Tides and Batteries for Green H_2 Production

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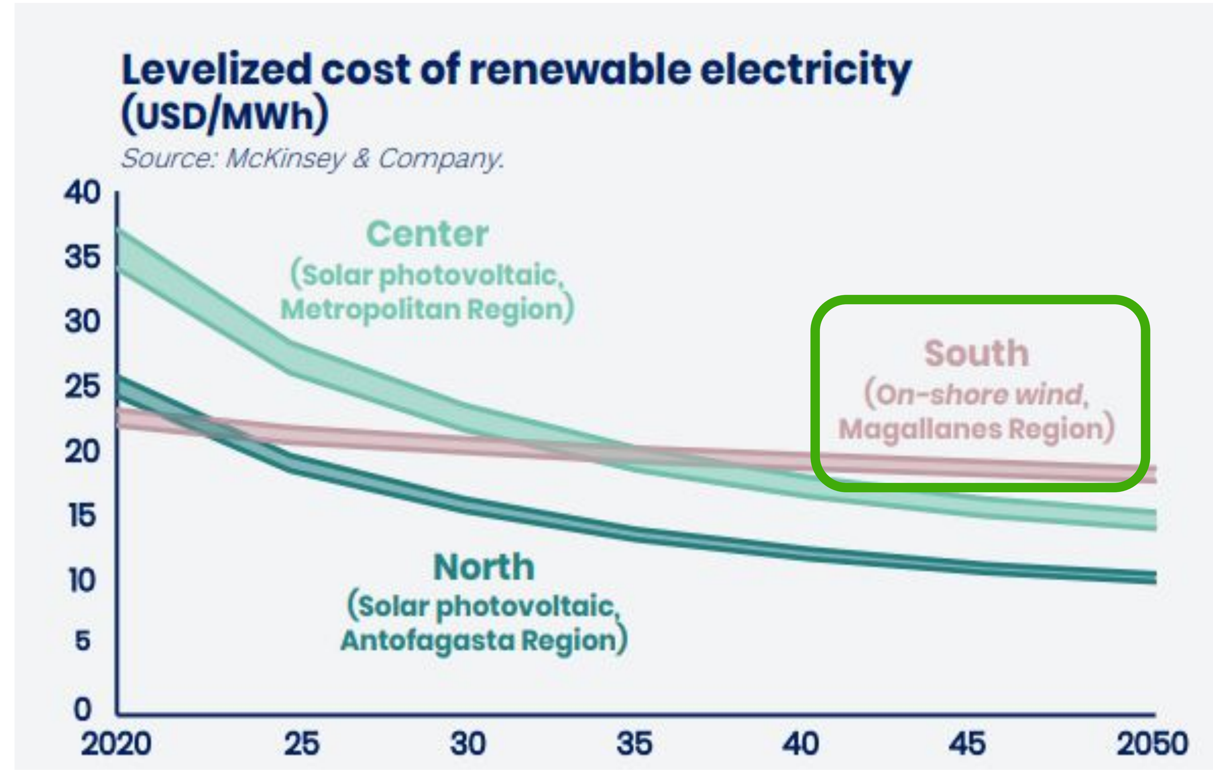
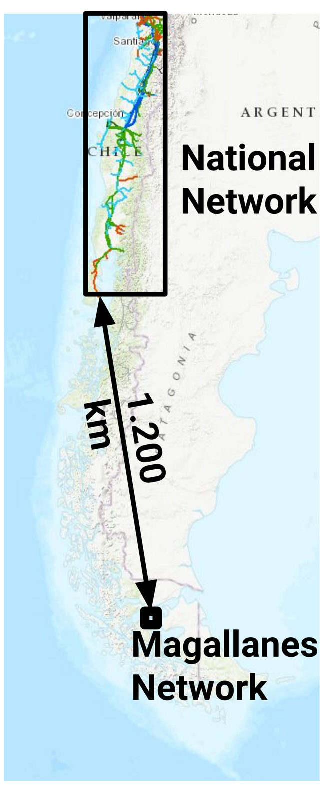
Introduction

Chile is aiming to produce the lower levelized cost for green hydrogen generation [1] throughout its privilege wind resource in Magallanes Region, for 2030. Despite this, there are 3 main challenges in the energy supply aspect:

1. Natural **wind intermittency**
2. **Electrical system isolation** from the national transmission network.
3. **Insufficient solar and biomass** energy sources

Furthermore, the chemical process of generate the GH_2 derivatives (eg. E-metanol and E-fuels) need a continuous energy supply. Therefore these projects will have to resort to storage systems to support the intervals without wind energy generation.
However, the high cost of current storage systems (~$1M/MWh) could have an excessive impact on the expected levelized cost of H2V production [2].
Local and renewable energy sources must be found to support wind-free intervals, making a 100% green hydrogen/derivatives.





