Chilean case study: marine energy roadmap

Hydrokinetic energy workshop

Brasilia, 27th April 2016

Tom Wills IEng, Senior Consultant, Aquatera
Aquatera’s history in Chile

2008
• Managing Director Gareth Davies travels to Chile and establishes first collaborations

2009
• Chilean delegation visit Orkney

2011
• Director Ian Hutchison visit to Magallanes

2011 - 2014
• First commercial contracts:
  o HydroChile Orkney visit and Aquatera workshop
  o Marine energy infrastructure study for ENDESA
  o Recommendations for Chile’s marine energy strategy
  o Technology development support with Maestranza Diesel

2014 - 2016
• Tidal energy market study for OpenHydro DCNS
• Salmon farm energy study with Austral University and AlbaTERN
• Renewable energy training for remote communities in Los Lagos
• Local representation for international technology developers
• Activities elsewhere in Latin America (Colombia, Barbados, Brazil)
Recommendations for Chile’s marine energy strategy: a roadmap for development

The study was funded by the British Embassy in Santiago and developed in partnership with the Chilean Ministry of Energy and Renewable Energy Centre.

Aquatera collaborated with a team of local partners who provided specialist insight in areas including oceanography, marine resources, port capacity, electricity markets and financial support measures:
Chilean Government strategy (2013)

“The Chilean Government recognises the importance of developing renewable energy sources from Chile’s extensive marine resource in order to improve security of supply and mitigate climate change effects whilst contributing to the economic and industrial development of the nation.

To guarantee the maximum economic benefits associated with the use of the country’s marine energy resources, the Chilean Government wishes to establish a “Development Strategy for Marine Renewable Energy” which will allow the country to support the growth of the sector and take an active role in the development of marine energy in Chile’s territorial waters”

(Chilean Ministry of Energy, 2013)

The following strategy pillars were defined and guide the structure of Aquatera’s final report:

- I: Regulatory Framework
- II: R&D+i
- III: Infrastructure and Supply Chain
- IV: Finance
- International Cooperation
The project included:

- A programme of regional consultation events in 9 of Chile’s 15 regions.
- Input from > 200 stakeholders from government, academia and industry.
- 11 new marine energy maps.
- The development of 58 specific recommendations to enable and support marine energy in Chile.
Background: Chile’s power supply

Power generation and marginal cost (SIC-SING)

Based on information from the National Energy Commission (CNE)
Why marine energy?

Previous Chilean studies:

- Preliminary site selection, Garrad Hassan (2009)
- Marine energy development, Errazuriz & Asociados, University of Edinburgh (2012)
Chilean electricity networks

SING
(Sistema Interconectado del Norte Grande)

SIC
(Sistema Interconectado Central)

SEA
(Sistema Electrica de Aysen)

SEA
(Sistema Electrica de Magallanes)

Source: CIFES / Chilean Ministry of Energy
Electricity grid access
Regional resources

Sources: CDEC-SING; CDEC-SIC; Baird & Associates
- Chile measures over 4,000km from north to south: equivalent to the distance between Norway and Nigeria.

- Chile’s fifteen regions have very different energy resources and energy markets.
## Norte Grande

<table>
<thead>
<tr>
<th>Technology</th>
<th>Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>kW-scale tidal (off-grid)</td>
<td></td>
</tr>
<tr>
<td>MW-scale tidal (grid-connected)</td>
<td></td>
</tr>
<tr>
<td>kW-scale wave (off-grid)</td>
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<td>Desalination and water pumping for the mines</td>
<td></td>
</tr>
<tr>
<td>Energy for remote communities</td>
<td></td>
</tr>
<tr>
<td>Aquaculture (salmon)</td>
<td></td>
</tr>
</tbody>
</table>

### Key:
- **Good potential**
- **Some potential**
- **No potential**

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### CHILE

**Norte Grande**

[Map of Chile with Norte Grande highlighted]

**Key:**
- Potencia instalada: 4600MW (25% capacidad del país)
- Máx. demanda: 21690MW
- Generación anual: 16,877TWh
- Población: 6.25% del total

**Iquique**
- 2GW Recursos undométricos
- 205GW/Mot Clima de oleaje promedio
- Generación anual: 997TWh
- Población: 9.22% del total

**Antofagasta**
- 12.7GW Recursos undométricos
- 22.7GW/Mot Clima de oleaje promedio
- Generación anual: 165GW
- Población: 165GW

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**SING sistema eléctrico**

- Potencia instalada: 4600MW
- Máx. demanda: 21690MW
- Generación anual: 16,877TWh
- Población: 6.25% del total

**SIC Sistema eléctrico**

- Potencia instalada: 135GW
- Máx. demanda: 669MW
- Generación anual: 997TWh
- Población: 92.2% del total
Los Lagos

<table>
<thead>
<tr>
<th>kW-scale tidal (off-grid)</th>
<th>MW-scale tidal (grid-connected)</th>
<th>kW-scale wave (off-grid)</th>
<th>MW-scale wave (grid-connected)</th>
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- Device fabrication
- Community desalination
- Desalination and water pumping for the mines
- Energy for remote communities
- Aquaculture (salmon)

**Key:**
- Good potential
- Some potential
- No potential

**CHILE**

CHILE
Los Lagos

Key:
- Good potential
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Map showing potential areas with different colors indicating potential for tidal and wave energy.
# Magallanes

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<td>Some</td>
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<td>kW-scale wave (off-grid)</td>
<td>No</td>
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The mining industry consumes ~80% of the electricity generated.

