

Geothermal Energy:

Unleashing the Earth's Power to Fuel Chile's Future



Chile is privileged with abundant geothermal energy resources that can help meet the nation's growing energy demand. Yet to date, this source of stable and clean energy remains largely undeveloped. A series of barriers have so far limited the expansion of the sector. To overcome existing hurdles to geothermal energy production and unleash the sector's full potential, concerted action is needed, particularly from the public and private sectors. Chile's decision makers should consider a series of policy mechanisms that could help attract—and grow—early investment. It will also be necessary for the government to reduce lingering legal and regulatory ambiguity and demonstrate strong political will to overcome institutional constraints and move geothermal energy forward, along with other nonconventional renewable energy technologies that are already more established in the country.

Chile faces important choices about how to meet its future energy demand. The country has increasingly relied on imported fossil fuels and hydroelectric plants, sources that have proved both unpredictable and expensive in recent years. Fossil fuels are subject to volatile price fluctuations, and hydroelectric plants have been plagued by several years of drought conditions. These sources also come with high environmental and social costs and have been subject to widespread public disapproval. Fortunately, Chile's abundant nonconventional renewable energy (NCRE) sources like wind, solar, biomass, and geothermal can help stabilize supply, reduce the country's exposure to price fluctuations of imported fossil fuel resources, and deliver energy to the country without the high environmental or social costs of traditional sources. With just over 1,000 MW of NCRE online, out of an estimated gross potential of more than 350,000 MW, there is still much room for growth.¹

Chile's geothermal energy sources represent a significant opportunity to meet some of the needed growth in capacity. Boosting geothermal development would provide Chile with a clean, stable, and local base-load power source for its growing economy without the detrimental impact of conventional base-load alternatives such as coal or large hydro. Despite its great potential and interest from the private sector, however, geothermal development in Chile lags behind other NCRE sources. To discern what is holding the sector back, an analysis of Chile's geothermal sector supported by the Natural Resources Defense Council has drawn on insight from actors in the public, private, and academic sectors to identify key barriers to growth and needed actions to boost geothermal production.

Geothermal energy has significant benefits for Chile

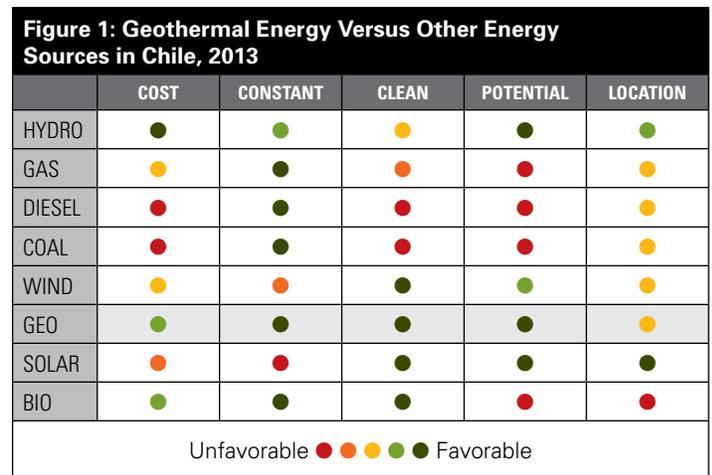
1. It is a clean NCRE resource and can pose fewer environmental and social risks. Geothermal plants produce only one-sixth of the carbon dioxide produced by a relatively "clean" natural gas field. Additionally, they produce little or no nitrous oxide or sulfur-laden gases.² And, unlike large hydroelectric facilities, geothermal projects do not have major, irreversible impacts on fragile ecosystems. A report by the Massachusetts Institute of Technology notes, "The general conclusion from all studies is that emissions and other impacts from geothermal plants are dramatically lower than other forms of electrical generation."³ While all types of energy production can affect local natural resources and communities, a well-managed impact assessment process can reduce the potential impact of geothermal development on surrounding areas.

2. Chile has abundant potential capacity for geothermal energy generation. According to preliminary estimates, feasible potential in Chile is roughly 3,350MW.⁴ This amount is equivalent to nearly half of the increase in energy capacity the government predicts will be needed by 2020.