Wind and Tidal Current Energy: a Complement for Magallanes

Based on the current model developed and validated [3], a study of energy generation potential concentrated in the 2 Narrows of the Strait has been developed. For this preliminary work, three world-leading tidal energy conversion technology developers collaborated. The results showed preliminary annual capacity factors of 55% and daily capacity factors of up to 75%.

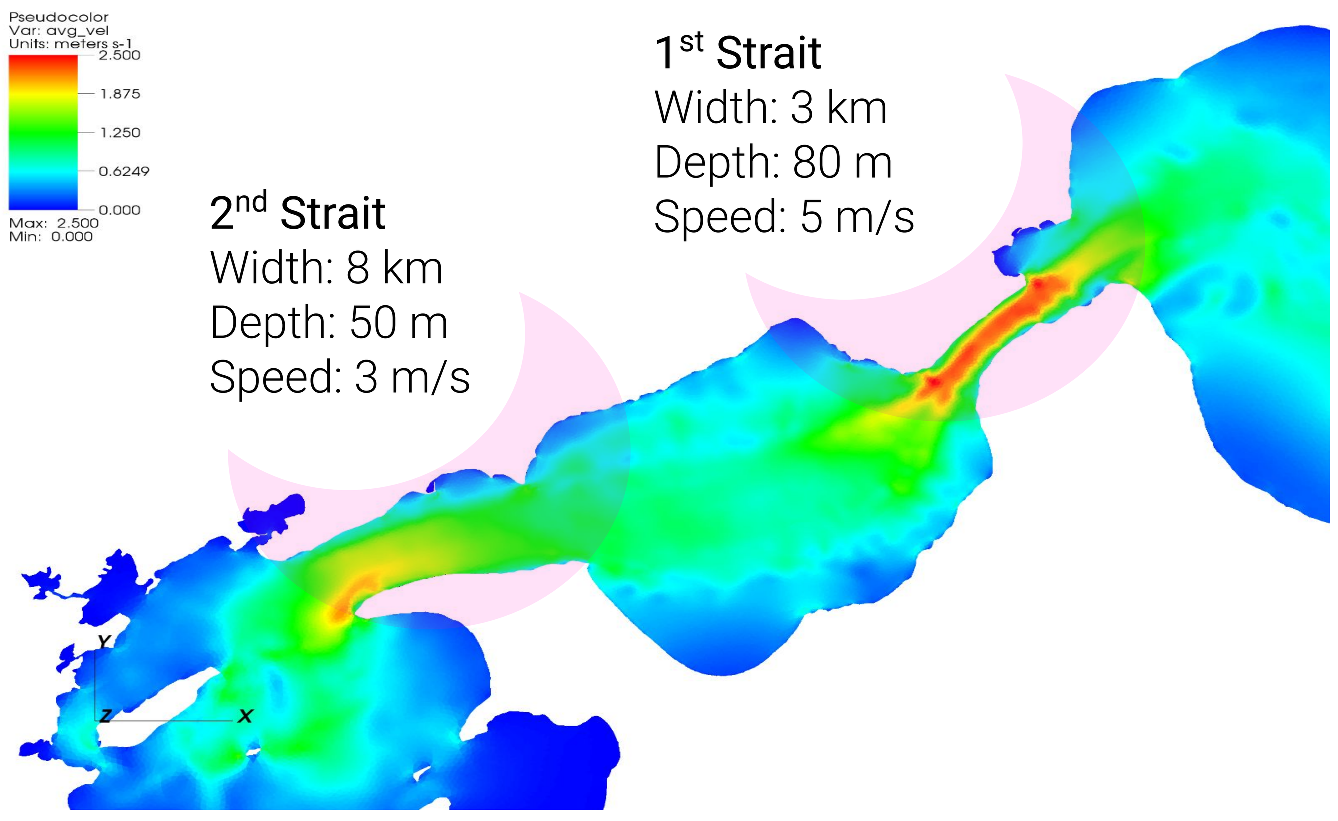


Figure 1. Tidal current energy resource in the Magallanes Strait

Based on climatological reconstruction data between 1980-2017 at 80 m high in the areas where the first GH_2 and e-fuels plant is expected, choosing a model of commercial turbines that operate in this speed range, 145 m high. rotor diameter and nominal speed of 10.4 m/s and a nominal capacity of 5 MW, a simulation of the operation of a field composed of 60 of these turbines (300 MW) was carried out. Despite having a privileged capacity factor (58%), 405 stops were recorded, where the wind speed is less than 5 m/s, with an average duration of 2 hours and a maximum duration of 38 hours.