Water scarcity means desalination and water pumping attractive.

Wave energy would compete with – or complement – solar power.
Central Electricity Grid (SIC)

Installed generation capacity compared to marine energy resources

- Huge potential for scale grid-connected wave and tidal power projects.
• 87GW wave resource dwarfs national demand but very difficult to exploit

• Tidal resource exceeds local demand and could be used now

• There are also some interesting smaller tidal streams in Aysén
Permits and Concessions

- A manual for project developers was proposed to outline the permits and processes that marine energy projects require in Chile.

- The potential for reducing the number of licences required and regulators involved was considered.

- A lot of permits can be needed in Chile, but they may be easier to obtain than in other markets such as the EU.
Marine planning

Right hand map source: Marine Scotland
Chile’s Marine Energy Research & Innovation Center (MERIC) was set up in 2015 and will play a crucial role in supporting and leading projects.

Graphic based on Carbon Trust, Accelerating Marine Energy, 2011
Market niches (mining)

<table>
<thead>
<tr>
<th>Company</th>
<th>Operation</th>
<th>Feedwater</th>
<th>Capacity (m³/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHP Billiton</td>
<td>Coloso plant at Escondida</td>
<td>Desalinated water</td>
<td>45,360</td>
</tr>
<tr>
<td>++ Minerals</td>
<td>Michilla Mine</td>
<td>Direct use of seawater for leaching purposes</td>
<td>6,500</td>
</tr>
<tr>
<td>Antofagasta Minerals</td>
<td>Esperanza</td>
<td>Direct use of seawater for copper flotation</td>
<td>62,200</td>
</tr>
</tbody>
</table>

*Source: (GWI, 2011)*

There are a number of niche markets within marine energy which have received comparatively little attention to date where Chile (or Brazil) could take a leading role.
Market niches (salmon farming)

- Typical salmon farm has ~200kW generation capacity

- Diesel costs ~US$ 13,000 per month

- Salmon farms typically located in protected areas, but some wave and tidal power companies are specifically targeting these sites:
  
  **WaveNET** cut-in @ ~0.3m Hs
  
  **Minesto** cut-in @ ~1m/s current

Source: Universidad Austral
Research, Development and Innovation (RD&I)

• RD&I effort needs to reduce technology risk and lower costs

• Coordination with international developments important alongside support for Chilean technology developers.

• Technology will need to be adapted to Chilean conditions:
  o Highly energetic and consistent wave energy regime
  o Steeply sloping seabeds
  o Earthquake and tsunami risk

• There are niche markets where Chile has a natural advantage or large market:
  o Wave powered desalination (for communities and the mines)
  o Seawater and fresh water pumping for the mines
  o Community scale systems for isolated areas
  o Aquaculture projects
Wave and tidal development scenarios

**Deployment scenario**: some enabling adjustments to the regulatory system are implemented and R&D+I activity is supported by MERIC and pilot projects.

→ **1,200 jobs and USD 0.4bn invested by 2030**, limited technology development in Chile

**Development scenario**: greater support for pre-commercial projects i.e. market niche projects in the short term and a 10 – 30MW grid connected demonstration by early 2020s.

→ **3,000 jobs and USD 1bn invested by 2030**, active role in tech. development

**Accelerated development scenario**: extensive support is made available for multiple pre-commercial farms, e.g. regulatory changes to fast-track projects and a feed-in tariff.

→ **4,500 jobs and USD 1.5bn invested by 2030**, Chile plays a leading role
Summary

• Chile is one of the best places in the world for wave energy and has a number of attractive tidal power sites.

• Imported technologies will still need to be adapted to Chilean conditions.

• Market niches such as aquaculture, remote communities and mining water supply may be commercially viable before grid-connected projects.

• Specific regulatory changes can enable projects by removing barriers and streamlining processes.

• Funding pre-commercial deployments would support projects and help a country play a leading role in marine energy technology development, creating more jobs and investment.

- Aquatera’s final report identifies 58 specific recommendations across government, industry and academia which were developed in collaboration with more than 200 Chilean stakeholders.
Obrigado

For any further enquiries please contact tom.wills@aquatera.co.uk

Aquatera’s Chilean roadmap report is available online: