments in property shall benefit local communities and their economies.

FIGURE 4.2 BENEFIT SHARING ACTIVITIES ALONG THE VALUE CHAIN

<table>
<tr><th>Legislation and planning</th><th>Enabling infrastructure investments</th><th>Feasibility, financing, and project tendering</th><th>Project design and procurement of inputs</th><th>Construction, transport, and commissioning</th><th>Operation and maintenance</th><th>Decommissioning and recycling</th></tr>
<tr><td colspan="2">• Evidence generation
• Information creation and provision
• Initial engagement and dialogue/s with stakeholders including local communities
• Identification of benefit sharing mechanisms</td><td rowspan="2">• Evidence generation
• Information creation and provision
• Detailed engage-ment and dialogue/s with stakeholders, including local communities
• Detailed design of benefit sharing mechanisms
• Procurement and pilot benefit sharing activities</td><td rowspan="2">• Design benefit sharing (CSR) strategies/plan (in coordination and/or discussion with local government, and other stakeholders)
• Information provision
• Procurement for benefit sharing programmatic activities
• Continuous community engagement</td><td colspan="3" rowspan="2">• Implement benefit sharing activities (infrastructure provision, capacity building, revenue sharing)
• Continuous community engagement and with local governments (e.g., tours on site, one-on-ones, events)
• Continuous provision of updated information (e.g., directly with communities, boards in local government offices/project sites)
• Increase partnerships with other stakeholders to maximize socioeconomic benefits (e.g., market reach for enterprise development products, educational institutes for long-term trainings and education opportunities to local community members including youth, women and girls)
• Monitor continuously and (re)evaluate. Readjust strategies and plans, budgets.</td></tr>
<tr><td>• Policy and regulations</td><td>• Assessments for potential investments in socioeconomic activities</td></tr>
</table>

Source: Original compilation, 2023.

Note: CSR = corporate social responsibility.

- **Türkiye** requires all licensees to pay the state a yearly fee corresponding to 1 percent of their income. Twenty percent of this fee is then allocated to the budget of the local municipality where a project site is located (BBA 2018).

Although not common, opportunities exist for governments to bring about the desired socioeconomic impacts within local communities through their project procurement process or project negotiations. Governments could either mandate specific benefit sharing actions or reward potential developers that commit to certain desired outcomes with additional points in the project selection process. The World Bank handbook *A Sure Path to Sustainable Renewable Energy: Maximizing the Socioeconomic Benefits Triggered by Renewables* (World Bank 2022b) outlines these approaches and successful cases from other industries, including wind and solar PV. Some examples might include setting a requirement for a percentage of revenue to be directed to community development activities, or setting a target for local employment opportunities.

Understanding community needs

At the initial stage of a geothermal program or project's development, evidence is gathered through socioeconomic studies and social mapping (see box 4.4). Diverse participation of community stakeholders is essential at this stage, including of women and disadvantaged groups, community-based organizations, local governments, international and national not-for-profit organizations, power industries, and development partners. These studies often include, for example, examining administrative boundaries, land uses and ownership, population, employment data, infrastructure and services, cultural and historical sites and customs, energy use, knowledge about and views on geothermal, potential for entrepreneurship, and gender and social equity (Karytsas et al. 2019; World Bank market sounding 2022).

These studies help governments and developers understand exactly how a project will affect livelihoods, culture, and the environment. They also present an opportunity to identify synergies that may be leveraged for the implementation of the priorities identified in regional and local development plans.

BOX 4.3

KENYA: INTEGRATING GENDER EQUALITY AND SOCIAL INCLUSION PROVISIONS WITHIN NATIONAL POLICIES

Geothermal policies and regulations often lack gender equality and social inclusion provisions, although at times, countries' constitutional or macrolegal frameworks make it possible to provide benefits at the project level. For example, Kenya's Constitution aspires to improve inclusion in all public committees and decision-making bodies, and mandates that 30 percent of the government's procurement budget be dedicated to women, youth, and people with disabilities (Lieu et al. 2020).

The Kenya Electricity Generating Company is fulfilling these constitutional provisions through human resource equity policies. Ten percent of jobs are provided to local communities, and 30 percent of boards and higher management positions are held by women. The company's "Pink Energy Initiative" also aims to create change within the organization and within the energy sector, encouraging women by building capacity and nurturing them to be brand ambassadors of gender equality. Equity considerations are also included in projects with local communities. For example, an equal number of boys and girls (50:50 ratio) receive student scholarships.

Source: World Bank market sounding 2022; KenGen 2022.

BOX 4.4

INDONESIA: SOCIAL MAPPING ON MOUNT UNGARAN

As part of the preparation for a project in the geothermal development area of Mount Ungaran, whose potential was estimated at 40–50 megawatts, a social mapping project covering 26 villages was conducted. The study found that 17 percent of community members and nongovernmental organizations opposed the development because they believed it posed a threat to cultural heritage and the local environment.

Meanwhile, the study highlighted that the rural communities were religious and that religious institutions had a strong influence in the surrounding communities. It also showed that village heads, women, and youth leaders had a strong influence over development plans in the region.

Based on these findings, the survey concluded that knowledge and acceptance of project benefits could be increased if information could be channeled through these influential community members.

Source: Setiyono B. et al. 2019

In addition, dialogue can help establish trust and address emerging issues, enabling projects to benefit from mutual agreement and acceptance. Critical to this process is transparency of information and actions (Karytsas et al. 2019; World Bank market sounding 2022). In St. Lucia, for example, one-on-one engagements and ongoing community consultations are proving to be extremely important in building trust (see box 4.5).

BOX 4.5

ST. LUCIA: PROVIDING TRANSPARENT INFORMATION, AND BUILDING TRUST IN PLACE OF LOCAL RESISTANCE

St. Lucia has a long history of utilizing geothermal resources for tourism, and it is in the exploration phase to examine its electricity generation potential. The government secured funding in 2021 to drill up to four test wells based on a scoping study finalized under the 2017/18 Geothermal Resource Development Project.

