

# **Chile's Marine Energy Strategy – a Roadmap for Development and Funding Needs**

**ADEMAR , AEPA, Birchman**

ECLAC – January 15th 2014

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# Visión

- Chile es el Arabia Saudita en reservas de Energía Marina.
- Esto nos obliga a hacernos algunas preguntas:
- Chile quiere explotar esta reserva, o la va a dejar oscilando improductivamente?
- Si la va a explotar, va a ser un simple seguidor de tecnología?
- O va a aprovechar esta ventaja competitiva para construir una industria tecnológica de despliegue global?

# ADEMAR: Asociación de Energía del Mar



- Baird
- EAI
- Proconsa
- Endesa Renewables
- BZ Naval
- On-energy
- Birchman Group
- Siemens
- Hidrochile
- Aquatera
- Wilefko

- Aguas Andinas
- KDM (Urbaser)
- Cristalerías Toro
- SK Ecología
- DCNS Chile
- Proyectos Vision
- ETYMOL
- Andritz Hydro
- Natural Power
- Inria

## Institutional:

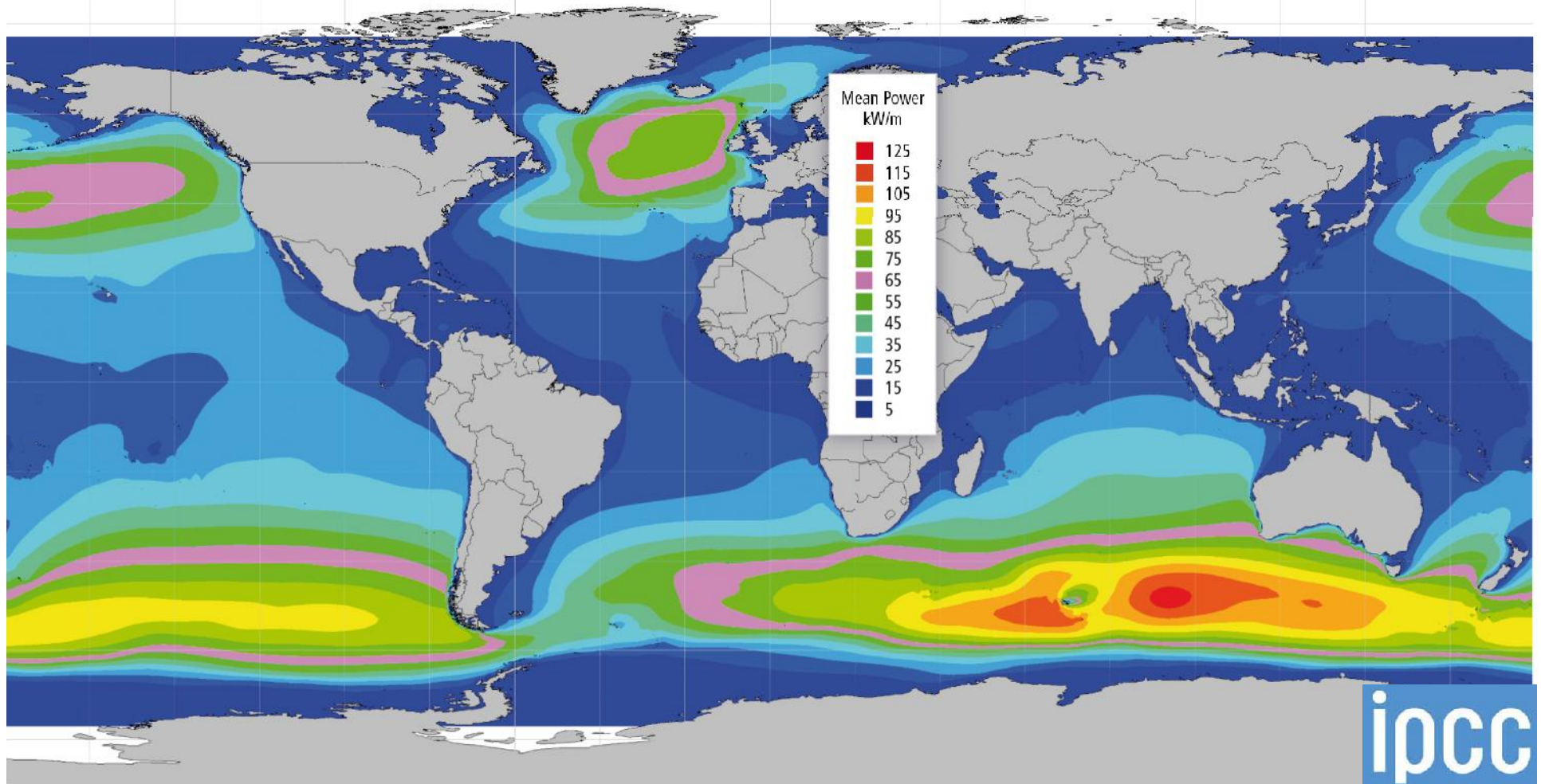
- CER
- CORFO

# Qué es Energía Marina?

La energía marina se puede **definir** como la **energía que se genera a través de tecnologías que explotan los movimientos del agua, su gradiente de temperatura o su gradiente de salinidad.**



La **Energía Undomotriz** se genera por la transferencia de energía kinética del viento a la superficie del mar. El **recurso teórico** de energía Undim.en Chile se estima **en 32,000 TWh/yr** (115 EJ/yr), el doble que toda la energía eléctrica global en 2008.



# Potencial de recursos ERNC en Chile

Tecnología ERNC	Potencial Optimista [MW]	Potencial Conservador [MW]
	a	b
Hidroeléctrico (1)	23.000	20.400
Geotermia (2)	16.000	3.300
Biomasa (3)	13.700	470
Biogás (4)	400	400
Minihidro (5)	1.400	1.400
Eólica (6)	40.000	7.200
Solar (7)	228.000	100.000
Undimotriz (8)	240.000	164.000
Mareomotriz (9)	800	600
<b>Total</b>	<b>563.300</b>	<b>297.770</b>

(1) (a) CNE/ (b) Estudio UTFSM 2008: Estimación de potenciales brutos al 2025, publicado por ACERA.

(2) (a) ENAP 2005/ (b) Estudio A Lahsen 1986

(3) (a) Estudio CNE-GTZ 2008 (Residuos de manejo forestal) / (b) Estudio UTFSM 2008: Estimación de potenciales brutos al 2025.

(4) (a) Estudio CNE-GTZ 2007

(5) (a) Estudio CNE, CNR y MEN 2007- 2010: Potencial teórico bruto en de obras de riego existentes entre Atacama y Araucanía. No considera derechos no consuntivos.

(6) (a) Elaboración Propia MINEN 2011 en base a explorador eólico solar aplicado sobre Región de Antofagasta (con 30 Ha/ MW)/ (b) Estudio UTFSM 2008: Estimación de potenciales brutos al 2025.

(7) (a) Estudio CNE 2009 Potencial en Regiones Arica y Parinacota, Tarapacá y Antofagasta, (con 2 Ha/ MW)/ (b) Estudio UTFSM 2008: Estimación de potenciales brutos al 2025.

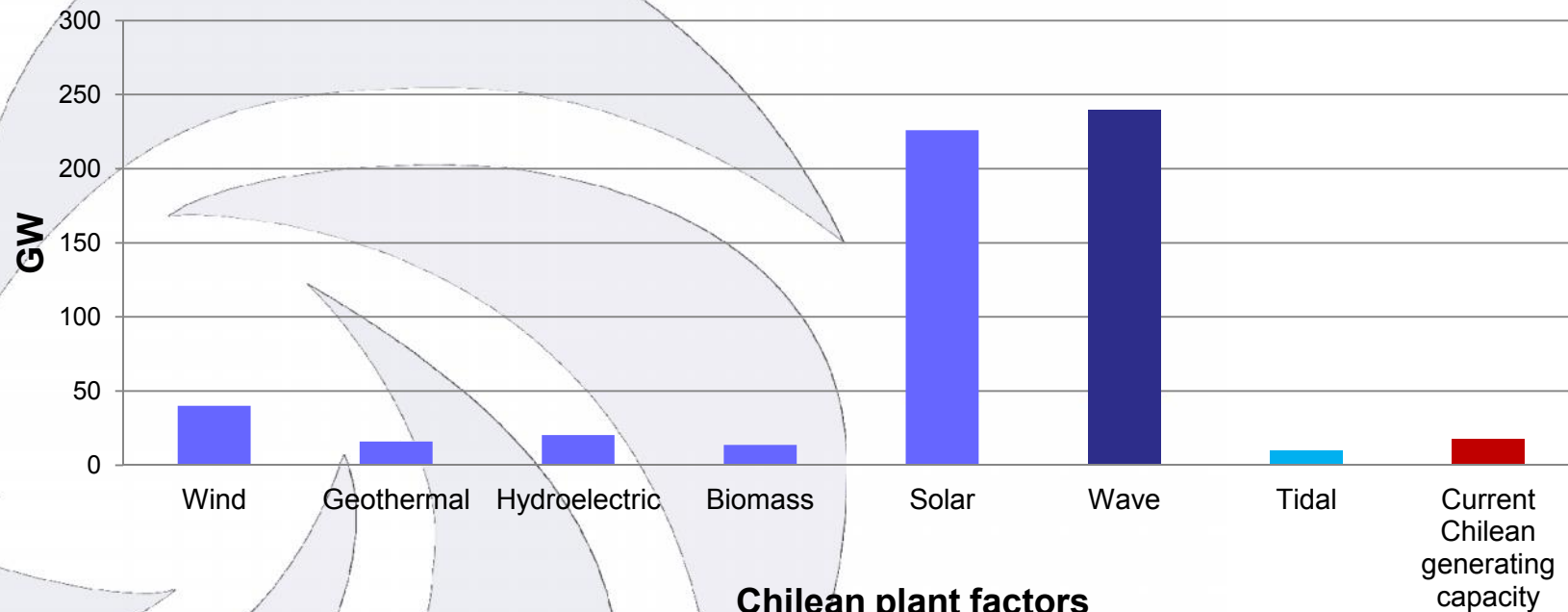
(8 y 9) (a) Estudio Garrad Hassan 2009

(8 y 9) (b) Baird & Asociados

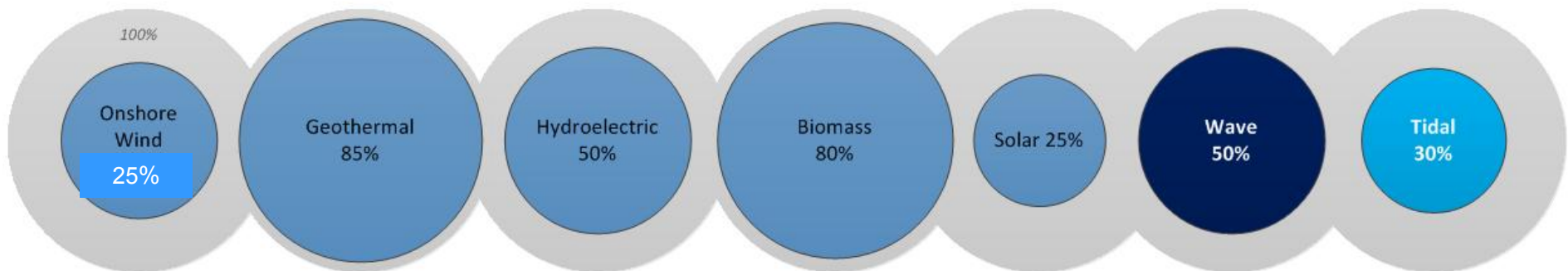
Rodrigo  
García (CER)