3. As a constant, domestic source of energy, it exposes Chile to less risk. As base-load energy, geothermal produces energy around the clock, making it an ideal substitute for costly fossil fuels and large-scale hydroelectricity. Unlike imported fossil fuels, geothermal would not be subject to fluctuations in international supply and prices. Unlike hydropower, geothermal would not be impacted by drought.

4. Long-term costs are cost competitive. According to an analysis of the levelized cost of energy in Chile through 2030, geothermal energy compared favorably with other alternatives. In fact, geothermal is one of the most cost-competitive NCRE sources and one of the more cost-competitive energy resources of any type—today.⁵

5. Resources are located closer to demand centers. While certain geothermal resources may be in remote areas that are currently not connected to the main grid, they are geographically much closer to demand, particularly industrial operations, than are large-scale dams in the south.



Source: Bloomberg New Energy Finance, 2013

STATUS OF RENEWABLES IN CHILE

There is growing political support for renewable energy generation in Chile. In 2008 Chile set the goal of producing 10 percent of the nation's power with NCRE sources by 2024.⁶ The present administration's National Energy Strategy for 2012–2030 recognizes the advantages of renewables and calls for greater NCRE penetration. In 2013 the Chilean legislature passed a law setting the more ambitious—yet still attainable—target of generating 20 percent of Chile's energy needs with NCRE by 2025.⁷ This new target should help spur further growth of renewables in Chile. The NCRE sector has already been steadily expanding: 2012 was a record-breaking year for the industry, with a 23 percent jump in capacity over the prior year.⁸ As of the third quarter of 2013, there are 1,072 MW of NCRE in operation, accounting for 6.06 percent of installed capacity in the country's two main grids—more than what was required for the year under the original renewable energy goal. Figure 2 shows that significantly more capacity is either already approved or under evaluation.⁹

STATUS OF GEOTHERMAL ENERGY IN CHILE

Despite the promising outlook for NCRE in general in Chile, development of the country's geothermal options still lags far behind development of other renewable sources. To date, only two geothermal plants totaling 120 MW of capacity have received approval: Enel Green Power's Cerro Pabellon and Mighty River Power's Tolhuaca. Yet they are still a few years away from beginning operation. Mighty River Power's Tolhuaca plant could begin producing energy at some point between 2017 and 2019.¹⁰ With a recent infusion of funds from the Philippines' Energy Development Corporation, Alterra Power is hoping its Mariposa geothermal project, with an expected potential of more than 300 MW, may be ready in coming years.¹¹ Various other energy development

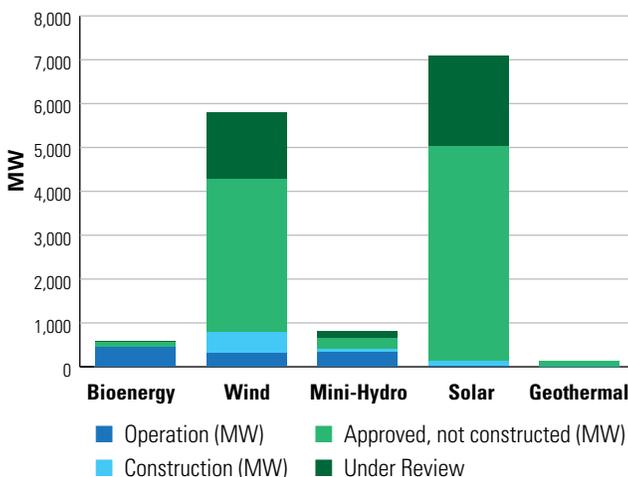
companies also recognize the potential for a larger, stronger geothermal sector in Chile and have established a presence in the market. In fact, a tender for 20 geothermal concessions that closed in April 2012 brought nearly USD \$250 million of anticipated investment from both domestic and international companies.¹² By the end of 2012, 76 concessions had been granted for geothermal exploration and 6 concessions granted for exploitation.¹³

GEOTHERMAL ENERGY IS A PROVEN TECHNOLOGY AROUND THE WORLD

The companies considering investments in Chile are not hoping to make history; they are hoping to repeat it. Iceland and New Zealand are well known for their success in turning to their geothermal resources to overcome energy constraints.¹⁴ Several other countries have also made geothermal energy production a part of (or even a cornerstone to) their energy strategies. The Philippines, for example, has exploited roughly 42 percent of its estimated domestic geothermal capacity. Mexico has taken advantage of nearly 60 percent of the geothermal resources within its borders, and Costa Rica and El Salvador are exploiting between 20 percent and 30 percent of their resources.¹⁵ Countries in Africa, like Kenya, are also very active in the development of geothermal resources. Indonesia has more geothermal projects in the pipeline—some 3.2 GW—than any other nation in the world.¹⁶

