Geothermal Energy in Chile

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Chilean Energy Sector
Macroeconomic Overview

• Last 30 years, the Chilean economy has had exceptional performances, and became a member of the OECD in 2010.

• Up to 2013, Chile has signed free trade and tax agreements with over 60 and 25 countries, respectively.

• Poverty was reduced from 50% in 1975 to 11% in 2012.

• Public debt was controlled and systematically reduced.

• In October 2012, the Chilean government issued US$1,500 million of debt in bonds at the best conditions an emerging economy has ever achieved:
  ➢ 10 year bond was issued at a record 2.38% annual rate.
  ➢ 30 year bond was issued at 3.71% annual rate.

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(1) World Bank; (2) United Nations Economic Commission for Latin America; (3) Chilean Ministry Of Finance; (4) Chilean Central Bank
Chilean Energy Sector

Energy Policy

- The basic principles of the present energy policy were defined in Chile in the early eighties.

- Objective: meeting energy demand at the least cost through the operation of competitive (private) energy markets, with a subsidiary role of the State.

- The concepts of diversification and reliability of supply were fostered in 2005 following the natural gas supply curtailments that Argentina started to apply in 2004.

Electricity Market

**Generation**
- No regulated prices
- Market competition
- Energy traders
- Economic optimum
- Centralized dispatch
- PPAs

**Transmission**
- Regulated prices
- Natural monopoly
- Open Access
- Expansion through bidding processes

**Distribution**
- Regulated prices
- Natural monopoly
- Open Access
- Control and standards
Chilean Electric System

Northern Interconnected System (SING)
- Installed Capacity: 3.8 GW
- Peak Demand (2012): 2.2 GW
- 100% Thermal:
  - 49% Coal
  - 42% Natural gas
  - 9% Oil
- Demand: 85% Mining Industry

Central Interconnected System (SIC)
- Installed Capacity: 13.5 GW
- Peak Demand (2012): 7.2 GW
- 53% Thermal
  - 42% Hydro
  - 5% Renewable
- 74% of the national demand
- 92% of population
- 76% of PIB

Aysén
- Installed Capacity 50 MW

Magallanes
- Installed Capacity 100 MW
Electricity generation by fuel - 2012

Electricity production: 65.6 TWh

Installed capacity

1996: 6 GW

2012: 17.5 GW

- Hydro (>20MW): 65%
- Coal: 24%
- Oil: 9%
- Natural Gas: 2%
- Renewables: 4%

- Hydro (>20MW): 65%
- Coal: 24%
- Oil: 14%
- Natural Gas: 26%
- Renewables: 22%
Renewable Energy Opportunities

Chile possesses a unique combination of quality and diversity in its renewable energy potential:

- The Atacama desert receives more annual solar radiation than any other place on earth with a clearest sky.

- Chile has excellent areas for wind energy development.

- Chile is located in a region of the world that has intense seismic and volcanic activity known as the “ring of fire”.

- Chile’s coast stretches 2,653 miles along the pacific, making it a prime candidate for marine energy.

- Chile has the potential to develop large amount of small hydropower from the central to southern regions.

- Rich in bioenergy waste from farming and forestry.

### Renewable Energy Potential

<table>
<thead>
<tr>
<th>Resource</th>
<th>Gross Potential (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small hydro</td>
<td>23</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>10</td>
</tr>
<tr>
<td>Wind</td>
<td>40</td>
</tr>
<tr>
<td>Geothermal</td>
<td>16</td>
</tr>
<tr>
<td>Solar</td>
<td>228</td>
</tr>
<tr>
<td>Marine</td>
<td>164</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>481</strong></td>
</tr>
</tbody>
</table>

Source: CER
## Renewable Energy Today
### Main data

#### Installed Capacity aggregate per year (MW)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Accum. up to 2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2011-2013</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>195</td>
<td>53</td>
<td>144</td>
<td>51</td>
<td>247</td>
<td>442</td>
</tr>
<tr>
<td>Wind</td>
<td>170</td>
<td>34</td>
<td></td>
<td>97</td>
<td>132</td>
<td>302</td>
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<tr>
<td>Small hydro</td>
<td>226</td>
<td>31</td>
<td>19</td>
<td>47</td>
<td>97</td>
<td>323</td>
</tr>
<tr>
<td>Solar</td>
<td></td>
<td></td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>591</strong></td>
<td><strong>118</strong></td>
<td><strong>166</strong></td>
<td><strong>198</strong></td>
<td><strong>481</strong></td>
<td><strong>1,072</strong></td>
</tr>
</tbody>
</table>