# Por qué energía marina?

Chilean renewable energy resources  
and total installed generating capacity (including non-renewable)



Chilean plant factors



Aquatera (2013/2014)





Es energía de las  
corrientes...



...y de las olas



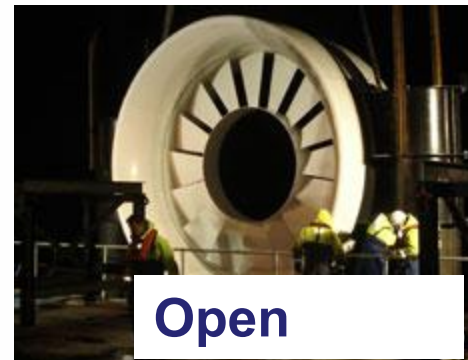
# Energía marítima - tecnologías



**Pelamis**



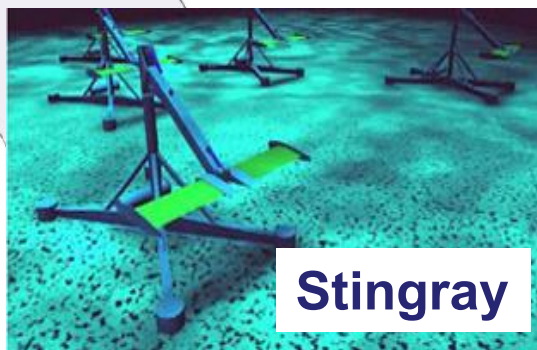
**Lunar Energy**



**Open Hydro**



**Sperboy**



**Stingray**



**TiDE**



**Atlanti**



**Seagen**



**Wavegen**

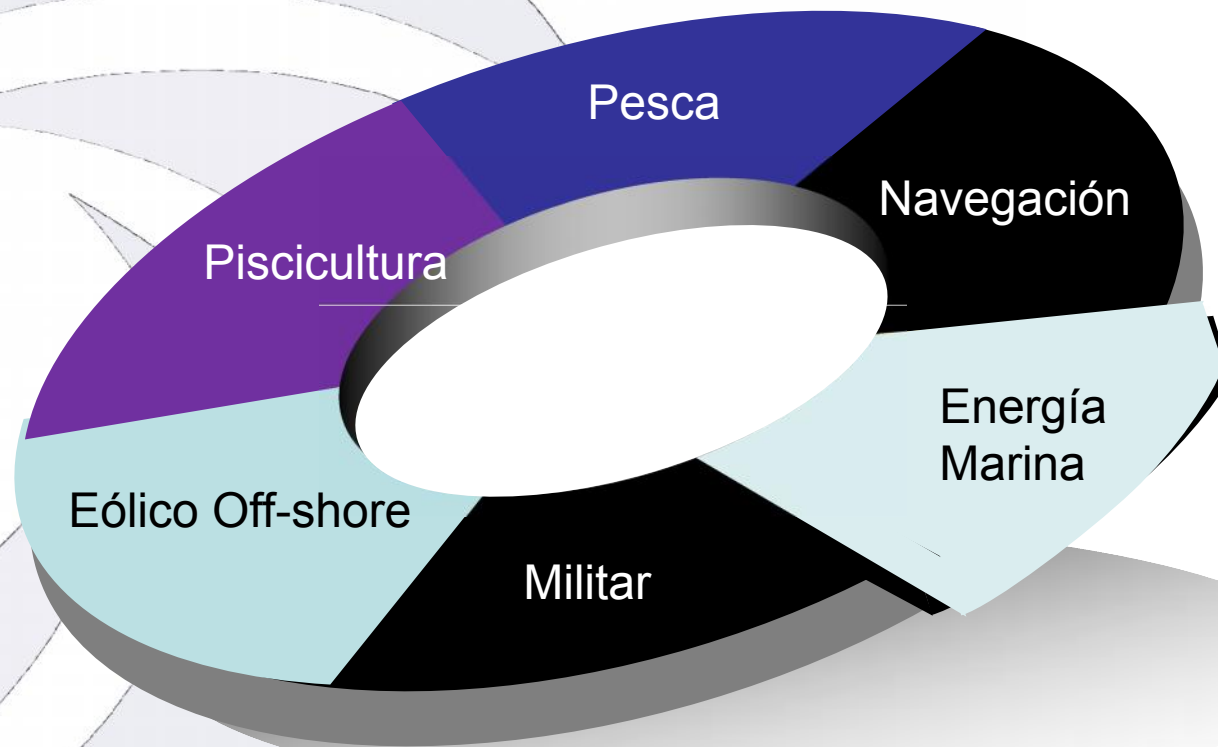


**Aquamarine**





# Desafío: Tiene que encajar en un manejo integral del borde costero

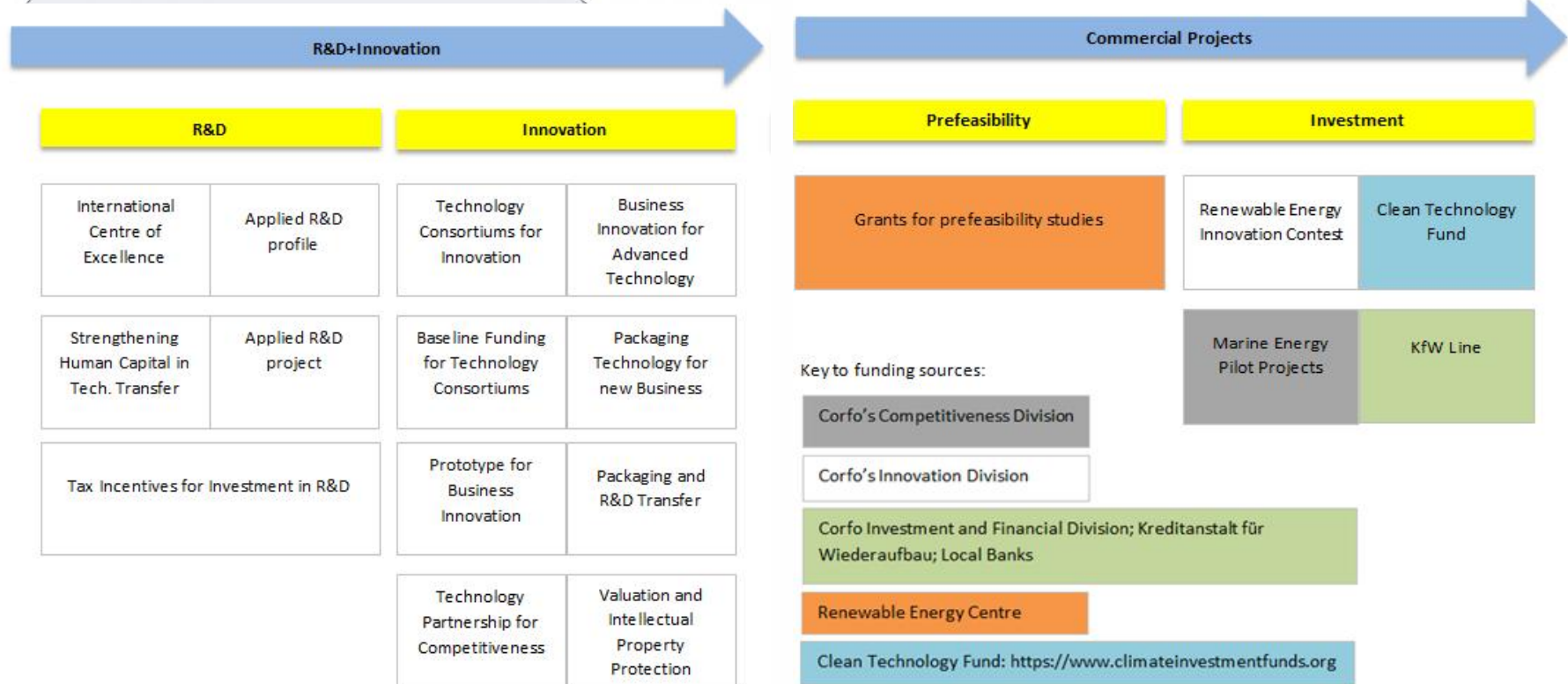


# Overview – update on Chilean marine energy development

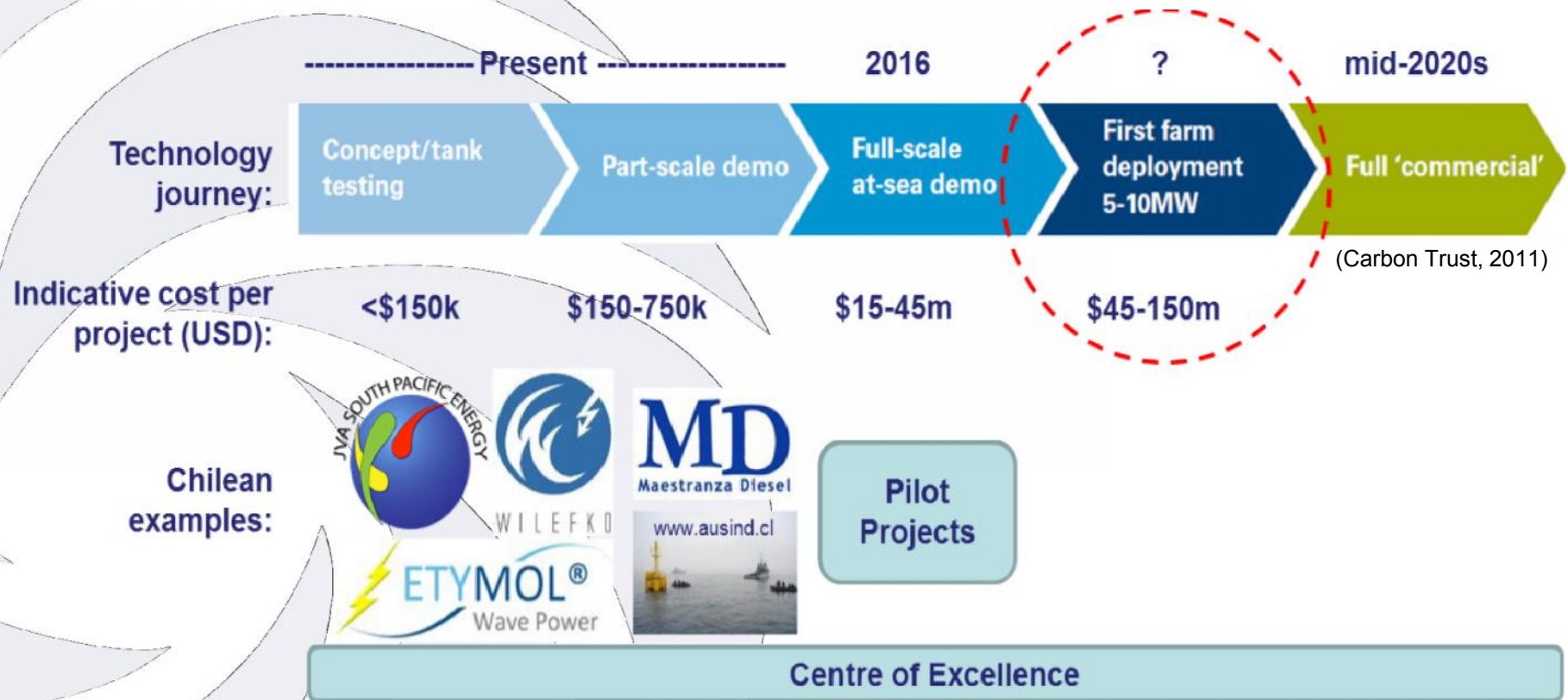
## Key points:

- Reference studies – Garrad Hassan; Baird; Errazuriz/University of Edinburgh; Aquatera
- Industry association ADEMAR; Universities; Technology developers
- Significant increase in government support over the last year: over US\$ 26m of funding announced for:
  - Centre of excellence
  - Wave and tidal pilot projects
  - Regulatory study
  - Environmental impact assesment guide
  - Infrastructure study

# Finance – existing funds



# Finance – the funding gap



# Ministry of Energy - marine energy strategy

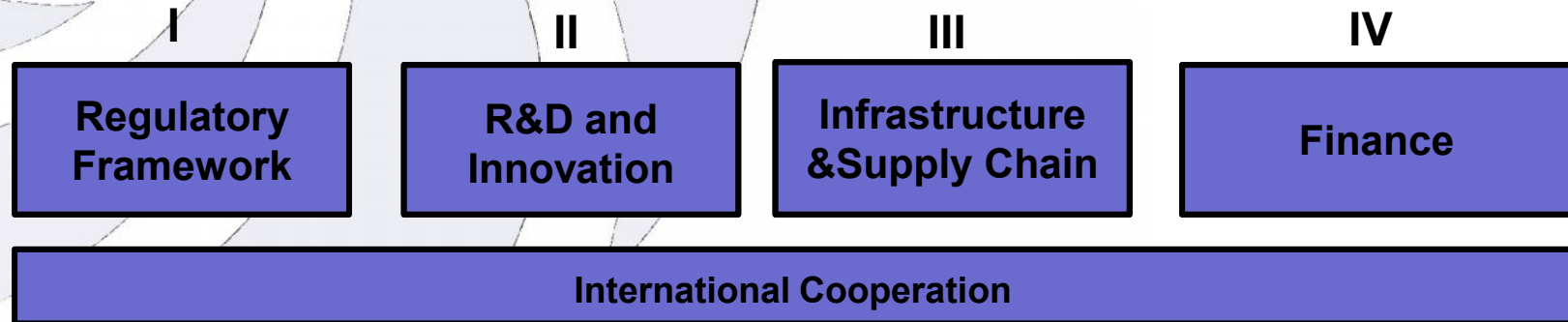
## Vision statement

*“The Chilean Government recognises the importance of developing renewable energy from Chile’s extensive marine resources, 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”*

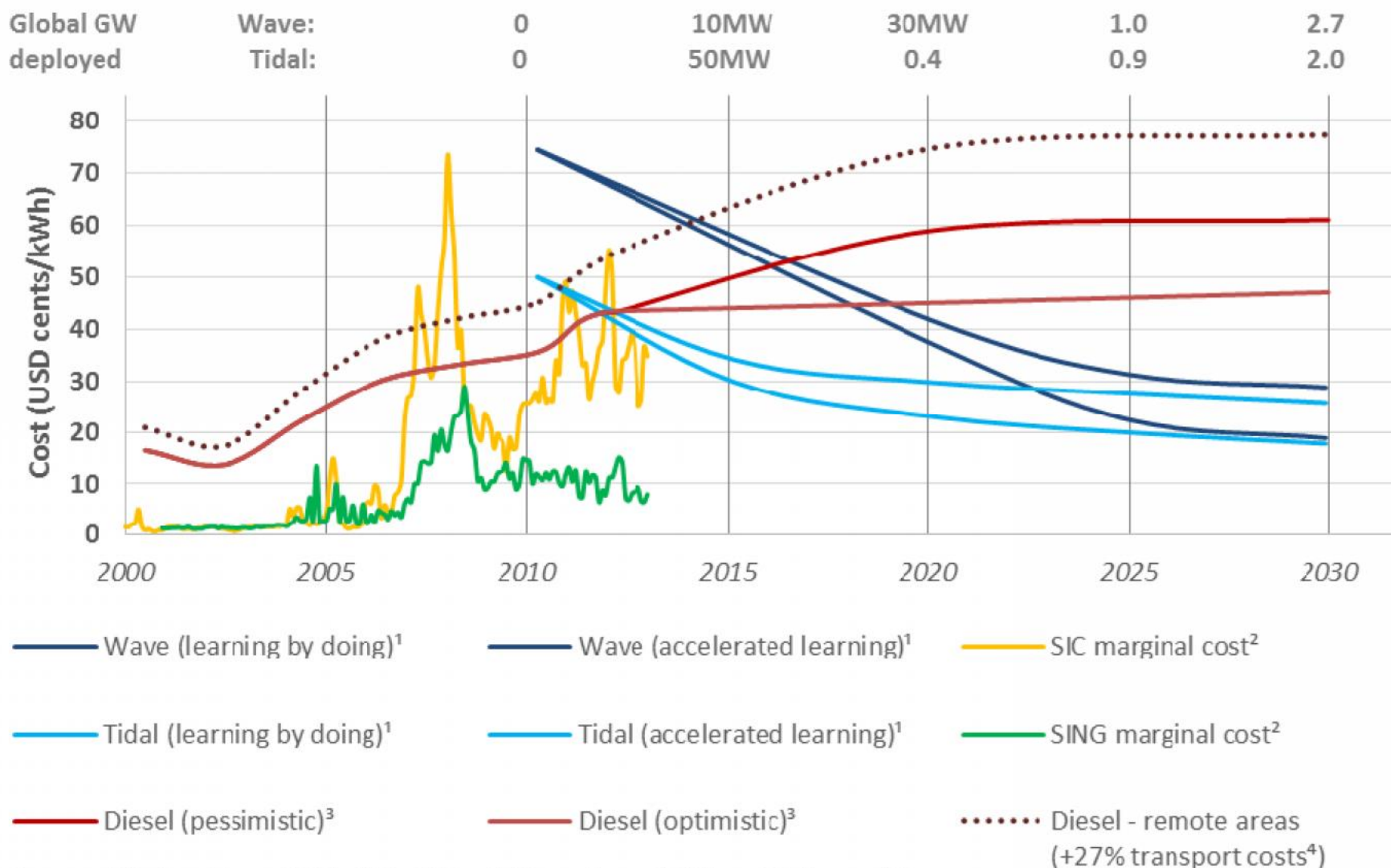