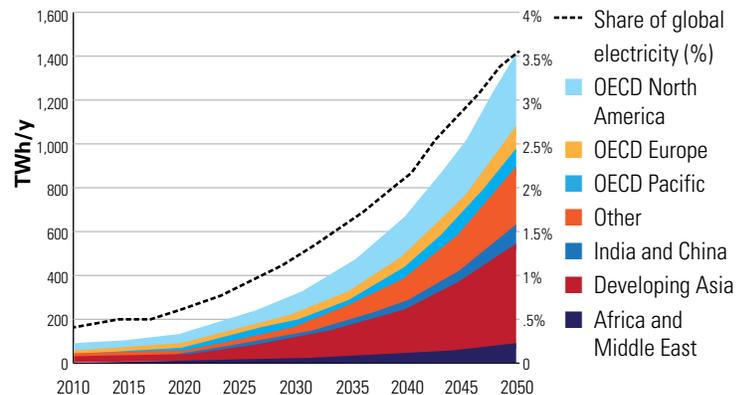
Clearly, geothermal development has not been limited just to certain economies, countries, or regions of the world. Outside of Chile, the footprint of geothermal energy is significant and growing. The International Energy Agency (IEA) envisions that geothermal energy could produce 1,400 TWh of electricity per year, or 3.5 percent of the world's electricity generation, by 2050 (see Figure 3).

Figure 2: Status of Renewable Energy Development in Chile, September 2013



Source: Center for Renewable Energy, Government of Chile, September 2013

Figure 3: IEA Vision for Geothermal Power Production



Source: International Energy Agency, 2011

WHAT HAS HELD BACK GEOTHERMAL DEVELOPMENT IN CHILE?

With its abundant resources, Chile has the potential to be a leader in geothermal energy production. However, while renewable energy quotas like the ones in place in Chile since 2008 are meant to spur development and use of renewable energy, they do not have an equal impact on all technologies.

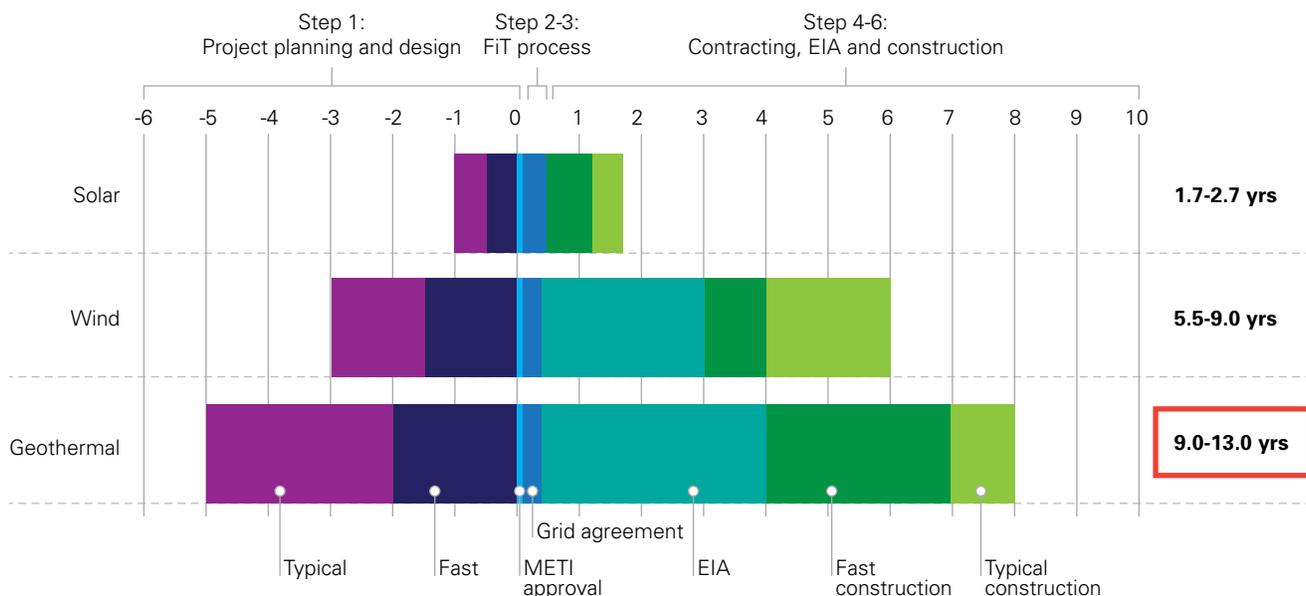
Despite geothermal energy’s low long-term costs and other benefits, other NCRE alternatives such as solar and wind have gained more traction in Chile in part due to their shorter lead times (see Figure 4). Geothermal projects may take up to 13 years to reach production because of a relatively lengthy exploration period that occurs prior to plant construction and full resource exploitation. In contrast, solar projects can often be brought online in one to two years and wind projects in as few as five years. The shorter project time lines of wind and solar technologies help them receive “first-mover” advantages such as the presence of more suppliers, developers, and service providers in the market. In turn, this helps make these options increasingly less expensive to bring online.

In addition to longer lead times, geothermal projects have higher initial costs. Significant expenses are incurred during the exploration period of a geothermal project: Deep wells must be drilled to determine if resources can produce an economically viable amount of energy. Recent data from the International Finance Corporation indicates that the success rate of wells drilled during exploration is 78 percent, but there is no guarantee that exploration will produce a viable resource. The IFC study, for example, focused on the power-generating capacity of wells, not the economics of individual wells.¹⁷

The challenges of exploration and site development are compounded in Chile because key resources are located outside of the existing electric grid, in areas with limited access to services.¹⁸ The country also faces a current lack of drilling contractors, drilling equipment, and service providers for geothermal projects; this contributes to higher exploration costs and is one crucial hurdle identified by geothermal energy experts.¹⁹ Geothermal projects use the same type of drilling rig used in natural gas and some other fossil fuel exploration. Since Chile does not produce these fossil fuel resources, rigs must be imported for geothermal projects alone and at a considerable cost. In addition, geothermal developers must compete with large, multinational fossil fuel energy companies to contract rigs, often resulting in long delays until equipment is secured.²⁰ The daily cost of a rig and crew in Chile can be as high as \$40,000, far above the global average of \$28,000 per day.²¹ The shortage of equipment and service providers, coupled with site remoteness, means the costs for geothermal exploration in Chile can be significantly higher than the averages elsewhere.²² These initial high costs in Chile can present serious financial hurdles for developers and make other potential investors wary of entering the market.

Geothermal development in Chile is further hampered by an insufficient legal and regulatory framework, in particular regarding concessions and environmental and community impacts that can lead to public opposition, delays, and cost overruns. Institutional constraints, particularly a lack of clear policy direction, are also a factor because they slow progress in addressing hurdles.

Figure 4: Estimated Time Line for Projects of 10 MW or Greater, 2013



Source: Bloomberg New Energy Finance, 2013

BRINGING DOWN BARRIERS TO GEOTHERMAL

To better understand the barriers that are hindering geothermal development in Chile, NRDC interviewed key representatives from industry, government, and academia. NRDC first presented the findings of this survey in April 2013 at a seminar titled “The Future of Geothermal in Chile: Barriers and Proposals for Development,” which it cohosted with the Andean Geothermal Center of Excellence (CEGA), a Fondap/CONICYT project. This seminar brought together participants from academia, government, industry, indigenous communities, as well as international experts.

This current issue brief is the result of insight gathered from the sector interviews and the seminar, as well as consultations with international geothermal experts at Bloomberg New Energy Finance. The research conducted as part of this process revealed the varying perceptions held by stakeholders regarding the intensity of barriers and the desirability of specific solutions. The research also indicates that to replicate the geothermal energy development seen in other parts of the world, Chile should consider concerted actions to help reduce the costs and decrease the risks of investing in geothermal energy in the country. It should also reduce lingering legal and regulatory ambiguity and strengthen institutional support for the resource.