The project was initiated with good intentions, and it sought to consult and engage landowners who would be directly impacted by the project. Unfortunately, some of the landowners were informed too late, and only became aware of the project plans when they saw their properties outlined on a map drawn for consultation purposes. These landowners were caught off guard. The team of a new project (the Renewable Energy Sector Development Project), which became effective in 2022, has since taken over the project and reported that they are still seeing residual effects of this communication error.

To regain the community's trust, the project team has opted to proceed with one-on-one consultations rather than large group meetings. They report that those affected feel a greater sense of being valued and appreciated when discussions are held in their own homes. Central to resolving the issues was to simply listen to the community and document their concerns.

It has also proved critical to build knowledge about geothermal energy and be transparent with all findings and information. The team is in the process of contracting an experienced public relations firm to support community engagement and improve perceptions around geothermal project development and operation. The team has committed to sharing all findings from consultations and drilling in the form of public documents and has also begun to publish a quarterly stakeholder bulletin to ensure that the community feels heard and represented. During consultations, the team also began to discuss the types of benefits that the community might desire, from a share of royalties to employment opportunities, to cascading the direct uses of the geothermal energy for local business opportunities.

Source: World Bank market sounding 2022.

Developers gather information and engage communities via consultations. The consultations may be in a group format or may be one-on-one depending upon the local culture, the context, and the unique needs of those being consulted. The literature review and interviews conducted for this report highlight several common approaches to community engagement and consultation:

- **Baseline studies are conducted** at the onset of project development to aid in tracking the impacts of benefit sharing mechanisms. After implementation, baseline data help to focus expenditure on successful activities, and amend those that did not go as planned.
- **Opportunities for benefit sharing are identified with the input of local communities.** A scoping activity necessarily includes consultations with a wide range of stakeholders.
- **Local input is critical to the design of a gender-sensitive benefit sharing plan that is within the boundaries of local culture and norms.** For example, will local communities accept the idea of women employed in certain roles? In Ethiopia, for example, a geothermal developer faced challenges when it did not arrange for women employees to travel separate from men.
- **Efforts are made to ensure that benefits are spread equitably across communities**, and that projects with the greatest potential to create long-term and sustained benefits are selected. For example, some developers prioritize activities that directly benefit women and disadvantaged populations.
- **Experiences from other geothermal projects are utilized** to help avoid missteps and implement best practices. Local communities can benefit from knowledge and information sharing with other communities that have already seen the development of geothermal power. A successful example is outlined in box 4.6.

Dialogue between developers and stakeholders must be sustained across project stages, even after a community has given consent for a project (Barich et al. 2022; World Bank market sounding 2022). Long, concerted, and repeated dialogue between developers and local actors (communities, local governments) leads to increased consensual support of projects and ensures that they are "locally anchored"—as opposed to "unbound," and developed due to favorable economic and national political contexts (Chavot et al. 2018). For example, some geothermal projects initiated in early 2010 in the Alsace region of France did not feature local dialogue, and faced strong opposition (Chavot et al. 2018).

> "You can make a huge investment in drilling, but without community support, it is worth nothing."
>
> **Pascal Manan,**
> *Geothermal Development Company, Kenya*

BOX 4.6

KENYA AND NEW ZEALAND: SHARING BEST PRACTICES ACROSS NATIONAL LINES

Countries with differing levels of experience in geothermal development can benefit from one another's experiences in project management. A recent, successful example of this centers on the lessons in community engagement shared between Kenya and New Zealand.

Recognizing the opportunity for other countries to learn from New Zealand's successes in community engagement and respect for sacred geothermal sites, Power Africa, the United States Energy Association, and the Geothermal Energy Association initiated a partnership between KenGen (Kenya's state-owned utility), a New Zealand–based company (Contact Energy), and two trusts (the Tauhara North No. 2 Trust and the Ngati Tahu Tribal Lands Trust).

Four exchange missions took place, including visits by representatives from New Zealand and Kenya to geothermal sites in both countries to learn and exchange ideas. Best practices in community engagement and partnership models were discussed.

Drawing on the lessons learned from New Zealand, KenGen developed a new state-of-the-art community engagement program. Further, the New Zealand counterparts supported Maasai community leaders in developing strategic visioning, including commercial ventures and social development goals.

Sources: World Bank market sounding 2022: USEA 2022.

In successful projects, developers both inform and engage communities, as detailed in table 4.1.

TABLE 4.1

Key ways that developers can inform and engage local communities

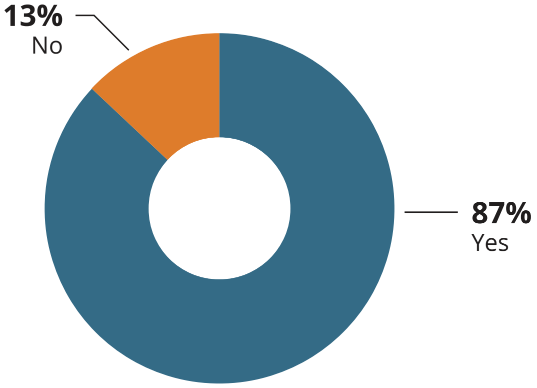
INFORM	ENGAGE
Perform social mapping to identify social and economic conditions prior to sharing information.	Engage community leaders and local government officials who may be long-term engagement partners in the project. Set up a team for working with municipalities and communities on all aspects of project development and operation.
Provide information on the project, for example, notifying communities that they may experience vibrations and induced seismicity.	Gain insights about local community needs and invite community members to bring their concerns and questions forward.
Set up booths and display posters at local festivals, provide project information and explanations on how money would be spent on the project; discuss emerging issues with the community.	Form a Strategic Stakeholder Coordination Committee to effectively design the consultation and engagement process and avoid duplication of efforts.
Post advertisements in villages at visible locations, particularly where women may have little exposure to news through other channels.	A female community liaison officer, who can enter households and talk to women there, may conduct door-to-door consultations before general meetings are convened.
Conduct information campaigns in the local communities where the project may be implemented.	Conduct focus group discussions and multi-stakeholder consultations.

Source: World Bank market soundings 2021 and 2022.

Designing a benefit sharing strategy

FIGURE 4.3

Percentage of developers creating a community development plan



Source: World Bank survey 2023.