#### Technology Operation (MW)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Operation (MW)</th>
<th>Under construction (MW)</th>
<th>Environment assessment approved (MW)</th>
<th>Under environment assessment (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>442</td>
<td>10</td>
<td>106</td>
<td>26</td>
</tr>
<tr>
<td>Wind power</td>
<td>302</td>
<td>490</td>
<td>3,585</td>
<td>1,537</td>
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<tr>
<td>Mini-Hydro</td>
<td>323</td>
<td>76</td>
<td>268</td>
<td>139</td>
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<tr>
<td>Solar</td>
<td>5,7</td>
<td>175</td>
<td>4,860</td>
<td>2,052</td>
</tr>
<tr>
<td>Geothermal</td>
<td></td>
<td></td>
<td>120</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,072</strong></td>
<td><strong>751</strong></td>
<td><strong>8,939</strong></td>
<td><strong>3,754</strong></td>
</tr>
</tbody>
</table>

Source: CER (sep 2013)
New Renewable target
Law 20.698, 2013

• In 2008, Chile promoted the increase of renewable energy share in the energy market through a renewable portfolio standard, to reach 10% by 2024.

• This law excludes hydropower plants larger than 20 MW.

• Recently, in October 2013, the new Law N°20.698, requires that 20% of the energy of new energy contracts comes from non-conventional renewable energy (NCRE) sources by 2025.

• In addition, the law creates a new bidding mechanism for new renewable energy projects, where they can get a stable price for 10 years according to the offer made, with a price cap.

• The new law will require by 2025, approximately 22,700 GWh roughly equivalent to 6,500 MW of renewable projects.
Geothermal energy in Chile

• Chile is one of the largest under-developed geothermal countries in the world.

• The geothermal systems in Chile are associated with volcanos.

• Over 15 percent of the world’s active and dormant volcanoes are in Chile, forming an almost continuous line about 4,000 km long. As a result, over 300 geothermal areas have been identified throughout the country.

• The geothermal-resource potential of Chile may reach 16,000 MWe, according to preliminary estimates.
Geothermal energy in Chile - Regulation

• Law No. 19,657 on Geothermal Energy Concessions, published on January, 2000; governs the granting of permits or concessions, by the government to geothermal developers.

• Rules of procedure for the implementation of Law, contained in Decree N° 32 – 2004 (by-law).

• In March 2013, a new regulation was approved (Decree N°114 - 2013), to streamline the concession process for geothermal projects and provide developers with long-term certainty over development rights.
Geothermal energy concessions

1. **Exploration**: Gives the developer the right to carry out exploratory work to determine geothermal potential.
   - Duration: 2 years extendable for 2 more.
   - Maximum area: 100,000 ha.

2. **Exploitation**: Awards the developer the right to carry out all the activities required for a geothermal energy generation plant, including drilling, construction, commissioning and operation of an extraction system; the production and processing of geothermal fluids in electrical or thermal energy.
   It confers the right to utilise the geothermal energy that exists within its boundaries.
   - Duration: indefinite.
   - Maximum area: 20,000 ha.
# Geothermal energy concessions

<table>
<thead>
<tr>
<th>Status</th>
<th>Quantity</th>
<th>Hectares</th>
<th>Commitment US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration Concessions</td>
<td>79</td>
<td>3 million</td>
<td>380 million</td>
</tr>
<tr>
<td>Exploitation Concessions</td>
<td>7</td>
<td>38,000</td>
<td>1160 million</td>
</tr>
</tbody>
</table>

**EXPLORATION CONCESSIONS**
Lifetime & Exploration wells drilled

- **14%**
  - 0-2 Yr
  - 0 wells

- **35%**
  - 2-4 Yr
  - 7 wells

- **51%**
  - 4-6 Yr
  - 11 wells
Geothermal concessions by area

3 million hectares in exploration stage

- Colpitas
- Puchuldiza
- Apacheta
- El Tatio
- Tinguiririca
- Chillán
- Lagun del Maule
Geothermal exploration concessions by company
Geothermal main projects

Cerro Pabellón (Apacheta concession), ENEL GP

- Environmental approval.
- 2 production wells (1800m, 245°C) + 2 injected wells + 1 slim hole (700m, 210°C)
- Estimated capacity: 50 MW (2018)

Source: Enel Green Power
Geothermal main projects
Curacautín (San Gregorio concession), MRP Chile

- Environmental approval.
- 2 production wells drilled (2500m, 290° C) + 4 slim hole (1100m, 300° C).
- Estimated capacity: 70 MW (2018)

Source: Mighty River Power
Geothermal main projects
Energía Andina (Origin Energy + Antofagasta Minerals)

Drilling Exploration

1) Tinguiririca
   1 Gradient 813 m core slim Hole (240 °C steam)

2) Pampa Lirima
   4 Gradient conventional slim holes 300 m
   1 Core Slim Hole 1,500 m

3) Colpitas
   1 conventional slim hole 1,007 m

4) Juncalito
   Drilling conventional slim hole

5) Puntas Negras
   Drilling conventional slim hole

Source: Energía Andina
### International Financing and Cooperation

Clean Technology Fund – Geothermal Risk Mitigation Program (MiRiG)  
([https://www.climateinvestmentfunds.org/cifnet/country/chile](https://www.climateinvestmentfunds.org/cifnet/country/chile))

#### Table 5: Chile Revised CTF Financing Plan (2013) (USD million)

<table>
<thead>
<tr>
<th>Financing source</th>
<th>Component I (CSPP)</th>
<th>Component II (LSPVP)</th>
<th>Component III (RESSEE)</th>
<th>Component IV (RESSEE Prep Grant)</th>
<th>Component V (MiRiG)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTF loans and grants</td>
<td>67</td>
<td>50</td>
<td>49</td>
<td>1</td>
<td>33</td>
<td>200</td>
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<tr>
<td>GoC</td>
<td>20</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>14.5</td>
<td>54.5</td>
</tr>
<tr>
<td>IDB loans</td>
<td>125</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>275</td>
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<tr>
<td>IDB’s Canadian Fund loan</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
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<tr>
<td>IBRD grants</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td>IDB grants</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>GEF</td>
<td>0</td>
<td>0.6</td>
<td>2.8</td>
<td>0</td>
<td>0</td>
<td>3.4</td>
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<td>IFC loans</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Bilaterals (KfW &amp; LAIF)</td>
<td>148.6</td>
<td>295</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>443.6</td>
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<tr>
<td>Other private sector</td>
<td>109.4</td>
<td>274.4</td>
<td>250</td>
<td>0</td>
<td>200</td>
<td>833.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>501</td>
<td>720</td>
<td>421.8</td>
<td>1</td>
<td>298</td>
<td>1,941.8</td>
</tr>
</tbody>
</table>

Co-financing figures to be revised at the time of program design.
Geothermal Challenges in Chile

• The high altitudes and arid environment of the north create logistical difficulties for the location of camps and the extraction of industrial sites.

• On the other extreme, the glacial morphology of the south complicates access and there is also a limited window of time when work can be carried out.

• High exploration cost, in Chile these costs become even more expensive given the absence –at this moment- of a consolidated geothermal industry.

Investment cost per unit 5,100 – 6,000 US$/kW

- Investment cost
  - Surface exploration: 43%
  - Drilling: 46%
  - Construction: 9%
  - Roads: 2%
Geothermal Challenges in Chile

• Companies need to find big resources that can justify long transmission lines.

• Access to the electricity markets (PPAs).

• Geothermal risk mitigation instruments.

• Geothermal security regulations for drilling.
  ➢ Technical collaboration from countries and institutions with the experience.

• Capacity building and communications on geothermal energy.
  ➢ To the community.
  ➢ To the public services involved in the environmental evaluation.
Global Geothermal Development Plan Roundtable
The Hague, Holland
November, 2013

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