1. Attracting investment that leads to development

The actors in industry, government, and academia whom NRDC consulted on barriers related to high initial costs and financing risks generally agreed that essentially all risk is currently assumed by developers.²³ Without appropriate policy mechanisms in place, the initial costs of exploration could remain too high to spur and maintain significant levels of growth in the private market. Yet Chile has not implemented some of the financial mechanisms that have been used to drive geothermal development in other countries. Unlike in many other markets, there is no guaranteed revenue stream for geothermal projects through a feed-in tariff. Additionally, there are no tax incentives provided by the government to encourage energy developers to pursue geothermal projects or for large consumers of energy (i.e., industrial offtakers) to purchase geothermal energy. Nearly every other country in the world that has developed geothermal fields has found it necessary to pursue such strategies, to varying degrees, to attract investment. Despite the shared recognition among actors that costs and risks are a strong barrier in Chile, there is less agreement on solutions to this issue.

Chile has, however, recently begun to investigate an exploration risk insurance model in conjunction with the Inter-American Development Bank and the World Bank. The government is also soliciting between \$30 and \$35 million in funding from the Clean Technology Fund to help

cover the costs of the program. If the program successfully moves forward it may help reduce the risk associated with geothermal development.²⁴

■ Price tariffs

Other nations attempting to spur geothermal development, including Japan and Indonesia, have implemented feed-in tariffs (price guarantees) for geothermal energy.²⁵ Such price guarantees are meant to enable investors to make a more specific estimate of a project’s return on investment, thus reducing uncertainty. Moreover, price guarantees can ensure that price fluctuations in other energy sources (such as fossil fuels) do not jeopardize an existing or proposed project’s viability. In Chile, for example, if gas imports from abroad increase, it is important to ensure geothermal development does not become unhinged by such an influx.²⁶ On average, individuals in industry and in academia felt feed-in tariffs could be a strong incentive in Chile. In contrast, government representatives, on average, did not feel a tariff would be as beneficial.²⁷

It is important to note that feed-in tariffs alone, even if generously priced, may not spur the desired level of development. Such is the case in Japan, where, despite high tariffs, development has remained slow due to other hurdles, including a difficult project approval process and issues with grid interconnection.²⁸ Indonesia is considering revamping its tariff policy and considering instead raising the ceiling price developers receive for geothermal power. This revised approach aims to avoid a situation in which developers make artificially low bids for concessions and then try to renegotiate tariffs, as well as outright speculation, two factors that have contributed to paralyzing projects.²⁹ A feed-in tariff of \$200 to \$300/MWh in Chile has been considered, but this would likely have no impact on geothermal development, according to experts at Bloomberg New Energy Finance, unless it is a piece of a larger policy package that considers institutional and legal elements as well.³⁰

■ Incentives for offtakers

Considering that obtaining a Power Purchase Agreement (PPA) is one of the most critical elements needed by a developer to begin a project, incentives for offtakers (those who purchase the energy) to enter into PPAs should be carefully considered. These incentives could largely come in the form of tax breaks provided by the government. That is, large consumers of energy that sign PPAs with geothermal companies could be eligible to receive additional benefits in the form of tax relief for making this purchase. Such tax relief could give these offtakers greater incentive to sign contracts with geothermal developers before projects come online. It would then be easier for geothermal developers to attract investment because there would be a more willing pool of potential buyers to sign PPAs. On average, individuals consulted in industry and in academia felt tax incentives for offtakers would be a moderately strong incentive in Chile,

while again, those in government generally did not feel the offtaker tax incentive would be quite as beneficial.³¹

Admittedly, this type of incentive in Chile might be politically very challenging, considering most of the offtakers would be very heavy users of energy (i.e., big industry). The public may be wary of the government's providing additional tax relief to large businesses rather than the average electricity consumer, who must purchase energy through a distributor.

■ Incentives for project developers

A Production Tax Credit (PTC) is a per-kilowatt-hour credit that is granted for generating and selling electricity produced from qualified energy resources. Simply put, renewable energy companies are entitled to a tax credit for each kWh generated, which they can use to offset taxable income. In the United States, since most power projects are formed as special-purpose entities and have very little taxable income in the early years, typically outside investors, known as “tax equity,” invest cash in projects in exchange for tax benefits. On average, individuals interviewed in industry and academia felt tax credits for developers could be a strong incentive in Chile. Meanwhile, those in government, on average, did not feel such a tax incentive would be as beneficial.³²

In the United States, the PTC for renewable energy has gone through several rounds of expiration and restart, and it is important to note that the effect of such a tax credit depends on a company's tax exposure. According to Bloomberg New Energy Finance, in recent years the PTC has not been a significant driver of geothermal development in this country; rather, the key driver has been a treasury cash grant program.³³ Under the 1603 Program from the U.S. Treasury, developers can receive a cash grant equal to up to 30 percent of a project's total eligible cost basis when the project goes into service.³⁴

Some type of incentive for developers of geothermal energy might be an interesting option to consider in Chile because of the way in which some energy projects are being developed. Some private companies—particularly those in the mining sector—have been forced to stray from their core businesses to develop their own energy projects to ensure supply.³⁵ That is, a company may not necessarily be just the offtaker; it may also be the generator. Tax incentives could both encourage companies to sign PPAs and spur them to choose geothermal projects over non-NCRE projects when developing their own generation facilities.

2. Reducing legal and regulatory ambiguity

Geothermal development companies in Chile face a myriad of regional regulations and, at times, complex negotiations with landowners near project sites, and in this they are not unique. Developers in many countries, including the United States, face similar issues when federal regulations and

incentives coexist with additional and distinct state policies.³⁶ However, years of experience with geothermal energy production in the United States has made certain states friendlier environments for development, particularly those in the western half of the country.³⁷ Chile does not benefit from the same history of development or the same shared understanding of the resource by federal, regional, and/or local officials.

In Chile, individuals in industry and academia, on average, found the current legal and regulatory framework in the country to be insufficient and felt the government could make improvements at both federal and regional levels.³⁸ Actors in government generally felt the legal framework was sufficient, suggesting that there is clear disagreement about the efficacy of the existing framework. Policy changes in this area may be particularly challenging to achieve in a short time frame, especially given the lack of agreement that issues identified are in fact barriers.

A primary concern among developers is site access. While a geothermal concession confers temporary rights to explore and/or exploit the geothermal resources on a given piece of land, Chile's concession system offers companies limited help in navigating difficult issues related to the ownership (or perceived ownership) of other resources within the boundaries of the concession. After approval of the concession, companies may deal with legal issues related to access to the site, access to water (an element crucial to the production of geothermal energy), transmission lines, and claims to the territory by local communities. Indeed, there is no guarantee that, if exploration yields a viable resource, there will be a clear path to exploitation. Geothermal concessions do not clearly or sufficiently address the broader resource needs of the geothermal company at the start of a project. Equally important, the concession law does not address the needs of local communities near the project site.

The potential legal costs and time delays associated with these issues add to the already high exploration costs and can severely damage public sentiment about geothermal energy development. In fact, some geothermal resources are located on environmentally, economically, and/or culturally sensitive areas and careful consideration of the unique qualities of such sites is necessary before a concession is granted and a project moves forward.

It would be helpful if the Chilean government better defined areas that are too risky for exploration and exploitation or are off-limits for other reasons. At present, geothermal projects are forbidden only in national parks. Reserves and other areas of special designation remain open to geothermal development, though not all of them are smart places for such development. A government initiative to prepare a geothermal planning study that would assess resource development through 2050 has been held up since 2011 due to questions regarding the legality of the study's tender process.³⁹ When this study moves forward it should carefully evaluate resource locations to determine

ahead of time in which areas concessions might have the least impact—when possible giving preference to land that is already disturbed—and which areas might require more careful review. Additionally it should ideally identify areas that are too sensitive for development and should not be eligible for concession.

■ **Earlier environmental impact studies**

Current regulations in Chile stipulate that an environmental impact study is to be conducted only when a project enters the period of exploitation. This means that developers are legally obligated to consult with local communities only after exploration occurs. Impacts to the surrounding environment can occur in exploration just as they can occur in exploitation. Communities near projects are generally uninformed about the potential impact of exploration activities, and this can generate mistrust. Conducting a preliminary environmental impact study at the beginning of the exploratory phase would help address potential concerns and ensure that local communities have a true voice in the decisions that affect their surrounding environment. An early-stage impact study would also provide valuable information about the baseline environmental conditions at the site, making it easier to identify, attribute, and remediate any potential environmental degradation that may arise during project development, or to identify sites where development would not be appropriate. Early impact studies are practiced in some countries with established geothermal sectors, like the United States, Nicaragua, and Iceland.⁴⁰

Waiting until the exploitation phase to require an environmental impact assessment from the developer may seem like a policy that helps streamline and reduce costs for businesses, but it can actually have the opposite effect. Relying solely on impact studies completed late in the project's life cycle can lead to significant delays and additional costs due to unanticipated findings and public opposition. Resources spent early to evaluate project impacts, address community concerns, and secure local support may help developers avoid the much larger costs of delaying exploitation due to unforeseen environmental concerns and/or social issues.