## Strategy pillars





# Finance



Sources: <sup>1</sup>Carbon Trust; <sup>2</sup>CER; <sup>3</sup>World Bank/Bloomberg; <sup>4</sup>Chilean Ministry of Energy

# Finance - recommendations

Recommendation:

The **Ministry of Energy** should consider introducing a **financial support mechanism** to support the **first pre-commercial farms of grid-connected** wave and tidal energy devices in Chile. This would help maintain the level of marine energy activity in the country until large scale grid connected projects become commercially viable, and would help Chile to take an active role in marine energy development.

Recommendation:

The **Ministry of Energy** in partnership with the **Regional Governments** should consider developing a financial support instrument specifically for **off-grid marine energy projects in remote areas** where energy costs are high. This would help maintain the level of marine energy activity in the country until large scale commercial projects become viable, and would also allow Chile to take the lead in a market area which has to date comparatively little support. They may wish to establish mechanisms to change the diesel subsidies for renewable energy subsidies.

Recommendation:

The **Ministry of Energy** in partnership with the **Ministry of Mining** should consider developing a financial support instrument specifically for **wave-powered water pumping and desalination** projects for the **mining industry**. This would help maintain the level of marine energy activity in the country until large scale commercial projects become viable, and would also allow Chile to take the lead in a market area which has to date comparatively little support.

