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Technical- and market barriers to cost effective geothermal drilling

Case study on Chile

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Trust

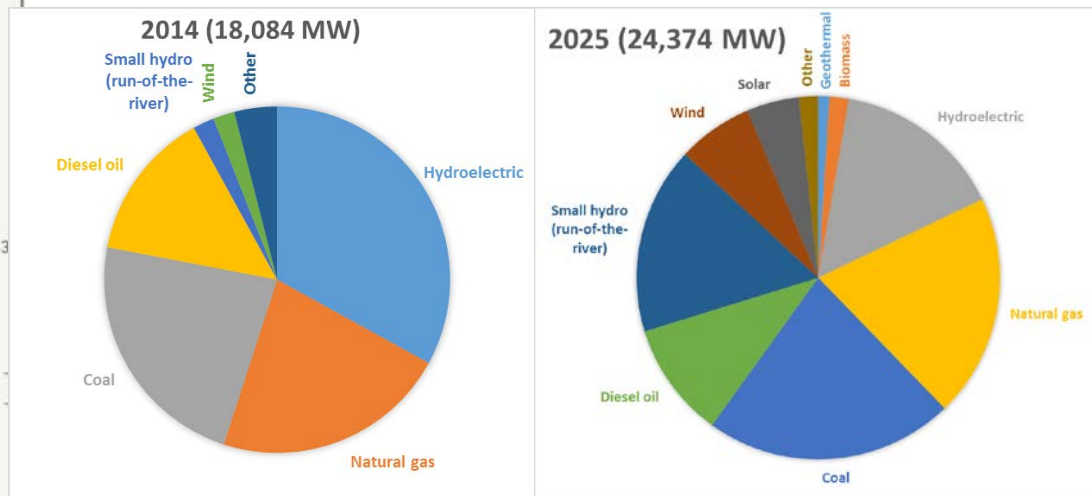
Open-mindedness

Knowledge

Well-being

Energy Market in Chile

- Present status & goals



- Geothermal potential is ~3350 MWs
- Current electricity price for long term PPA around 50-70 USD/MWh and expected to be in the range of 50-100 USD/MWh depending on bilateral negotiation.
- Renewable energy from 37 to 46% of the energy matrix.
- Geothermal from 0 to 1% of the energy matrix.
- Translates to 244 MW of installed geothermal capacity in year 2025.
- Long term goal for year 2050 to have renewable energy in 70% of the energy matrix. Of that geothermal is planned in the range of 178 – 3.310 MW.

Geothermal Industry in Chile

- Status of development (Dec. 2015)
 - 74 exploration rights
 - 9 exploitation rights
 - 1 project with PPA
 - Cerro Pabellón (Empresa Geotermica del Norte / ENEL)

- Geothermal projection scenario 2050
 - Energy Policy 2050 gives a wide range: 178 – 3.310 MW

Geothermal Projection scenario for year 2050 ⁽¹⁾	Average MW per year ⁽²⁾	Drilled wells ⁽³⁾ Average per Year / Total number of wells in 2050	Average Investment ⁽⁴⁾ 2016-2050 US\$ million
278	8	2 / 58	1,946
814	24	5 / 170	5,670
970umin	28	6 / 202	6,790
1,340	38	8 / 280	9,380

Note:

- 1: Scenario from the Waybill 2050.
- 2: Average MW to come online per year for the period 2016–2050.
- 3: 6 MW per well; 1 reinjection well every 4 producers; ; failure wells not included
- 4: Assumption for the investment per MW (optimistic for Chile): US\$ 7.0 million per MW

Barriers?

- History
 - Geothermal development in stages since 1920s
 - New geothermal law since 2000
 - Still no geothermal MWs online
- Sporadic development connected to public policies
- Type of barriers
 - Financial
 - Technical
 - Regulatory
 - Labor
 - Geographic
 - Environmental
 - Social