■ **Incorporation of the spirit of ILO Convention 169 into geothermal law**

In 2008 the government of Chile ratified the International Labor Organization (ILO) Convention No. 169, an international instrument that recognizes the aspirations of indigenous peoples to “exercise control over their own institutions, ways of life, and economic development and to maintain and develop their identities, languages, and religions, within the framework of the States in which they live.”⁴¹ By signing this convention, Chile signaled to the world it planned to make sure indigenous communities would be carefully considered in the institutional and legal framework of the country. Yet the government has not considered this

agreement in relation to geothermal concession law or any other institutional framework related to geothermal projects. The lack of clarity about indigenous issues and rights in Chile's legal and institutional framework has led to an increased level of uncertainty in all energy development projects, including those in the geothermal sector.⁴² Failing to involve local indigenous communities by providing clear and sufficient information on project plans and expectations early on can lead to disputes, damaged relationships, and costly delays in project development.

There has indeed been a significant lack of consideration for indigenous community rights in the concession-granting process. Concessions have been granted in areas that are important to indigenous groups, particularly areas the government designates as “natural reserves.” One example of a project that moved forward despite the concerns of the local indigenous community is Geotérmica del Norte's El Tatio project. A well failure led to even greater opposition, and the incident cast a shadow over geothermal development. To move beyond this early controversy, it will be important to consult and engage local communities and ensure they are on board.

The government should better understand the claims of indigenous communities in sensitive territories and consider these claims when granting concessions. For example, many communities—particularly those in the arid northern regions of the country—are particularly concerned about groundwater and perceive geothermal development as a threat to their already scarce water resources.⁴³ Geothermal plants often require significant amounts of water to be pumped from deep reservoirs to produce the necessary steam to turn turbines and generate electricity. The current law does not contain any provisions that would ensure these communities retain their water supply. Given this, local communities in dry regions may be particularly wary of geothermal development. Prior to granting concessions, the government should also require companies to be more proactive in consulting indigenous groups. This consultation could be part of the pre-exploration environmental impact study suggested above

■ **Flexibility of the concession**

Currently in Chile, exploration concessions have a period of two years and in some cases a two-year extension may be requested by the developer. A two-year period may be insufficient for some concessions in extreme climates that preclude year-round exploration. It may also be insufficient if local community concerns require a negotiation or mediation process. Finally, a two-year period may be insufficient for concessions located in areas that require lengthier environmental impact studies due to characteristics of the surrounding ecosystem and/or the geological context. While an extended concession period is not necessary for all projects, some may warrant more time for exploration than others. This would require both a change to the law

and a more careful review by the Ministry of Energy prior to granting the concession. At present, concession size in Chile is also very inflexible. The law requires that concessions have the shape of a parallelogram, meaning that all sides must be perfectly straight.⁴⁴ Some concessions, particularly those near international borders, may require a unique shape so they can fully and effectively exploit resources.

3. Addressing institutional constraints

A lack of direction in existing policy and an absence of general institutional support for geothermal energy can weaken regulation. Despite the existence of a renewable energy target, the government has not put forth a concrete plan for boosting geothermal energy generation as part of a broader energy strategy that should aim to deploy clean and sustainable energy alternatives. As detailed above, due to its time line and elevated early costs, geothermal may not reap the benefits of such a renewable portfolio standard. Yet in the face of this, mechanisms to spur development of geothermal are still not well defined.

Individuals from industry and academia who were consulted generally found this lack of direction to be a strong barrier for development; those in government did not feel as strongly.⁴⁵ This lack of consensus among key actors may make finding solutions in the short-run challenging, unless government leadership starts showing the political will necessary to make geothermal development, along with other NCRE alternatives, a priority going forward.