Recommendation:

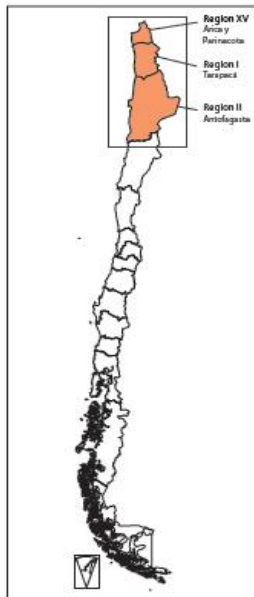
The **Ministry of Energy** may wish to consider the introduction of measures which **reduce the risk of financing marine energy** projects, such as **insurance or limited guarantees** for banks which fund these types of projects.

Recommendation:

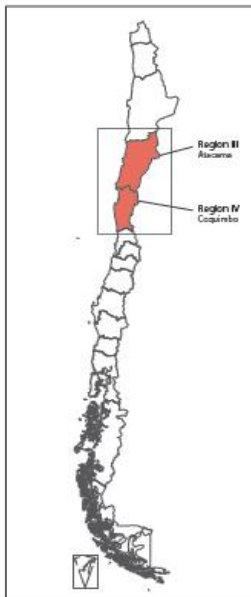
**CORFO** may wish to consider that promotion instruments available can not only be applied to power generation projects, should also be aimed to **developing specialized services and capability to built parts of equipments**, which directly affects the cost reduction of investment.

# Regional analysis

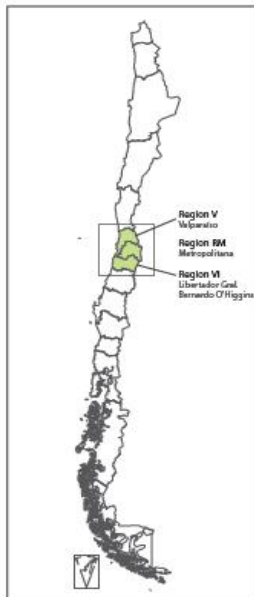
Norte Grande



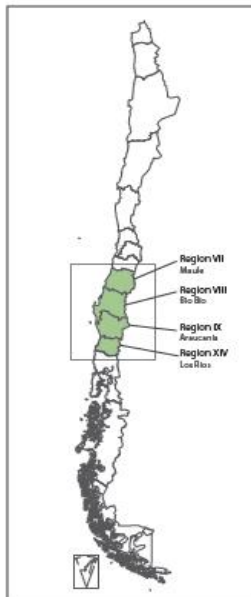
Norte Chico



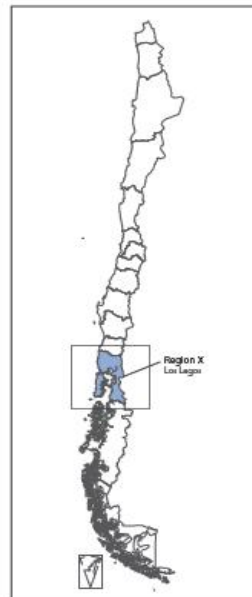
Centro



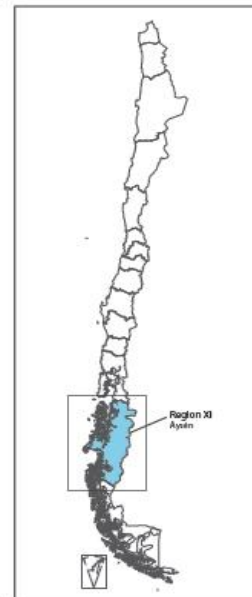
Centro Sur & Sur Frontera



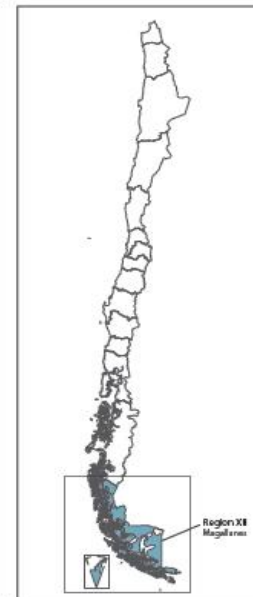
Los Lagos



Aysén



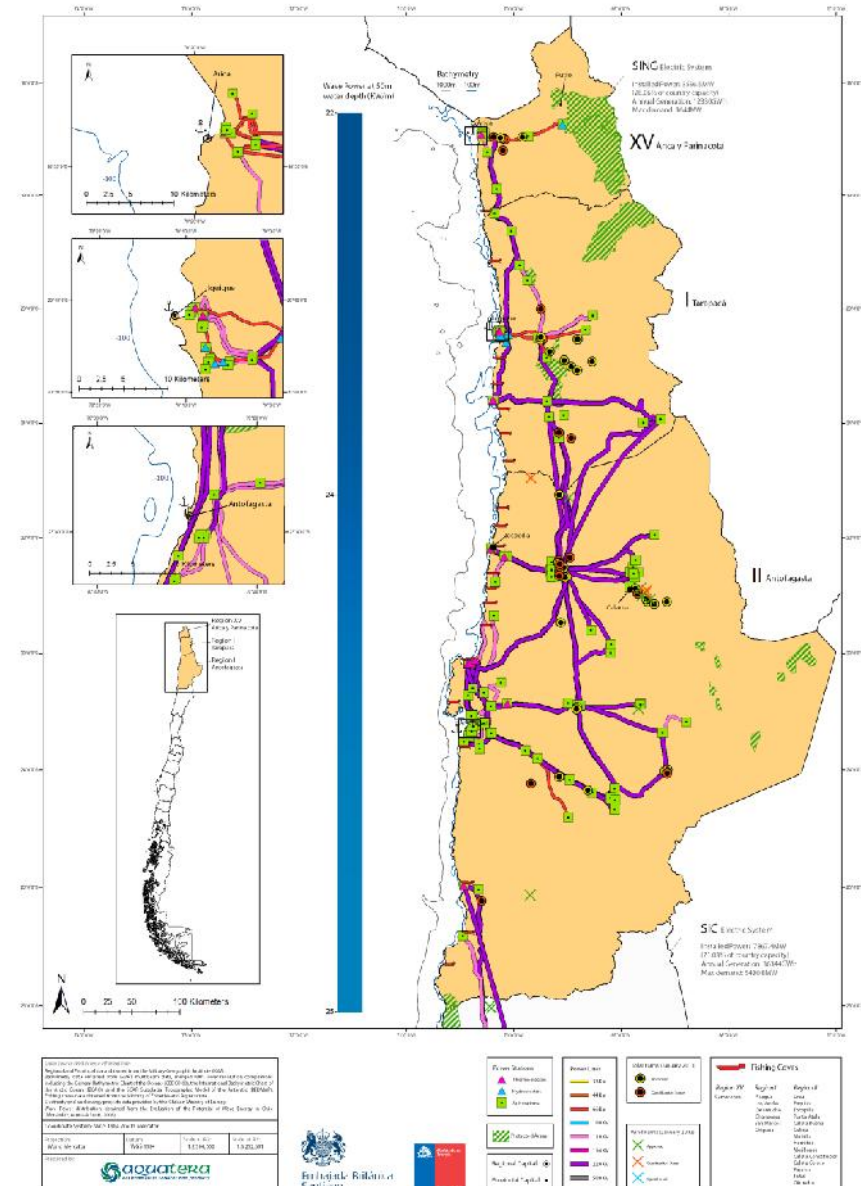
Magallanes



# Norte Grande & Norte Chico

- Wave resource – lower energy levels but easier to install and maintain
- Mining industry – big centres of demand
- Desalination and water pumping applications
- Robust grid near the coast
- Some suitable ports

## CHILE - NORTE GRANDE

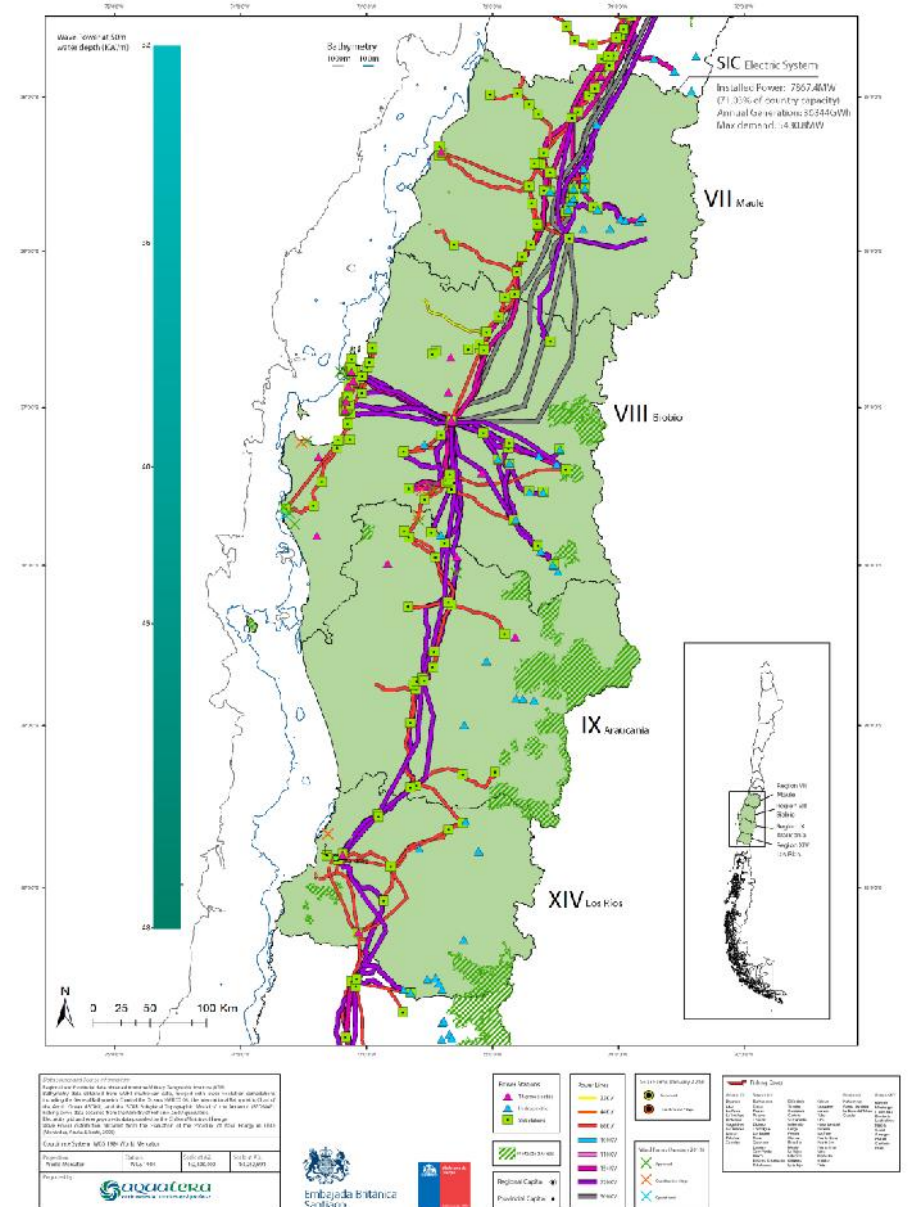




# Central / Sur

- Wave resource – high energy levels
- Centres of population industry – big centres of demand
- Significant ports and manufacturing capacity
- Robust grid near ports, SIC system