Following community consultations, and evidence generation, developers often design a multiyear strategy to engage with local communities. This becomes a critical component of a developer's CSR operations. Such a plan can be given different names: a benefit sharing plan (as highlighted in this report), community development plan, or a CSR plan, among others. Of the 15 developers surveyed for this report, 13 had such a plan in place (figure 4.3).

The process of designing a benefit sharing plan or strategy begins with detailed assessments and interactions with a wide range of stakeholders. Community members may be surveyed as a follow-up to these initial consultations, to further understanding of the needs and wants of communities. Such assessments allow developers to identify priorities that match the budgets set for benefit sharing activities. For example, in Ethiopia, one company developed a local investment guideline, including a three-year strategic implementation plan, as an output of socioeconomic baseline assessments and local consultations. The guideline included national and regional development targets for investments in education, health (including water), agriculture, and enterprise development. Business opportunities were identified, and gaps highlighted (World Bank market sounding 2022).

Developers have different approaches to designing strategies, as can be seen in the examples given below:

- In Kenya, the Geothermal Development Company identifies and collates all priorities, projects, materials, and resources to come up with a community action plan, which is then used to design a five-year strategic plan.
- In Indonesia, Sarulla developed an Integrated Social Program in three phases:
    - **Short term (two years), covering the construction phase**, when the focus was on physical assistance, and budget was limited. The activities included education assistance for students, improvement of school facilities, training in agricultural intensification, and sponsorship of cultural events, among others.
    - **Medium term (five years), covering the early operation phas**e, which would see a gradual increase of budget, and an increased focus on capacity development and a selection process for beneficiaries with commitment-related requirements from program participants.
    - **Long term (beyond five years)** to cover a wider area and create more independent and self-help programs for communities. Plans included intensive training in agriculture and productive activities, such as fish farming and animal husbandry (Sarulla Operations Ltd. 2022; an internal document shared for the purpose of the study).

- In Indonesia, PT Geo Dipa Energi (GDE) conducted social mapping and field analysis to develop the company's Community Development Program, which features four strategic areas of focus:
    - GDE Cares, for communication with relevant parties about different activities and programs (e.g., scholarships and counseling in schools), with a focus on women and vulnerable groups;
    - GDE Green, for environment-related programs;
    - GDE Community Empowerment, which focuses on business support, including in the management of coffee and palm trees and geotourism, among others; and
    - GDE Community Services, which focuses on local infrastructure and sponsorships.

Designing a strategy is an iterative process of learning, as can be seen from the example of the Energy Development Corporation (EDC) in the Philippines (see box 4.7).

Photo: Polaris Participant in agricultural education program.

BOX 4.7

PHILIPPINES: FROM RELIANCE TO EMPOWERMENT—THE EVOLUTION OF A CORPORATE SOCIAL RESPONSIBILITY STRATEGY

"Our philosophy for community engagement has shifted dramatically, from a transactional one based on philanthropy to a transformative one based on empowerment. We are no longer acting in response, we are strategic."

—CSR Lead,
Energy Development Corporation

The Energy Development Corporation (EDC) is the largest geothermal producer in the Philippines, and the third largest in the world. The company has decades of experience in project development and operation. Since its founding in 1976, EDC has developed and installed 1,189.3 megawatts of geothermal power.

While corporate social responsibility (CSR) has always been a central component of EDC's operations, the company's approach has evolved over time. Initially, the company supported a broad mandate of activities, including in health, infrastructure, and education. CSR activities focused on what could be given to communities, ultimately fostering a growing reliance on the company. The CSR team saw a critical need to shift from building reliance through transactional handouts to capacity building, which would lead to greater independence and empowerment. This entailed an overhaul of the company's CSR philosophy, and a shift in approach, from one that was philanthropic to one that is transformational.

BOX. 4.7 *(CONTINUED)*

Instead of being responsive only to the short-term requests of communities, the company began creating long-term strategies that prioritized a mission to protect natural resources, while simultaneously contributing to communities' livelihoods and enabling them to break out of intergenerational poverty. The focus of CSR activities was narrowed to: (1) the environment; (2) education; and (3) social enterprise development. Instead of providing handouts, the company now provides communities with the tools and capacity to better themselves.

The company's hugely successful environmental conservation program can be taken as an example. To date, it has planted over 6 million trees and restored over 10,000 hectares of land. However, the program's impact extends beyond environmental improvement. Community members have been at the center of this work; many have become social entrepreneurs who raise and sell tree seedlings, produce forest-friendly coffee, and lead ecotourism adventures. EDC has supported communities to organize into 121 peoples' organizations, three of which have been formalized as cooperatives. Each organization is provided with business training, for example, in financial management and marketing, supported to secure the required operating permits, and also given the initial capital required to cover start-up expenses.

Source: EDC website (accessed December 2022); EDC 2022.
Photo: Baslay Highland Brew Coffee, the Philippines.

Implementing appropriate benefit sharing mechanisms

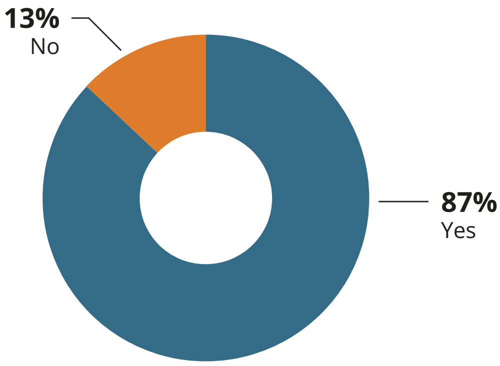
A benefit sharing strategy may entail a variety of mechanisms and implementation steps. As mentioned earlier, benefit sharing is of three main types: improvements or additions to services and infrastructure, skill and capability enhancement, and revenue/ownership sharing arrangements. Examples of each type are given below.

Improvements or additions to services and infrastructure

This type of benefit is commonly provided by developers. For example, almost all developers will contribute to community infrastructure by building roads, which are often also required for site access. A survey for this study showed that of 15 developers, 13 (87 percent) developed local infrastructure (figure 4.4). Examples include schools, plants for processing local agricultural products, wells and water distribution systems, sports areas, roads and bridges, traditional markets, renovations to places of worship, and health clinics.

FIGURE 4.4

Percentage of developers supporting local infrastructure development



Source: World Bank survey 2023.

The provision of local infrastructure may at times make communities dependent on developers. As can be seen from the example of EDC in the Philippines (box 4.6), their focus shifted from short-term multiple provision of infrastructure services to longer-term skill development and revenue generation programs. While project developers often construct community infrastructure that is to be operational in the long term (e.g., health clinics, school buildings), funding for future operations or maintenance may be lacking. If such infrastructure is to offer sustained benefits to the local population, funds may need to be set aside in escrow accounts, in financing agreements, or otherwise guaranteed, possibly through public and private cooperation (Holtz and Heitzig 2021).

Skill and capability enhancement

Education and a variety of training programs are key to ensuring that local community members can easily access the new job opportunities brought by a geothermal project. Training may focus on skills relevant to geothermal, or another sector (e.g., training farmers to improve crop yield).

Table 4.2 outlines the training practices of the developers surveyed for this report.

TABLE 4.2

Skill and capacity enhancement efforts, by share of developers surveyed

AIM OF EFFORT	SHARE OF DEVELOPERS (%)
To prepare for geothermal employment opportunities	73 (11 of 15 developers surveyed)
To improve performance in other areas (e.g., literacy, computer use, agricultural practices)	53 (8 of 15 developers surveyed)
Enterprise development	80 (12 of 15 developers surveyed)

Source: World Bank survey 2023.

Detailed examples of developers' skill building activities are provided in table 4.3.

TABLE 4.3

Specific examples of developers' training and skill building activities

AIM OF ACTIVITY	EXAMPLES FROM DEVELOPERS
To prepare for geothermal employment opportunities	• **Philippines:** The Energy Development Corporation (EDC) through the Keitech Educational Foundation Inc. offers technical and vocational training in construction, metal working, engineering, and other skills to out-of-school youth. This training meets the requirements for possible employment in a variety of geothermal operations. • **Costa Rica:** The Instituto Costarricense de Electricidad coordinates training with state agencies primarily for construction-related work. • **Enerchange Türkiye** is working with one of the leading geothermal companies in Türkiye to run training programs for local communities in the Aegean region, with the aim of scaling them to be nationwide.
To improve performance in other areas (e.g., literacy, computer use, agricultural practices)	• **Indonesia:** PT Geo Dipa Energi conducted a food processing and marketing training program in 2021. The program trained six groups from six villages and assisted in the value chain of the fruit *Carica papaya*. • **Indonesia:** Supreme Energy Group of Companies conducts various training programs that suit local communities' needs and improve their livelihoods, knowledge, and skills. Example subjects include conversational English, coffee farming and marketing, chili and rice planting, and embroidery. • **Indonesia:** PT Pertamina Geothermal Energy enhances the quality of the education offered in projects areas through its Smart Together program, Green School, Training in Management of Waste Banks, Geothermal Zones, Management Goes to School, and Geothermal Education project. • **Philippines:** EDC supports 120 host communities in organizational strengthening and management, financial literacy, and social enterprise development; and offers technical training in forest restoration, biodiversity conservation, and forest protection. It also links communities with development partners. • **Nicaragua:** Polaris Renewable Energy supports educational opportunities for children, youth, and adults, including women. It provides computer training for teachers, and providing tablets and computers to schools. The company also supports farmers' technical capacity, including in product commercialization.
Enterprise development	• **Indonesia:** As part of a community development program, PT Geo Dipa Energi supported village-owned enterprises (BUMDes), including through lesson sharing. • **Indonesia:** PT Pertamina Geothermal Energy supports local communities in integrated farming and coffee business development, innovation in potato farming, the formation of palm sugar groups, brand strengthening, tour guide training, and the establishment of community economic zones, among others. • **Philippines:** EDC is supporting financially viable and environmentally friendly enterprises to generate short- and long-term revenue streams for partner communities. Examples include mangrove ecotourism and conservation, coffee and cacao production, handicraft development, and agricultural production and trade. • **Nicaragua:** Polaris Renewable Energy supports entrepreneurship in service areas such as food, and successfully supported communities to manage a $1 million water project on their own.

Source: World Bank survey 2023.

In Kenya, entrepreneurship and self-employment skills are the foci of a youth empowerment program. The program's rationale is that long-term job prospects are dwarfed by growing demand. As box 4.8 explains, supporting young people to create new businesses will bring a broad range of benefits.

Photo: Computer literacy program in Nicaragua funded by Polaris Renewable Energy

BOX 4.8

KENYA: CHAMPIONING YOUTH EMPOWERMENT AND EMPLOYMENT

The Geothermal Development Company (GDC) is a government-owned entity tasked with developing Kenya's geothermal resources. GDC has an operational capacity of 320 megawatts (MW) and is planning an additional 1,065 MW by 2030. GDC works closely with communities to ensure that they benefit from geothermal projects and that their situation is better than what it was before development. While GDC prioritizes local employment, realistically, there are never enough jobs to meet demand.

To support local community members in building their own businesses and developing their skills, GDC has established a collaboration with various state entities, including the Department of Cooperatives and the State Department of Youth Affairs. Through the initiative, community members can access funds to purchase equipment, ranging from vending machines to power tools, as well as to cover the costs of entrepreneurship training. Skills training focuses on mechanized equipment, such as a concrete mixer or a concrete pump.

Paticipants in the initiative set up their own Organized Youth Investment Groups, which the GDC links with contractors requiring unskilled and semiskilled labor. In essence, this structure has functioned as an employment bureau for short-term, casual labor. Through this program, 300 youth have been trained. Six of the Organized Youth Investment Groups are women-only organizations. When casual employment opportunities cease or are in low demand, the hope is that community members can become self-reliant through entrepreneurial activities.

Source: World Bank market sounding 2022; GDC 2019, 2022.