■ Clearer policy signals

It will be critical for Chile to provide a clear policy direction for geothermal that addresses lingering regulatory and legal ambiguities and helps reduce costs and risks to investment. Unclear policy signals regarding the government's level of support for geothermal energy as part of a broader energy strategy may make investors wary of supporting projects. No country, with perhaps the exception of early activity in the United States in the 1970s, has developed a robust geothermal energy sector without very clear incentive mechanisms and/or significant expenditures aimed at advancing and sustaining projects.⁴⁶ Countries with significant levels of geothermal energy production—namely Iceland, the Philippines, and New Zealand—all began large-scale development via strong state involvement.^{47,48,49}

■ Broadening the base of geothermal experts

Perhaps the most important symptom of the lack of a clear policy for energy is manifested in the manner in which geothermal energy regulation is handled by government institutions. While Chile's Ministry of Energy is technically the figurehead department for all energy resources, responsibility for geothermal energy projects, information, and evaluation is scattered across several government institutions including (but not limited to) the Ministry of Energy, the Center for Renewable Energy, and the National Service of Geology

and Mining. Moreover, these institutions have very few people dedicated specifically to managing and advancing geothermal development. In contrast, New Zealand has a much larger government support staff for the geothermal sector.⁵⁰ A greater number of experts under the roof of a single government entity could help elevate the profile of geothermal energy within Chilean institutions, ensuring that it is more explicitly included in future resource planning. This could also help strengthen coordination and effectiveness in the management of geothermal resources.

Continuing to build local expertise and technical capacity is also key, especially as Chile looks toward how it will sustain and grow the industry once it matures. The government and industry can help ensure the training of the next generation of geothermal professionals by collaborating with local academic institutions to promote continued research and development.

CONCLUSION

Chile has the natural and human resources to become a leader in clean and sustainable energy generation. To do so it must create an appropriate energy policy framework that will help leverage all of its abundant NCRE resources. The new commitment to produce 20 percent of its energy needs by 2025 with NCRE is a good step forward. But in the case of geothermal energy, it will also be necessary to evaluate actions and mechanisms that can address specific hurdles the resource faces. This will help ensure that geothermal eventually contributes to the energy matrix as sustainable base-load power.

To unleash Chile's geothermal potential, it is necessary to carefully consider barriers and policy solutions related to: (1) attracting investment, (2) reducing legal and regulatory issues, and (3) addressing institutional constraints. The stakeholders consulted as part of this analysis expressed varying sentiments with regard to these issues, indicating that it will be necessary to engage in serious and forward-looking dialogue on how to strengthen the role of geothermal power. Policy solutions may be most achievable initially for problems related to financing, given the consensus that high risks and costs can be barriers to development, although there is still no clear consensus as to the strength of particular solutions to these issues. There is less apparent consensus regarding the significance of legal and regulatory barriers, so finding solutions to these issues may be more challenging in the short term. However, these hurdles too must be addressed proactively, in particular with regard to potential community and environmental impacts and public participation. Institutional constraints to geothermal energy, which have ramifications for most other barriers as well, will be corrected when there is sufficient political will to set a clear policy direction for the energy sector that addresses geothermal energy as part and parcel of Chile's future energy matrix.

The following set of actions could help spur geothermal development in Chile.

Actions by Government:

- Provide clear direction for geothermal energy development, and reevaluate institutional support and structure for geothermal development.
- Investigate and encourage establishment of financial incentives or mechanisms to boost geothermal development.
- Reevaluate laws and regulations governing geothermal development—particularly those related to impacts on and engagement of local communities, the concession system, and the time line and requirements for environmental impact studies.

Actions for Developers:

- Ensure transparency with communities near projects.
- Develop industry-wide standards for developing sites near established communities, particularly those in arid northern regions.
- Demonstrate willingness to engage in more thorough preliminary environmental impact studies.

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The research conducted to prepare this issue brief included interviewing members of the Chilean public sector, private companies, and academic institutions. These interviews capture the opinions of the individuals interviewed and not necessarily the official position of the companies, organizations or firms with which they were affiliated. As part of its research, NRDC also consulted with Bloomberg New Energy Finance. NRDC clarifies that the conclusions and recommendations presented in this document reflect solely the views of NRDC.

ENDNOTES

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