## CHILE - CENTRO SUR & SUR FRONTERA

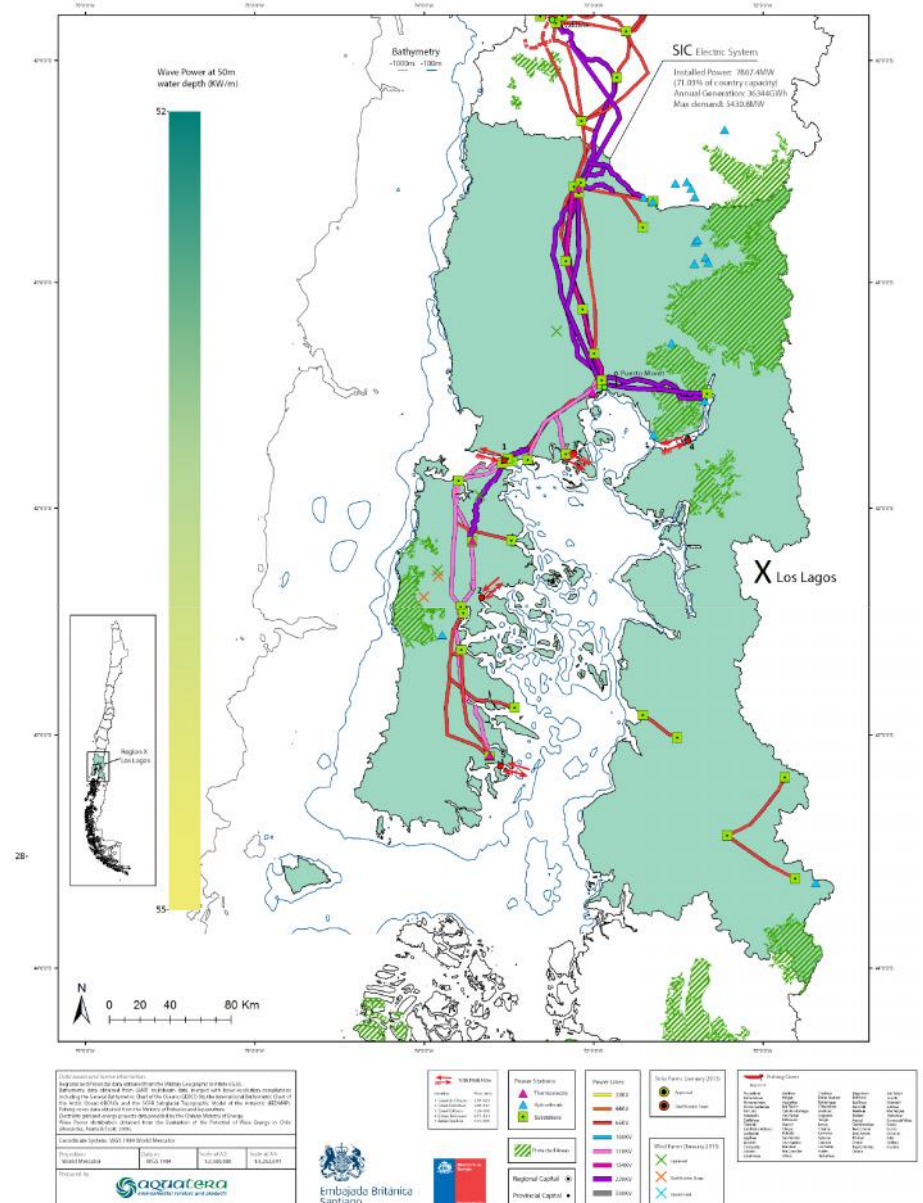




# Los Lagos

- Large wave resource
- Large tidal resource
- Connected to SIC
- Salmon industry
- Remote communities

## CHILE - LOS LAGOS



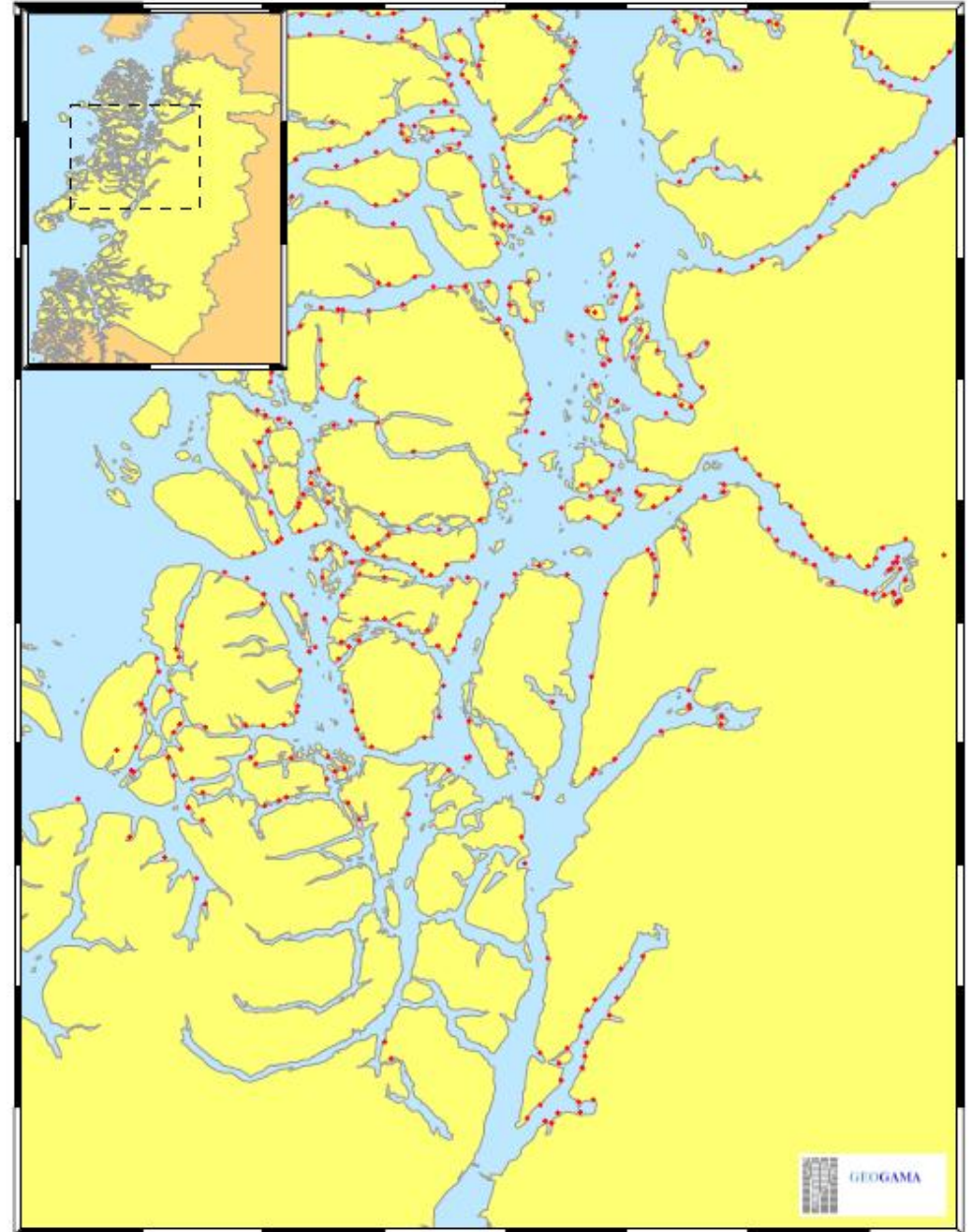
# Aysén

- Significant tidal resources for kW-scale projects
- Salmon farms – each red dot on the diagram opposite represents between around 200kW when operational.
- Isolated communities
- No grid near sites, so independent energy management is required.

Recommendation:

The **Regional Government of Aysén** should consider commissioning a study of Aysén's marine energy potential, so that the areas with most potential can be identified and marine energy included in the regional coastline use plan.

## XI REGIÓN AYSÉN DEL GENERAL CARLOS IBÁÑEZ DEL CAMPO





# Magallanes

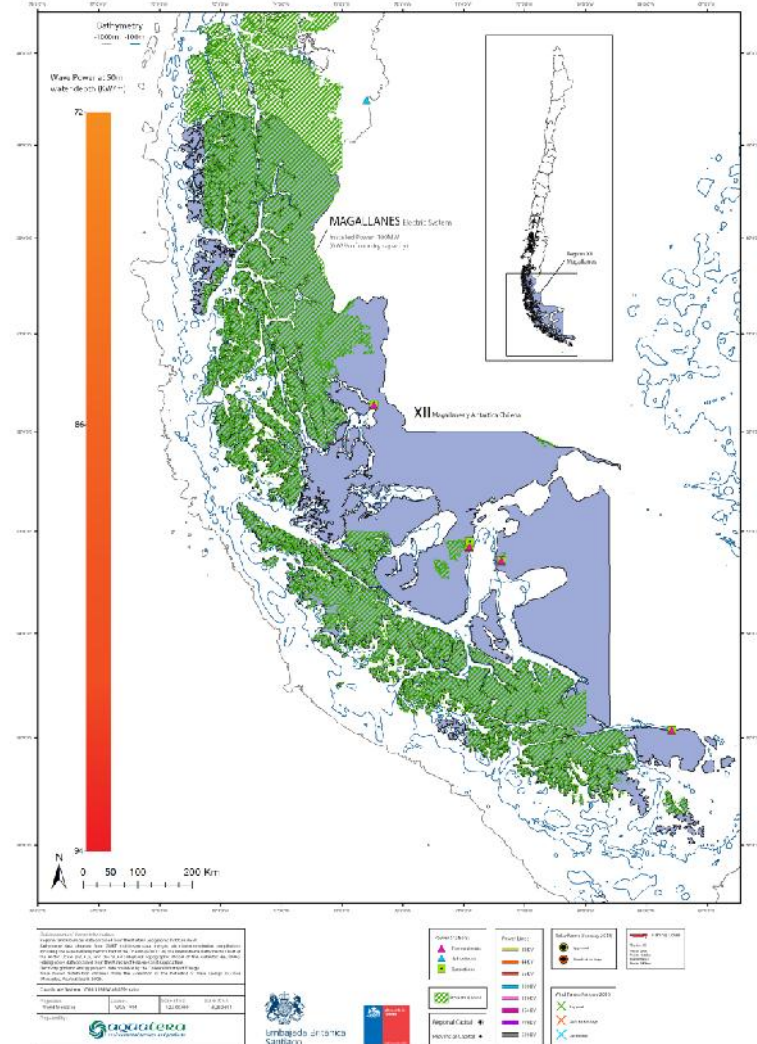
- Significant tidal resources for kW-scale projects
- Salmon farms
- Isolated communities
- No grid near sites

## Recommendation:

Chile's **Regional Governments** and the **Subsecretary of Regional Development** may wish to consider including an assessment of the regional potential for marine renewables to provide energy and/or water for remote communities as part of the *strategies for remote communities* that they are required to develop.

Note: Some regions are already considering a collaborative scheme with local universities, funded by Corfo's Innovation for Competitiveness (FIC) fund.

## CHILE - MAGALLANES



## Recommendation:

The Chilean **Government** may wish to support the development of Chilean expertise in small-scale marine renewable technologies targeted specifically at remote communities.

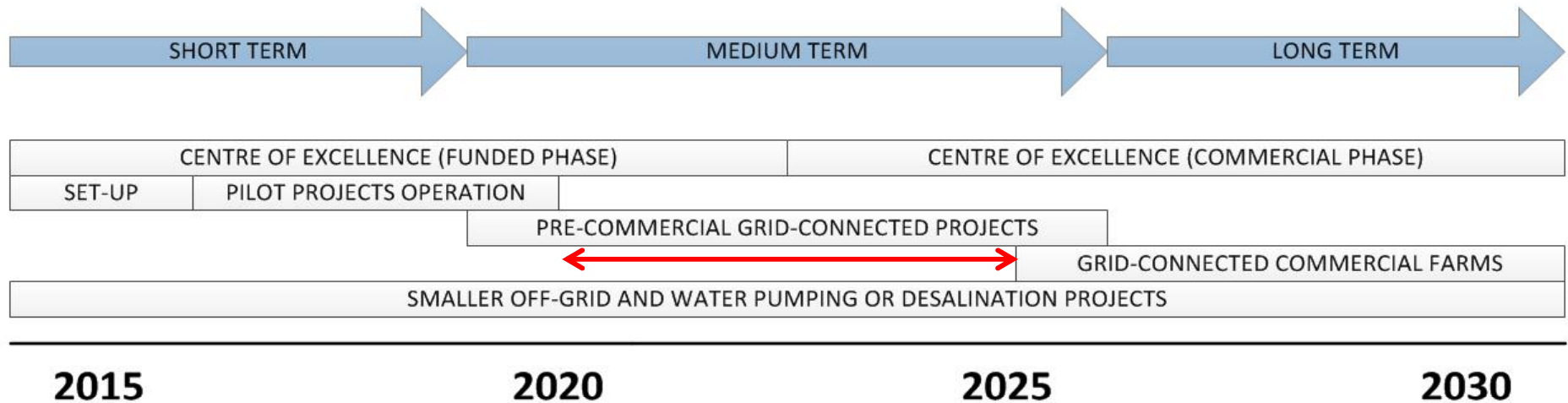
## Regional Priorities

Regional priorities	Northern	Central/ Southern	Los Lagos	Aysén	Magallanes
kW-scale tidal projects					
MW-scale tidal projects					
kW-scale wave projects					
MW-scale wave projects					
Manufacturing MW-scale devices					
Desalination / water pumping					
Salmon farms					
Remote communities					



- regional priority
- potential
- not a priority (or not possible)

# Overview – sustaining activity



- Additional government support may be required to realise MW scale farms in the SIC/SING before 2020-2025.
- Excellent potential for kW-scale projects (tidal in particular), particularly in remote areas where energy costs are higher.
- Market niches such as water desalination/pumping and replacing diesel generation on salmon farms provide opportunities for Chile to become a market leader in specific marine energy applications.



# Scenarios

Three potential scenarios are considered:

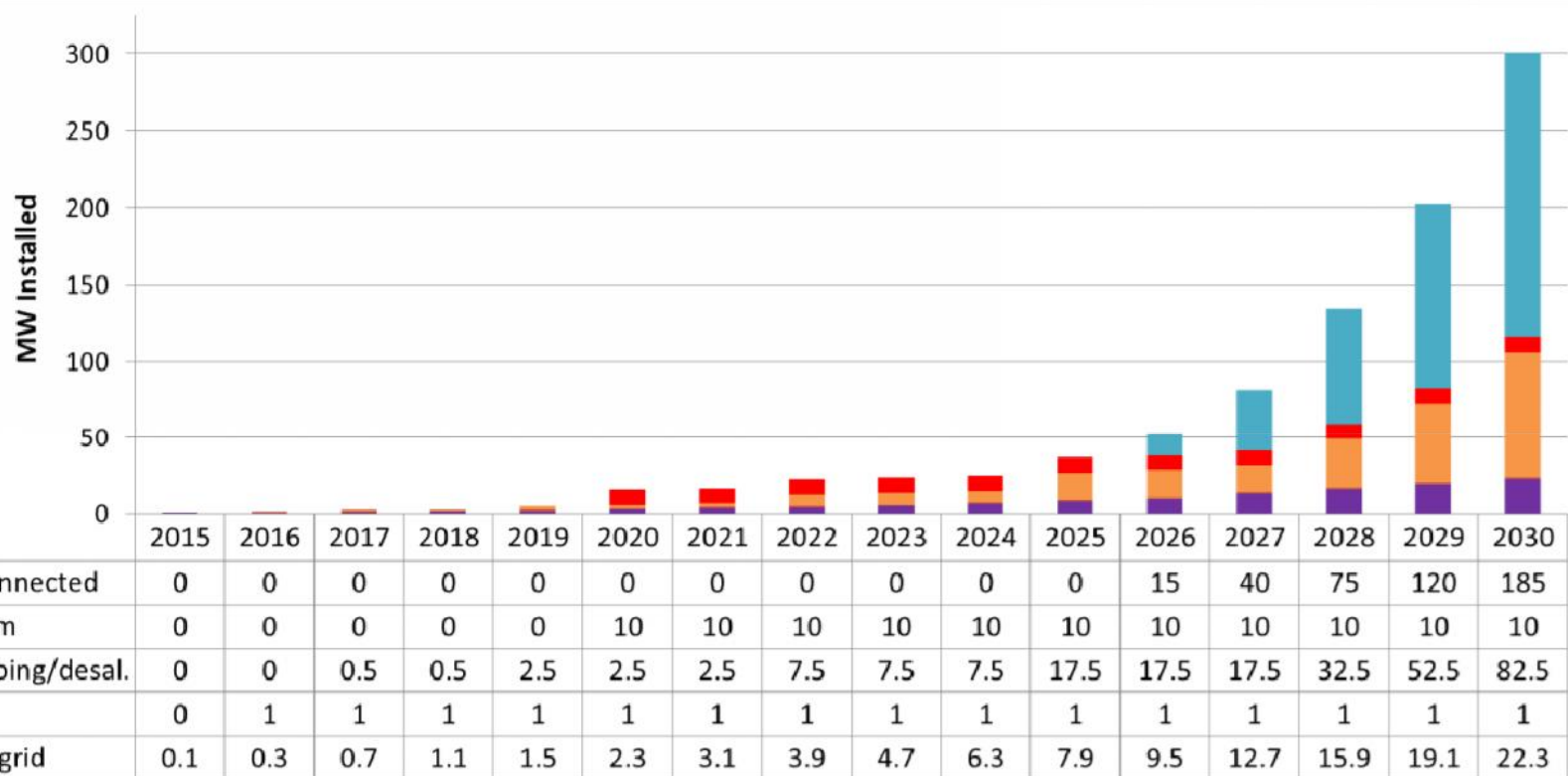
**Deployment Plus Strategy** - pilot projects, centre of excellence and proposed regulatory changes are implemented successfully, but no further support for the installation of wave and tidal devices is announced. Potentially limited activity in the sector between the end of the pilot projects and the advent of commercial projects. This is the current state of marine energy policy in Chile.

**Development Strategy** - above activities are realised and additional support measures for small scale, remote and market niche projects are introduced by the next government. Support for a pre-commercial grid-connected wave farm is made available by 2020.