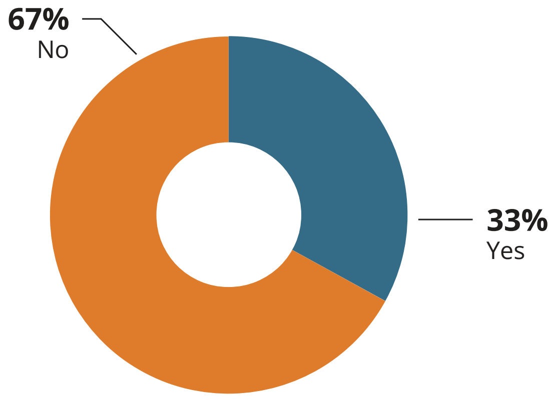
Revenue/ownership sharing arrangements

While CSR programs are common across all major developers, some companies go beyond the status quo in sharing financial benefits with the communities affected by geothermal plant development and operation. Revenue or ownership sharing is not compensatory, and is a long-term benefit sharing arrangement. The arrangement may include payments into, or equity shareholding by, community entities, such as community trusts, cooperatives, enterprises, or non-profit organisations. It may also assist the development of small businesses in the local area through payments via funding channels and programs.

Of the 15 developers surveyed, only 5 (33 percent) had set up some form of revenue sharing arrangement (Figure 4.5).

FIGURE 4.5

Percentage of developers that share revenue with communities



Source: World Bank survey 2023.

Table 4.4 outlines some of their approaches, each with its own set of benefits and challenges. Creating a community-controlled trust, for example, can ensure that funds are controlled democratically and utilized in the communities' best interest. Conversely, such an approach can also be afflicted by corruption, mismanagement, and, under certain circumstances, result in competition with neighboring communities that are not benefiting in the same way.

Photo: Geothermal power plant

TABLE 4.4
Examples of revenue sharing approaches

APPROACH	EXAMPLE
Equity stake in projects	The Māori business entity Tauhara North No. 2 Trust has a 35 percent equity stake in the Nga Awa Purua Power Station (140 megawatts [MW]) and a 50 percent equity stake in the Ngatamariki (84 MW) and Rotokawa (34.5 MW) developments in **New Zealand**. Revenue from these commercial operations, estimated at $NZ 6 million per year, is directed to grants and programs to support Māori people (Blair n.d.).
Percentage of revenue directed to a community-controlled entity (trust or cooperative)	In **Kenya**, the Energy Act 2019 repealed the Geothermal Resources Act 1982 and detailed royalty rates. As per the act, a licensee needs to pay a royalty on the extracted geothermal resources' value at the wellhead. This royalty is not less than 1 percent and not more than 2.5 percent of the energy produced during the first 10 years of production, and 2 percent to not more than 5 percent annually after the first 10-year period. Royalties are to be apportioned to three parties: the national government (75 percent), county government (20 percent), and local community (5 percent). The community's share is payable through a trust fund managed by a board of trustees established by the local community in accordance with the regulations under the Energy Act 2019 (Republic of Kenya 2019).
Percentage of company's annual budget directed to a foundation or a nonprofit	LaGEO, in **El Salvador** has established a nonprofit foundation called FundaGeo to support community development activities. Although FundaGeo is a separate entity, LaGEO plays a role in directing the foundation's strategy and programming. LaGEO has committed to contribute 20 percent of the company budget to the foundation on an annual basis. The budget can be adjusted during the year with the company board members' approval if more funds are required to support the communities (World Bank market sounding 2022).
Percentage of revenue shared with the local government	In **Indonesia**, for all geothermal projects with existing units, the corresponding producers are required by law to pay a production bonus to the government of the region where a project is located. They also need to pay an exploration levy for fields in the exploration stage. The production bonus is calculated based on the sale of geothermal steam and/or the electricity generated from geothermal energy. Producers are required to pay either 1 percent of the gross income from the sale of geothermal steam or 0.5 percent of the gross income generated from the sale of electrical power. The payment of production bonuses has been demonstrated to have a positive correlation with a rise in GDP. In the **Philippines**, the Energy Development Corporation has a revenue sharing agreement with the local government units hosting its geothermal facilities. The agreement is equivalent to 1 centavo per kilowatt-hour (0.01/kWh) of the total electricity sales and is from the accrued monies as prescribed under the Energy Regulations (ER) No. 1-94. In addition to the ER 1-94, the Energy Development Corporation is also sharing a royalty with the Manobo Apao Descendants Ancestral Domain of Mt. Apo to allow the company to continue operating two geothermal plants in this ancestral domain (World Bank market sounding 2022).

As seen in some projects, allowing community members to take a debt or equity stake in a project can boost social acceptance. Box 4.9 describes a project of EU Horizon 2020, called CROWDTHERMAL.

BOX 4.9

EUROPEAN UNION: SPURRING COMMUNITY INVESTMENT IN GEOTHERMAL PROJECTS

CROWDTHERMAL is an EU-funded project that was established to empower society to partake in, and financially benefit from, the development of geothermal projects. The project has developed alternative financing schemes to allow community members to become investors in geothermal projects. It has also developed a number of community engagement tools to ensure that proposed projects get communities' acceptance and are able to progress without delay or litigation.

A major deliverable of the project is a Web-based tool designed to support not only community members but also developers and local authorities to work through questions surrounding social acceptance, community engagement, alternative financing, and risk mitigation. The tool can be accessed online through the CROWDTHERMAL website. A full list of project deliverables is provided in table B4.9.1.

TABLE B4.9.1

Overview of CROWDTHERMAL services and tools

Service	For whom	What?
Decision tree	Project developers & Local authorities	Offering a workflow with questions on social, environmental, financial, and risk mitigation factors to help you identify appropriate strategies for your project.
Interactive guide to integrated finance in geothermal energy	Community investors & Project developers	A self-assessment with regards to the financial and risk mitigation framework to consider in developing a geothermal project, according to the profile of your community.
Toolbox for risk-evaluation and mitigation	Project developers	Parameters to help you perform a complete economic modelling of geothermal projects, with or without community funding.
Implementation framework for community-based geothermal development	Community investors & Project developers	Five fundamental aspects to consider for any geothermal energy project developed by a community of citizens.
Information Catalogue for self-learning	Community investors & Geothermal professionals	Offering in-depth information on anything related to the CROWDTHERMAL pillars: community financing, social aspects, risk mitigation, and geothermal energy.
FAQ	Community investors	Answers to all your questions around community financing for geothermal projects, social engagement strategies, risk mitigation, and geothermal energy.
Meta-database of geothermal projects	Community investors & Project developers & Local authorities	Your platform of geothermal projects that are potentially suitable for alternative financing schemes.