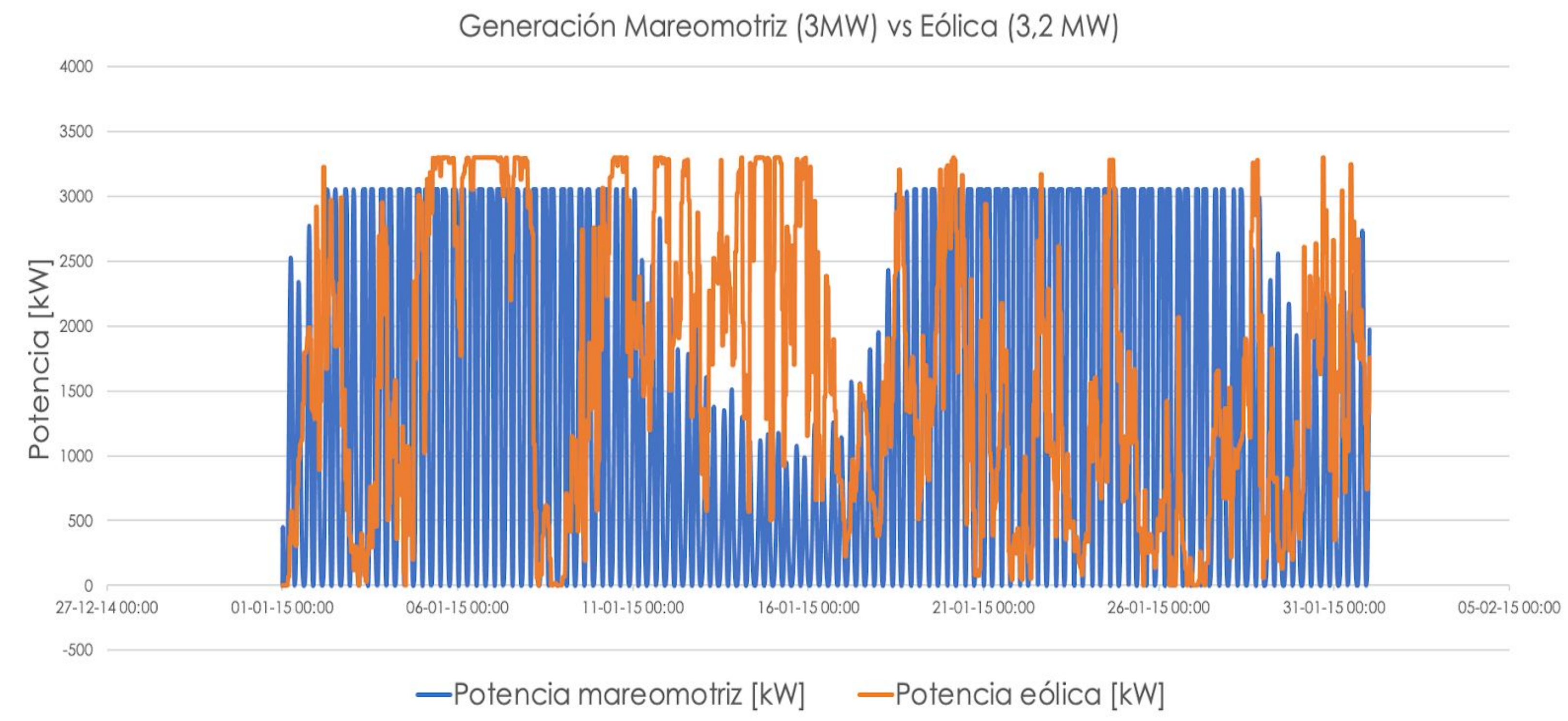
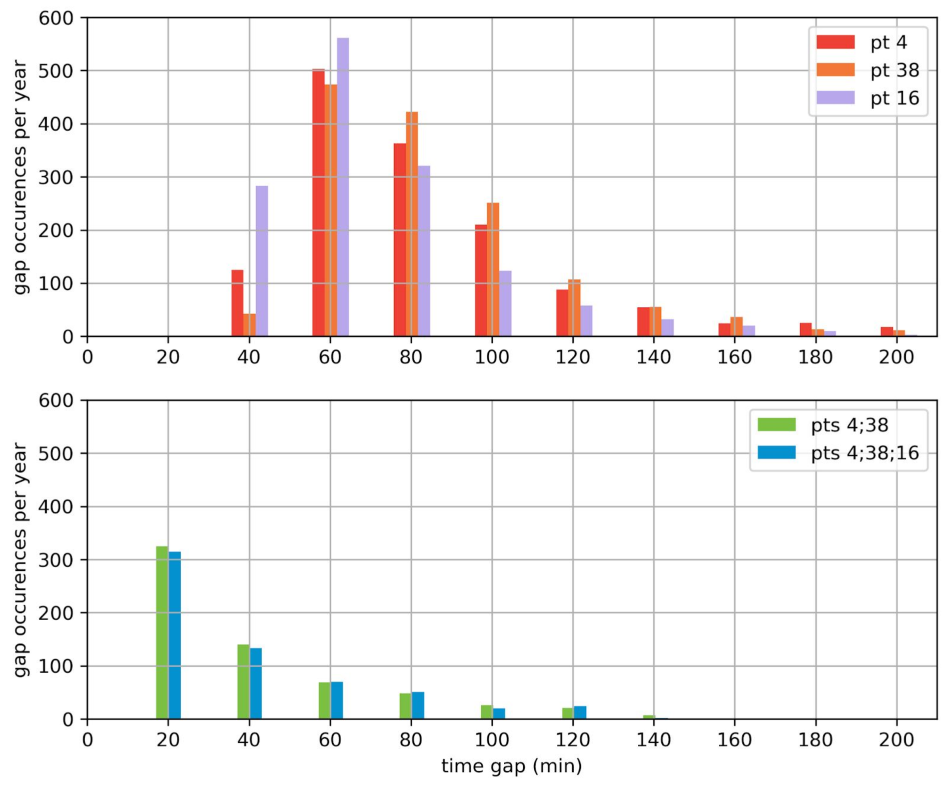