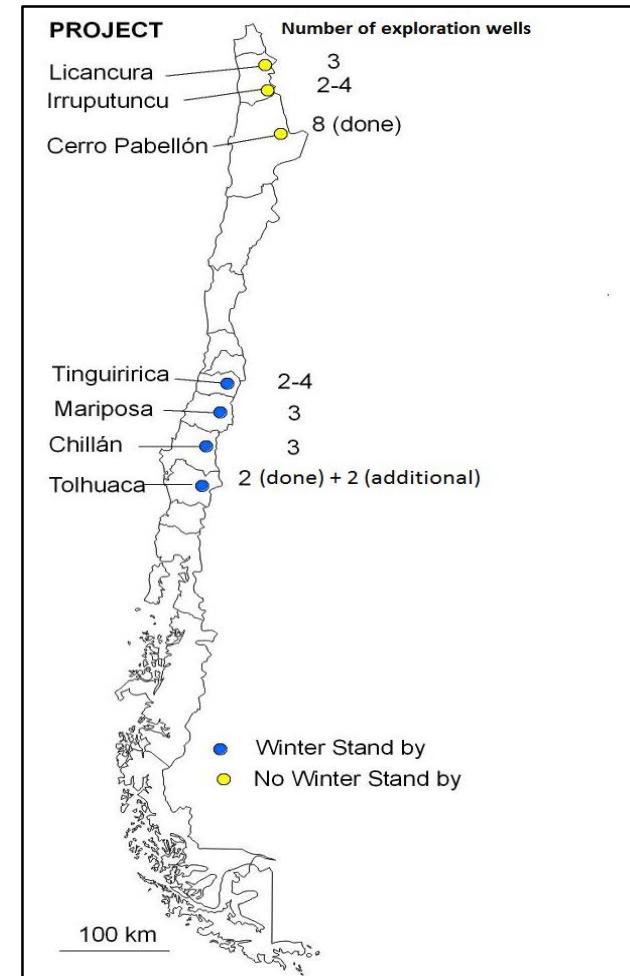
Barriers

- Financial
 - Achieving PPA
 - Profitability of geo projects
 - High CAPEX of wells
 - Electricity price
 - No incentives, like tax reductions
 - High risk of capital makes project funding challenging
- Technical
 - Rig availability
 - Lack of service providers
 - Low interest in drilling contracts for few wells
 - Infrastructure e.g. connection to grid
 - Operation of machines in high altitude



Further Barriers

- Regulatory and Labor Barriers
 - Long permitting process
 - Lack of qualified staff in institutions
 - Lack of experienced developers
 - Lack of experienced rig crews
 - Altitude sickness
- Geographic, Environmental and Social Barriers
 - Remote areas
 - Long transport route
 - Difficult access
 - Severe winter conditions
 - Local opposition to GEO development



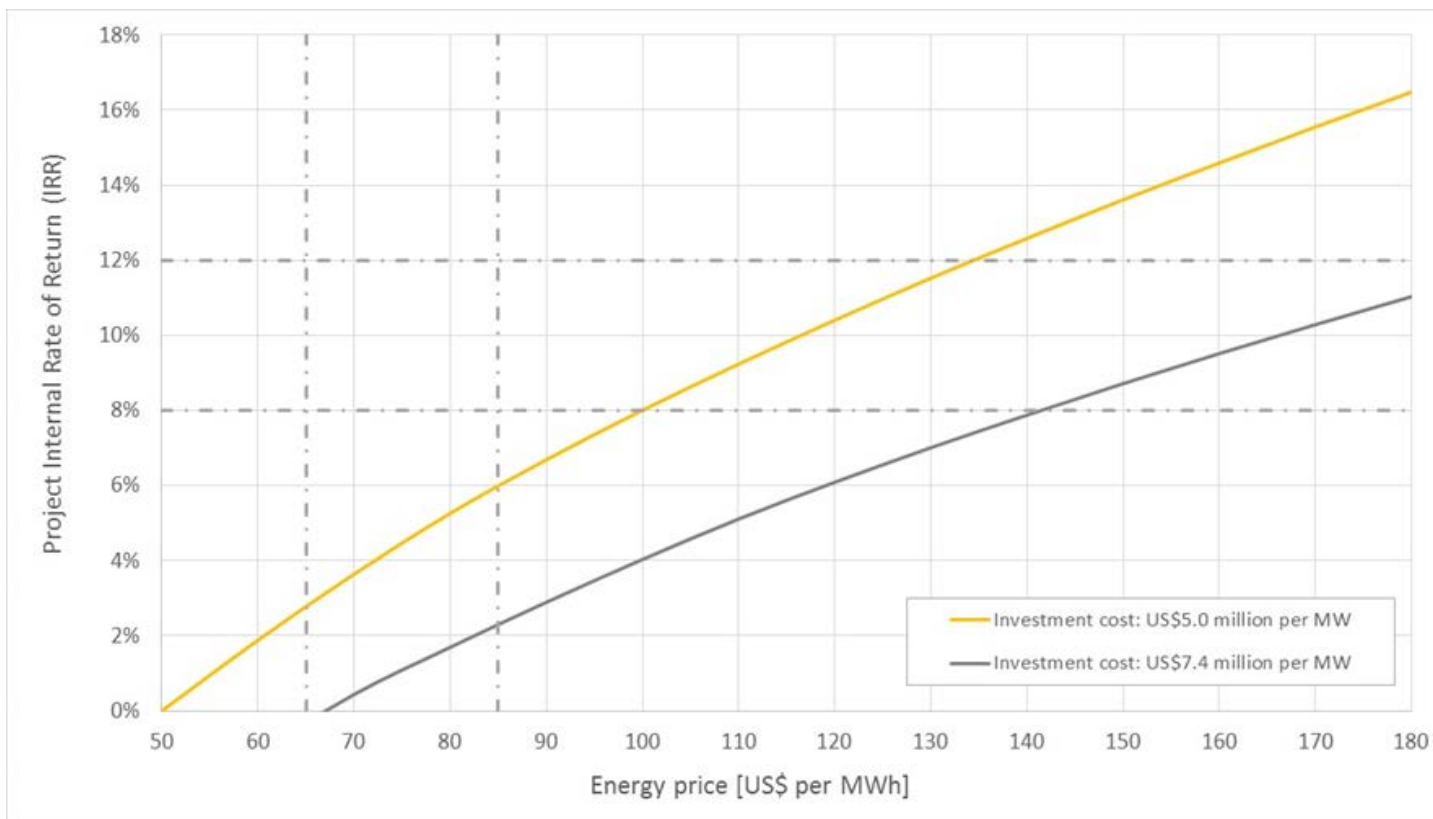
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Closing the gap