Source: World Bank market sounding 2022; table extracted from CROWDTHERMAL (2022).

Note: FAQ = frequently asked question.

Monitoring and post-project support to ensure benefits

Monitoring the progress of benefit sharing mechanisms is essential. Economic and social benefits may be monitored using a variety of indicators and measurement methods. The World Bank handbook, *Maximizing the Socioeconomic Benefits Triggered by Renewables*, offers an annex of sample indicators that could be utilized to monitor and evaluate the success of local development efforts.

Economic impacts tend to be the easiest to monitor and evaluate. The process requires little qualitative data that can be gathered through surveys, modeling exercises, and official statistics, such as censuses. Social benefits, while equally important, can be more difficult to measure, and questions of attrition may be greater. Measuring social benefits requires a more interactive and participatory approach. Data collection methods include one-on-one interviews, focus group discussions, and social mapping.

Monitoring is also important for developers to know whether they are executing their plans effectively and if their commitments and benefits programs are working as intended. Box 4.10 highlights example outcomes.

Monitoring helps developers identify approaches to sustain, and also helps them visualize an exit plan, including the handover of assets to communities. To maximize socioeconomic benefits, it is vital that opportunities for long-term impact are assessed carefully.

BOX 4.10

PHILIPPINES AND ETHIOPIA: OUTCOMES OF PROGRAM MONITORING AND EVALUATION

In the Philippines, a developer refocused its corporate social responsibility strategy on education (see box 4.6) after conducting a community survey that asked which programs had the most impact and were the most meaningful.

In Ethiopia, a developer refocused its benefit-sharing program on water supply to a local community. After surveying the community, the company found that girls were dropping out of school because they needed to fetch water for their households from far distances. Adjusting its benefit-sharing plan to address this need has had the significant and long-term impact of helping girls stay in school and attain higher academic achievements.

Sources: World Bank market sounding, 2022.

FIVE.
CONCLUSION

Some of the key highlights from the analysis of socioeconomic categories outlined in this report are summarized below.

Participation of domestic companies in the geothermal value chain

- Mapping the geothermal value chain can help to identify opportunities to maximize the socioeconomic benefits of geothermal project development and operation. Where goods, services, and labor are available domestically, it may be possible to “localize” activities, creating added value and contributing to the gross domestic product of the country where a project is being developed.
- Identifying gaps in domestically available goods, services, and labor creates an opportunity to design support programs to build the capacities of the domestic industry over the medium and long terms to capture greater added value.
- There is significant potential to localize the construction and operation and maintenance (O&M) segments of the value chain. Even when international companies are hired, there are opportunities to subcontract out portions of work to domestic companies, or hire domestic labor.
- Turbines, condensers, cooling towers, and generators are highly specialized pieces of equipment, and their manufacturing is very unlikely to be localized. Much of the other equipment required for a geothermal power plant (e.g., heat exchangers, pumps, valves, piping, and cladding), however, are off-the-shelf products, which can be provided by multiple suppliers.
- Governments have used project procurement as an avenue to localize some activities along the geothermal value chain. For example, incentives created for developers to procure certain components and services from the domestic market have served to nurture the growth and development of domestic companies. Such procurement practices should be considered carefully so as not to negatively impact project viability and tariffs.
- Clusters and industry associations can play an important role in building the capacities of the domestic industry by providing training, facilitating interactions between different sector players, and creating a positive environment for technology transfer and research and development.
- Creating tailored financial products can support domestic companies in adjusting their business activities and scale up operations to participate in the geothermal value chain.

Geothermal employment and skill development

- The geothermal sector employed 196,000 people in 2021, and it is possible that this figure will reach 296,000 by 2030 (IRENA 2021).
- Women are underrepresented in the geothermal sector, accounting for only 22 percent of the total employment. There are also discrepancies in the types of roles held by

women, with fewer women in technical positions and more in administrative and support roles. Governments and companies are addressing these gaps through progressive policies, support programs, and female employment targets.

- Construction and O&M are the two project phases that create the most jobs. While construction jobs are more plentiful, they last only 2–3 years. O&M jobs are fewer but they last the lifetime of a geothermal facility (30–50+ years). On a person-years basis, O&M creates 20 times more employment over a project's life cycle than does construction.
- Direct use projects offer significant employment opportunities, especially for women, youth, and disadvantaged groups.
- Skill shortages in the geothermal sector are the most acute for high-skilled roles and less so for medium-skilled roles. Developers report very few issues in recruiting for low-skilled roles domestically. Skill shortages not only impact project development, but also the ability to develop supportive policies and institutions at the government level to enable exploration and private sector investment.
- Many of the skills required by the geothermal sector are easily transferable from the oil and gas sector, and many governments and companies have explored opportunities to reskill individuals from this declining industry to not just leverage capabilities but also preserve jobs and economic prosperity.
- Governments and developers have responded to skill shortages by developing new geothermal curricula and/or sending individuals abroad to receive training in developed geothermal markets, such as Iceland, Japan, and New Zealand. Developers often hire individuals without geothermal-specific experience, and then offer on-the-job training.
- Many countries will not have the demand to justify the creation of geothermal-specific education programs, whether in universities or technical and vocational education and training institutes. Many countries are thus choosing to organize programs at the regional level, to take advantage of economies of scale.
- Sharing information on job opportunities with students and people working in adjacent industries will be key to expanding the geothermal workforce. Student competitions, mentorship programs, internships, and apprenticeships have an important role to play in introducing individuals to career opportunities in the sector.
- Some governments have encouraged developers and their subcontractors to hire domestic and/or local labor by creating incentives or setting requirements as part of the project procurement process. Similarly, several governments have set targets for women's participation in the workforce.