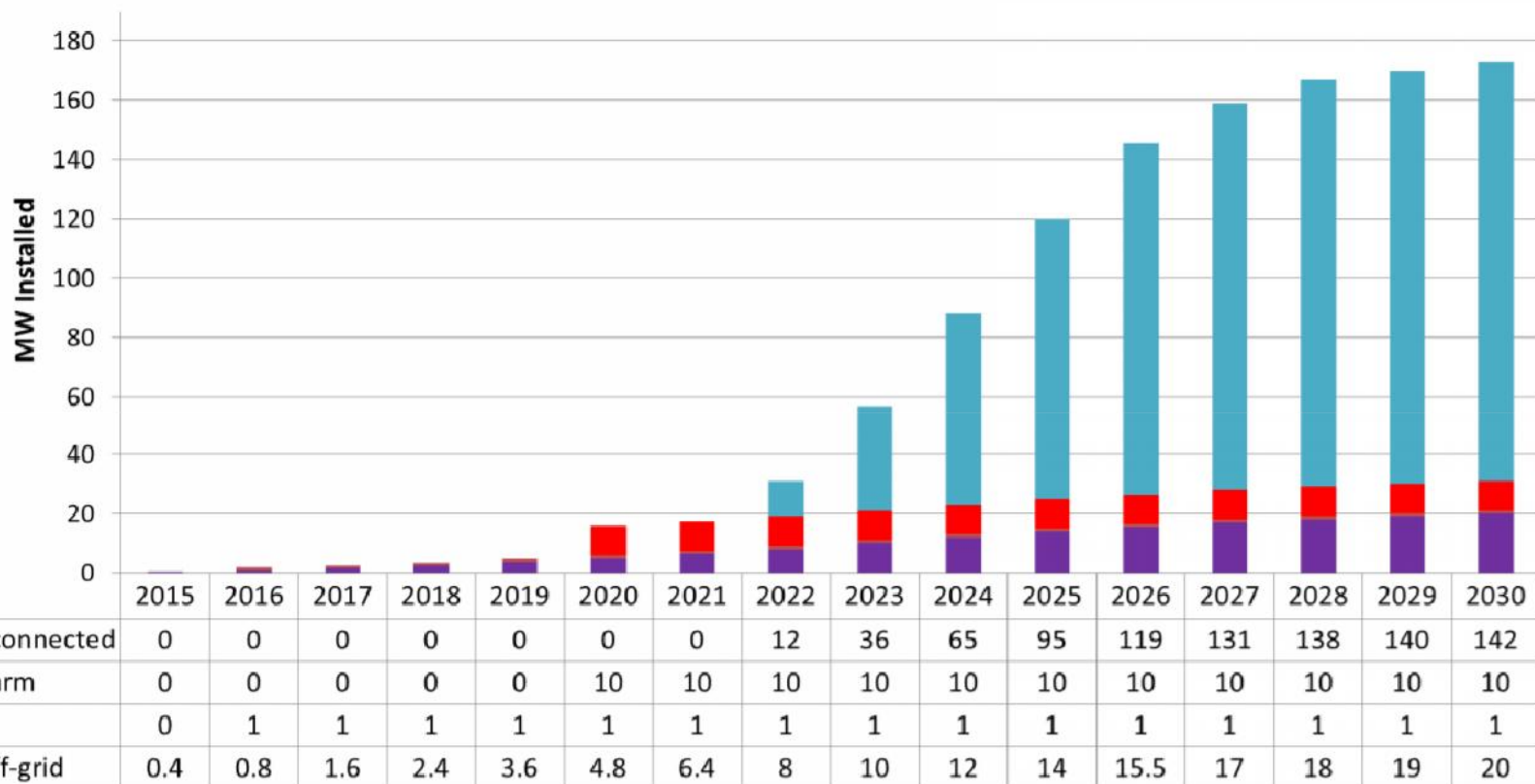
**Accelerated Development Strategy** - above activities are realised and a market-pull incentive (e.g. Auction) is introduced which is sufficient to realise multiple grid-connected wave and tidal farms as well as small scale, remote and market niche projects.

- The development strategy scenario is shown in detail on the following slides

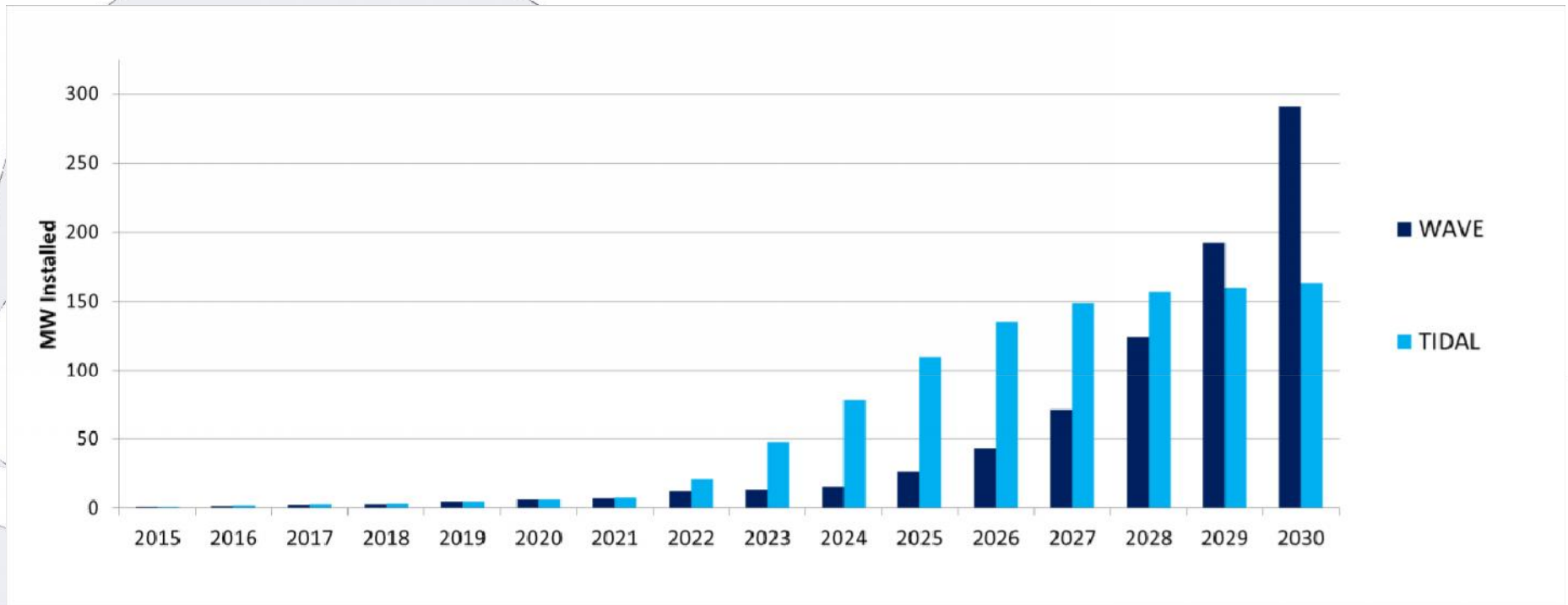
# Development strategy scenario (wave)



# Development strategy scenarios (tidal)



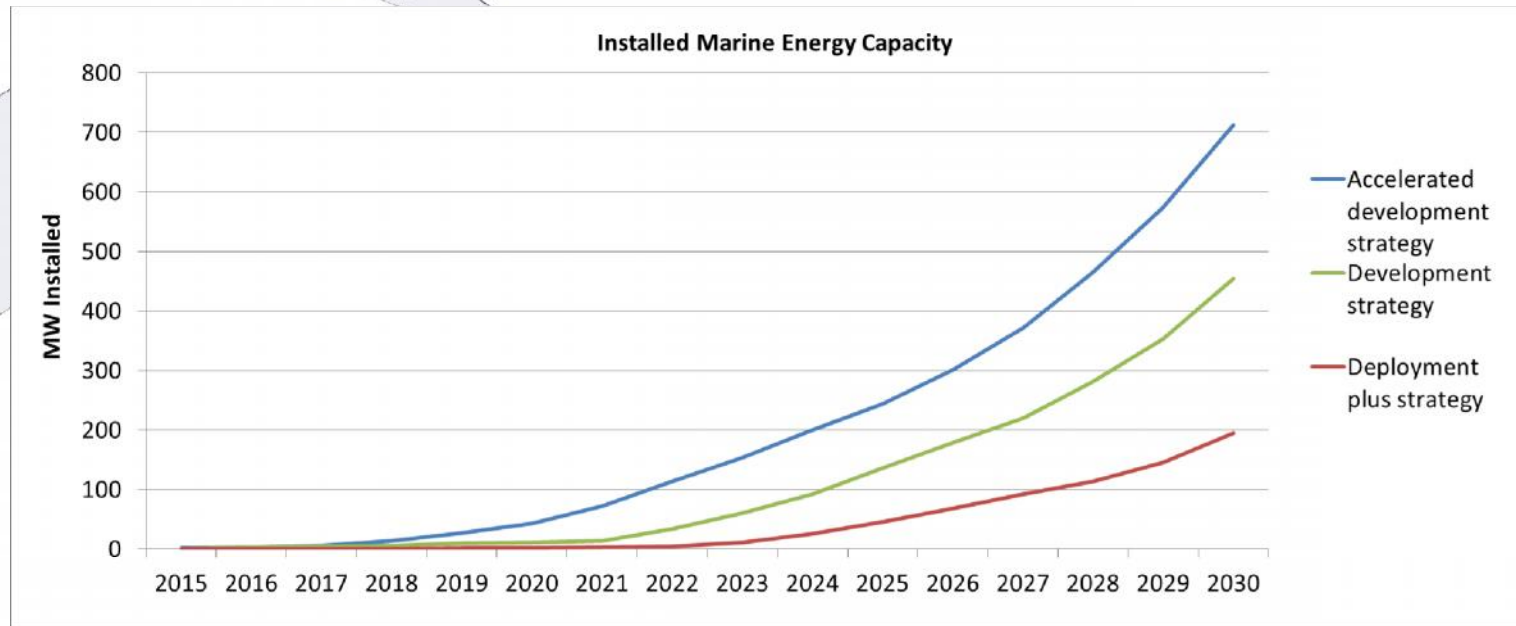
# Wave and tidal comparison



Tidal power is a more developed technology than wave, and the total potential in Chile is perhaps a hundredth of that in wave. Given these two considerations it could be argued that the requirement for support for a pre-commercial tidal farm is less pressing than for wave. Tidal will be commercialised sooner, so installation activity is likely to outstrip wave for the most of the 2020s. There are a relatively limited number of suitable sites for tidal power developments in Chile. The Chacao Channel for example is one of Chile's most important tidal sites, and is estimated to have around 800MW of total resource. As a rule of thumb, typically 10% of such a resource may be economically extractable (ref. Figure 13), and so after around 80MW is installed the site will effectively be saturated. In the space of perhaps five years from the first large commercial tidal projects therefore, it is likely that there will be a slowdown in tidal installation activity. Wave installation activity on the other hand (which can take place in coastal and nearshore sites as well as offshore) has the potential to continue to experience rapid growth in Chile for a decade or more – see Figure 42.