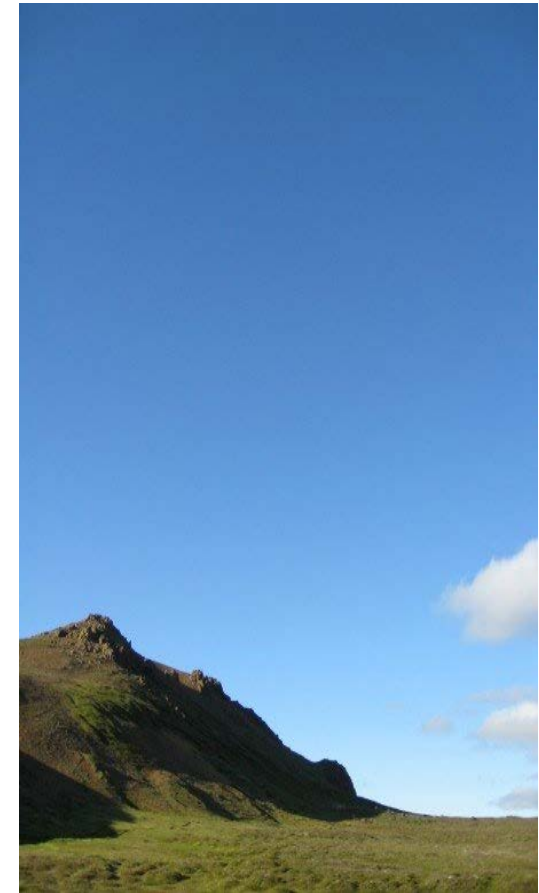
Industry role during drilling phase

- Find ways to lower CAPEX
 - Design
 - Construction
 - Effective tendering
 - Bulk procurement
 - Consider contract form
- Careful planning for local conditions
 - Remote locations, altitude
 - Winter conditions
 - Regulation and permits



Government role during drilling phase

- Strengthen development framework e.g. permits, laws and regulations and their implementation
- Analysis and practice of:
 - Public drilling company
 - Super Single Rig Type
 - Financial tools to “close the gap” for developers
 - Tax incentives (e.g. VAT)
 - Risk mitigation fund
 - Cost sharing e.g. investment in first unit, infrastructure
 - Loan guarantees



Wrap up

- All investigated successful geothermal countries invested public funds
- A few central located easy access projects developed by private efforts
- Challenges such as low enthalpy or remote sites can render the opportunity unfeasible due to high CAPEX, in case of Chile: 7 MUSD/MW (average)
- Without a model showing positive cash flow, and thus a PPA, developers are not willing to start confirmation drilling
- Exploration phase thus connects to project profitability
- A mix of ways is necessary if the gap is to be bridged
- To fulfill the Energy Agenda and Energy Policy 2050 public investment will be necessary
- Work in progress with the Ministry of Energy to find possible ways.

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