Ensuring that geothermal projects' socioeconomic benefits are felt by local communities

- Developers need a social license to operate. To gain trust, it is critical that they build and maintain a positive and long-standing relationship with communities, and contribute to lasting benefits within the communities.
- Developers share benefits with local communities and stakeholders, including local governments, for multiple reasons, such as to gain acceptance and collaborate, to ensure compliance for legal reasons, and to build community resilience. Such benefit goes above and beyond what is required by law to compensate for losses or damages incurred through project development (as mandated by countries' environmental and social frameworks).
- Timely and transparent information, detailed consultations, and collaborative programmatic interventions are needed to share benefits with local communities. There is a need for developers to find the right balance between communities' wants and needs and what developers can realistically deliver.
- There are three key categories for benefit sharing:
  - Improvements or additions to services and local infrastructure (e.g., schools, health centers),
  - Skill and capability enhancement at the community level (e.g., training in skills specific to geothermal, or other subjects that can help trainees initiate enterprises or enter other industries),
  - Revenue/ownership sharing arrangements (e.g., equity stakes in projects, or a percentage of revenue directed to a community-controlled entity, such as a trust or local government).
- In a few countries, constitutional or macro level legal frameworks distribute benefits at the local level, for example, through royalties and production bonuses. Similarly, gender equality and social inclusion policies have allowed for the greater workforce participation of women and vulnerable groups.
- Integrating benefit sharing requirements into procurement documents can help to ensure that developers deliver on their promises to communities. Project procurement also presents an opportunity for government to identify synergies with their own local development plans.
- Above all, building long-lasting trust with local communities is paramount. Sustained engagement and flow of transparent information allow projects to move forward without costly delays or litigation. A dedicated team, with an equal gender representation, is required to maintain trust and relationships with communities over time.

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ANNEX 1
Role of the public and private sectors in geothermal project development

The public sector has consistently played a critical role in the development of geothermal resources. As such, the public sector, alongside the private sector, continues to have an essential role to play, both in gauging the socioeconomic benefits of geothermal energy and in implementing strategies to maximize those benefits.

Public sector participation and leadership have largely been required because of the capital intensity of geothermal exploration and the risks associated with finding a resource or reservoir that can be developed in a bankable manner. The public sector has had a prominent role in financing geothermal development; 76–90 percent of project investments utilize some element of public debt or equity (Micale, Oliver, and Messent 2014).

In Kenya, for example, the government formed and owns the Geothermal Development Company (GDC), a special purpose vehicle with a target of developing 1,065 megawatts of geothermal power by 2030. The GDC is tasked with developing steam fields and selling geothermal steam for electricity generation to KenGen, the state-owned utility, and private investors (GDC n.d.). In Iceland, all geothermal energy development was traditionally supported by public sector investments. However, in 2007, one power plant was sold to the private sector, and in 2010, the private sector became the majority owner (World Bank market sounding 2022). Small companies started to be involved in the direct use of geothermal energy, earlier, in the 1980s (World Bank market sounding 2022). Many other countries, for example, El Salvador, Indonesia, the Philippines, Poland, and Türkiye, have benefited greatly from public sector investment and risk mitigation, and now have developed geothermal markets.

Besides making critical investments, the public sector plays a vital role in designing and implementing a policy landscape conducive to geothermal development. A long-term geothermal strategy with specified targets can help build confidence in the market, attract private investment, and develop the domestic industry. Private sector investors seek a clear and straightforward regulatory environment. Easy-to-navigate and predictable laws and permit requirements can significantly reduce risks in exploration and project development. Figure A1.1 outlines several key roles.

Many governments developing their geothermal resources are beginning to simultaneously examine how the socioeconomic benefits of project development can be maximized. For example, they are taking note of potential skill gaps and working to find solutions to create more domestic employment. They are also finding ways to increase the participation of women and disadvantaged groups in the geothermal workforce. Experience has shown that a single project without a long-term vision for future development is not likely to make a significant contribution to a country's socioeconomic development; this necessitates planning for socioeconomic benefits in coordination with an overall geothermal strategy. The World Bank handbook *A Sure Path to Sustainable Renewable Energy: Maximizing Socioeconomic Benefits Triggered by Renewables* (World Bank 2022b) outlines many of the steps that governments can take to leverage project development in order to ensure positive socioeconomic outcomes (World Bank 2022b).

Some countries have successfully advanced their socioeconomic aspirations through project procurement by placing specific requirements on developers to generate the desired outcomes. For example, both Türkiye and Indonesia have created incentives for developers to procure goods and services from local companies. The intent is to develop their domestic industries.

Even as contexts vary between countries and even among sites within a country, so does the private sector's role. In some cases, the private sector will lead from the exploration phase up to the operation of a geothermal plant. This has been the case of the Ethiopia-based Tulu Moye project, for example. In other cases, a private sector developer may enter the market once a resource has been proven and specific permits granted. The Chilean government has adopted this approach. In yet other cases, the private sector may fulfill only certain responsibilities, for example, designing and building a power plant and a steam field. This is

FIGURE A1.1

Public and private sector roles in generating socioeconomic benefits

Public sector

- Policy, planning, regulations, and incentives toward overall progress of geothermal sector and an improved economy.
- Promote and protect gender equality and enhance social inclusion through policy and requirements for developers.
- Investments in exploration, drilling, and development to reduce risks to the private sector.
- Education and workforce planning and investment.
- Work toward meeting the international commitments (Sustainable Development Goals, energy transition etc.).

Private sector

- Investments and new knowledge on technology and business models to progress the geothermal sector.
- Investments in, and sharing benefits with, local communities and governments leading to greater acceptance and a shared positive impact.
- Building capacities of the workforce leading to an improved and wider pool of domestic skills.
- Work with governments on standards for the sector, and provide industry feedback on policies and regulations, to promote best practice in-country.

Source: Original compilation for this report, 2023.

the case for LaGEO, the government-owned entity in El Salvador. The roles assumed by the public and private sectors will largely be determined by a country's geothermal strategy and willingness to take on early stage exploration risks.

Regardless of the specific role and the level of investment, the private sector plays an important part in the geothermal value chain, including in exploration, drilling, project development, and operation. In many countries, private sector players, including developers and engineering, procurement, and construction contractors, have helped to inform policy development, catalyze investment, gather data, upskill the domestic geothermal workforce, and build critical knowledge and experience. In some cases, geothermal developers have supported local universities and technical and vocational education and training institutes in developing new geothermal-specific curricula, provided scholarships for students to pursue studies in geothermal energy, and taken on interns to build hands-on technical capacities within the country.

To date, few governments mandate developers to contribute to community socioeconomic development beyond what is required by national social and environmental safeguards. However, even in the absence of such requirements or incentives, the private sector has done much to build the resilience of communities near project sites. Their motivations are numerous but are primarily driven by a need to obtain and maintain social acceptance and community buy-in. Without such community approval, however informal it may be, projects will often be delayed or even permanently halted. This report captures many ways in which government- and privately owned developers worked collaboratively with communities to significantly improve community members' socioeconomic conditions.

ANNEX 2
Methodology

Overall approach

The report follows the approach outlined in the World Bank's Sustainable Risk Mitigation Initiative (SRMI) report A Sure Path to Sustainable Renewable Energy: Maximizing Socioeconomic Benefits Triggered by Renewables (World Bank 2022b). In this report, there are four socioeconomic categories which are detailed in Section 1.2 and Figure 1.2 respectively. To reiterate, these are:

- Participation of domestic companies in the geothermal value chain
- Geothermal employment and skill development
- Local development/benefit sharing
- Gender equality and social inclusion (a cross-cutting category)

Methods

The information for these socioeconomic categories in the report was derived from extensive literature review and interviews with stakeholders. A thorough literature desk review was initially conducted that included information and data gathering on each of the categories, including policies and regulatory instruments in the geothermal sector of various countries to assess if socioeconomic benefits were addressed. Literature was also provided by experts from the industry as well as World Bank–related projects and task team leads. The literature review was consolidated into a draft note, and research gaps were drawn up by the team, which outlined the need to gather additional data through the interviews.

Interviews were held in October and November 2022. Over 40 stakeholder institutions in the geothermal industry participated, including government, industry associations, international organizations, academia, public and private sector developers, and two technical experts. Each interview took about 1–1.5 hours, with some stakeholders providing additional written information and reports post interview. These consultations provided insights and understanding of ongoing initiatives, projects, and/or research around socioeconomic benefits in the geothermal sector. While the four socioeconomic categories provided the overall frame, consultations were tailored depending on the type of institutions and experts interviewed. For example, more detailed discussions were held with private sector players on the topic of domestic companies' participation in the geothermal value chain, and their ongoing efforts on benefit sharing.

Following the online consultations, a survey questionnaire was designed specifically for geothermal developers to gather quantitative data. A total of 15 developers provided detailed inputs on focused queries around the socioeconomic categories. Queries were both quantitative and qualitative. The survey was drawn up mainly for companies to review the information of the various figures produced on aspects of the value chain, such as the participation of domestic companies, total capital expenditure for each segment, jobs, and if any roles were missing or miscategorised. In addition, several queries were also added on the other categories of skill development, gender, and local development.

Table A2.1 provides a list of all stakeholders that were consulted as well as those companies (public and private) that provided information through the survey questionnaire.

TABLE A2.1

Stakeholders consulted for the study (interviews and survey)

NO.	INSTITUTION	TYPE OF INSTITUTIONS	CONSULTATION	SURVEY
1	Andean Geothermal Centre of Excellence, Chile	Educational, research	■	
2	Arctic Green Energy, International	Private sector company		■
3	Baseload Capital, Sweden	Private sector company	■	■
	Boise State University, United States	Educational, research	■	
4	Comisión Federal de Electridad (CFE), Mexico	Public sector company		■
5	Czech University of Life Sciences Prague, Czechia	Educational, research	■	
6	Enel, Italy	Private sector company	■	
7	Enerchange Türkiye	Private sector company		■
8	Energy Development Corporation (EDC), Philippines	Private sector company	■	■
9	GEORG Geothermal Research Cluster, Iceland	Educational, research	■	
10	Geothermal Council of Chile	Association	■	
11	Geothermal Development Company (GDC), Kenya	Public sector company	■	
12	Geothermal Villages Network, Kenya	Research, network	■	

NO.	INSTITUTION	TYPE OF INSTITUTIONS	CONSULTATION	SURVEY
13	Government of St. Lucia	Government		
14	GRÓ Geothermal Training Programme, Iceland	Educational, research		
15	Gudmundur Hagalin Gudmundsson, Iceland	Geothermal expert		
16	Indonesian Geothermal Association, Indonesia	Association		
17	Institut National de la Recherche, Canada	Educational, research		
18	Instituto Costarricense de Electricidad (ICE), Costa Rica	Public sector company		
19	Instituto Nacional De Electrificación (INDE), Guatemala	Public sector company		
20	Inter-American Development Bank, United States	Multilateral development bank		
21	International Geothermal Association (global)	Association		
22	International Renewable Energy Agency, United Arab Emirates	Intergovernmental agency		
23	Izmir Institute of Technology, Türkiye	Educational, research		
24	Jóhann Jónasson, Iceland	Geothermal Expert		
25	Kenya Electricity Generating Company (KenGen)	Public sector company		
26	LaGeo, El Salvador	Public sector company		
27	Landsvirkjun, Iceland	Public sector company		
28	Mexican Center for Innovation in Geothermal Energy, Mexico	Educational, research		
29	Mexican Geothermal Association, Mexico	Association		
30	National Renewable Energy Laboratory, United States	Government, Research		
31	Ormat Inc., Türkiye	Private sector company		
32	Oserian Development Company Limited, Kenya	Private sector company		
33	PT Pertamina, Indonesia	Private sector company		
34	Polaris Energy (Nicaragua)	Public sector company		
35	PT Geo Dipa Energi (Persero), Indonesia	Public sector company		
36	PT Supreme Energy, Indonesia	Private sector company		

NO.	INSTITUTION	TYPE OF INSTITUTIONS	CONSULTATION	SURVEY
37	Reykjavik Energy, Iceland	Public energy and utility company		
38	Sarulla Operations Limited, Indonesia	Private sector company		
39	Services Industriels de Genève (SIG), Switzerland	Public local utility		
40	University of Geneva, Switzerland	Educational, research		
41	University of Glasgow, United Kingdom	Educational, research		
42	University of Texas, United States	Educational, research		
43	United States Energy Association, United States	Association		
44	Upflow, New Zealand	Private sector company		
45	Women in Geothermal Indonesia	Association		
46	Women in Geothermal (Global)	Association		
47	World Bank (global)	Multilateral development bank		
48	Zorlu Enerji, Türkiye	Public-private company		

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