Figure 2. Extract of an hourly tidal power data vs wind power data series from climatological reconstruction in a Magallanes site.

In parallel, a preliminary performance analysis in Magallanes, between a 1.7 MW wind generator and a 1.4 MW tidal generator, in the Strait of Magellan, has shown that the tidal device would be capable of generating energy 96% of the time that wind speed is insufficient for production.
On the other hand, it could be observed that by installing multiple devices at different points of the strait, an overlap of the energy generation curves is achieved, and a reduction in the time periods without generation can reach up to 2 hours.



In this way, non-generation gaps in tidal energy would not only be 100% predictable, but could impact the cost of the storage system, designed to support unpredictable intervals without wind generation.

Figure 3. Number of occurrences and duration of gaps without generation in the case of tidal energy devices. Upper graph corresponds to isolated sites, graph below corresponds to joint sites analysis.

Conclusion: Integration of Tidal Current Energy + Wind Energy + Storage Systems

In this work, tidal current energy was identified as a renewable source available in Magallanes, which could complement wind turbines and batteries in GH_2 electrical supply, since it has unique characteristics in the region:
1. Estimated annual plant capacity factors greater than 55%,
2. 100% predictable power generation,
3. Complementarity of generation with wind energy of more than 90%
4. Duration of non-generation time intervals compatible with energy storage systems.
5. Tidal current energy costs could be competitive with batteries.

Next steps:
From the collaboration between MERIC team, the tidal technology developer and a GH_2 company, it is expected:
- Characterize the energy demand necessary for the production of GH_2 derivatives and estimate the intermittency intervals of wind energy.
- Analyze the complementarity between tidal energy, wind energy and energy storage systems.
- Perform an LCOE and LCOS analysis combining different energy sources.
- Impact on total plant factor, energy supply stability and LCOH.

References:
1. Estrategia Nacional de Hidrógeno Verde - link: http://biblioteca.digital.gob.cl/handle/123456789/3772
2. Technoeconomic modelling of renewable hydrogen supply chains on islands with constrained grids, Ferguson, James. link: https://hdl.handle.net/1842/37920
3. Suarez, L., Escauriaza, C., Guerra, M., Williams, ME. TIdal energy resource assessment in the Strait of Magellan in Chilean Patagonia. Proceedings of the 15th European Wave and tidal energy conference, Bilbao, 2023.

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