# Total marine energy capacity – effect of strategy



**Deployment Plus Strategy** - pilot projects, centre of excellence and proposed regulatory changes are implemented successfully, but no further support for the installation of wave and tidal devices is announced. Very limited activity in the sector between the end of the pilot projects and the advent of commercial projects. This is the current state of marine energy policy in Chile.

**Development Strategy** - above activities are realised and additional support measures for small scale, remote and market niche projects are introduced by the next government. Support for a pre-commercial grid-connected wave farm is made available by 2020.

**Accelerated Development Strategy** - above activities are realised and a market-pull incentive or subsidy (e.g. auction, or ROC-like system) is introduced which is sufficient to realise multiple grid-connected wave and tidal farms as well as small scale, remote and market niche projects.

# Jobs and investment

Strategy	Installed capacity by 2030		Direct Jobs		Investment (million USD)	
	Wave	Tidal	Wave	Tidal	Wave	Tidal
Accelerated development	541	214	3,366	1,691	1,003	397
Development	292	166	1,818	1,314	541	308
Deployment plus	103	91	641	720	191	169

## ADEMAR promotes a multi-dimensional approach

- Building scale across geographies
- Find efficiency opportunities along the supply chain
- Identify local component opportunities in the supply chain
- Leverage on great job-creation opportunities to secure funding (?)
- Leverage on high environmental returns to secure green funding
- Simplify concession process (one-stop-shop)
- Building brains across geographies (Marine Knowledge Network)





# Conclusiones

- Desafío: “turn our planet from something with a past to mine to something with an insolation to exploit.”
  - O.Morton (2007)



# Conclusiones

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  - ~~O.Morton (2007)~~
- Desafío: “turn our planet from something with a past to mine to something with a marine displacement to exploit.”
  - Paul Griffiths (2014)

# Conclusiones

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  - ~~O.Morton (2007)~~
- Desafío: “turn our planet from something with a past to mine to something with a marine displacement to exploit.”
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- El potencial de energía es muy significativo

# Conclusiones

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- Desafió: “turn our planet from something with a past to mine to something with a marine displacement to exploit.”
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- Los científicos, los entrepreneurs, los grandes empresarios, los agentes de gobierno ya están

# Conclusiones

- ~~• Desafió: “turn our planet from something with a past to mine to something with an insolation to exploit.”~~
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- Desafió: “turn our planet from something with a past to mine to something with a marine displacement to exploit.”
  - Paul Griffiths (2014)
- El potencial de energía es muy significativo
- Los científicos, los entrepreneurs, los grandes empresarios, los agentes de gobierno ya están
- Ahora necesitamos a los financistas que permitan saltar la brecha del concepto pre-comercial a la aplicación comercial
- Recomendando ver informe (2013/2014): **Recommendations for Chile's Marine Energy Strategy – a Roadmap for Development** by Aquatera.





# Contacto

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- [paul.griffiths@birchmangroup.com](mailto:paul.griffiths@birchmangroup.com)



# **ANEXO: CENTRO DE EXCELENCIA**

# Marine energy R&D+i centres

INDUSTRY

UNIVERSITIES

R&D

Cash



CENTRE OF  
EXCELLENCE



Knowledge

Innovation

**EMEC10**  
TEN YEARS OF MARINE ENERGY EXPERIENCE

**narec**

**Wave Hub**

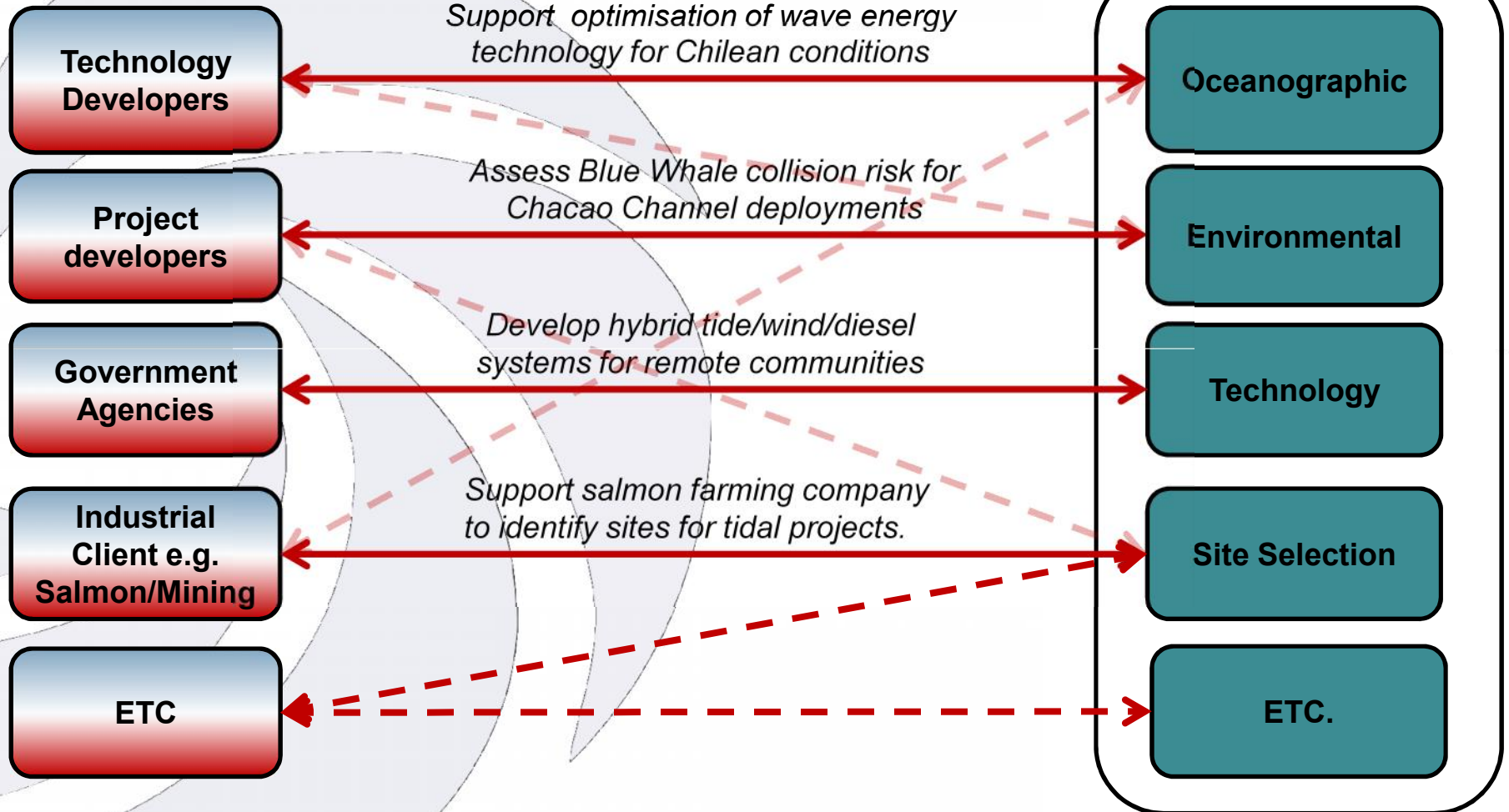
**aquatera**

# Centre of excellence service examples

## Clients

## Project Examples

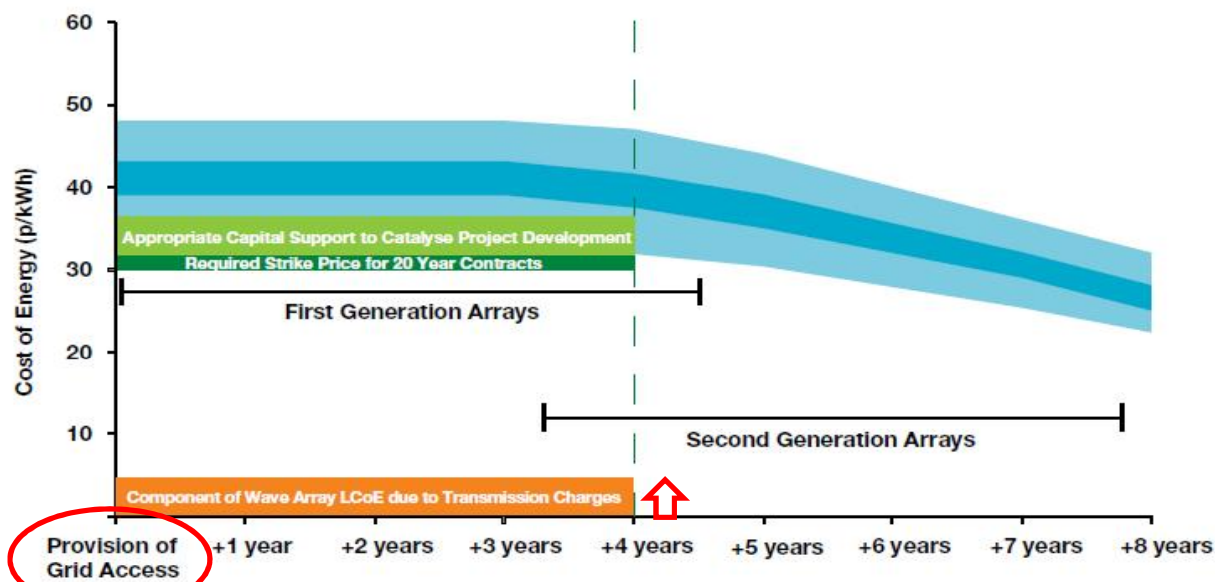
## ICE Chile





## 3.1 Infrastructure - Grid

Figure 5: Anticipated levelised cost of energy for wave energy based on recent data submissions.



Recommendation:

The **Chilean Grid Operators (CDEC – centres of energy despatch)** may wish to consider commissioning a study similar to the UK's ENSG study which considers the grid upgrades that would be required to connect significant amounts of marine energy to the Chilean networks.

Recommendation:

The **Chilean Government** may wish to consider how it could guarantee early access to electricity grid for marine energy projects, in particular around early demonstration zones.