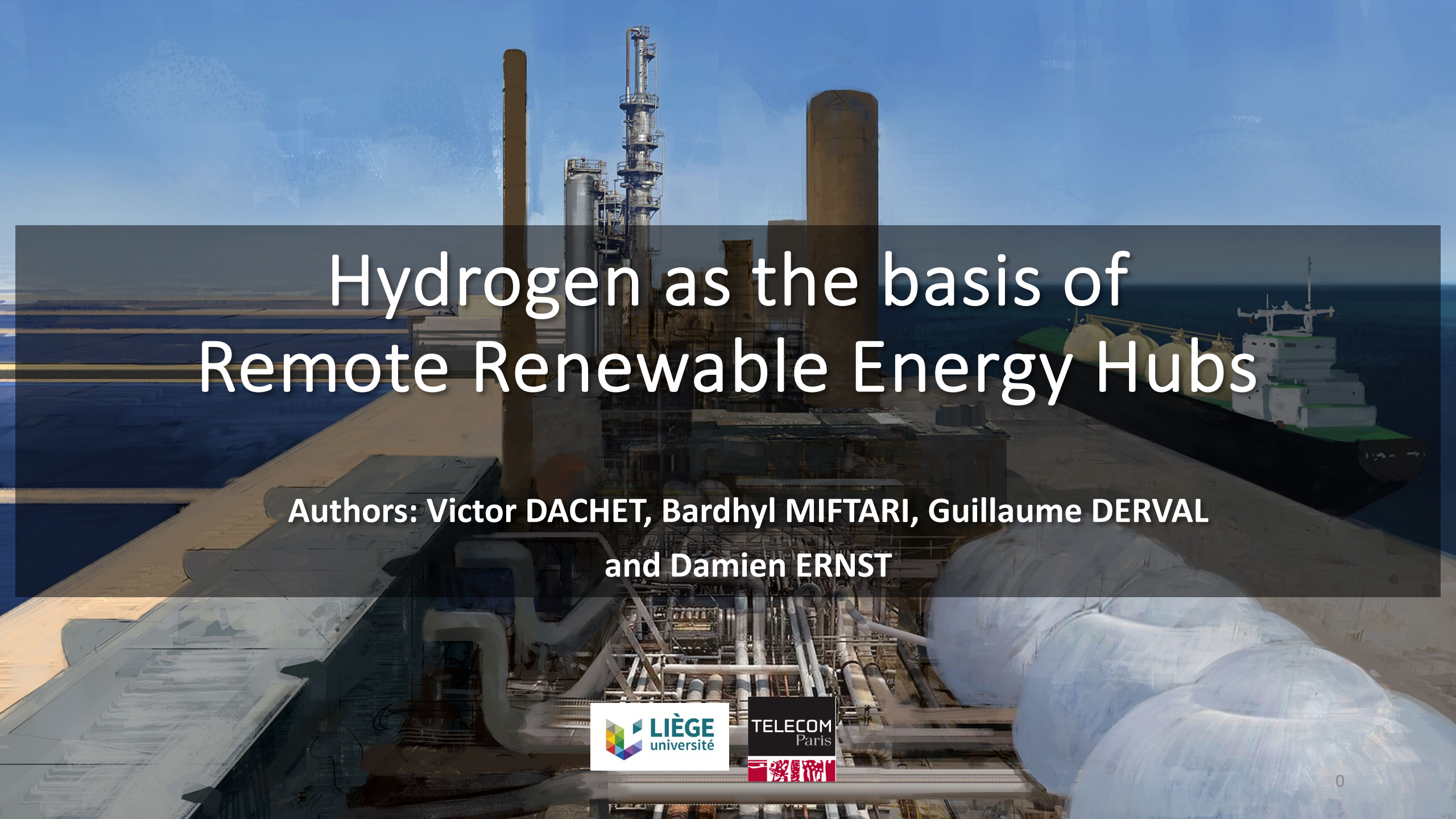
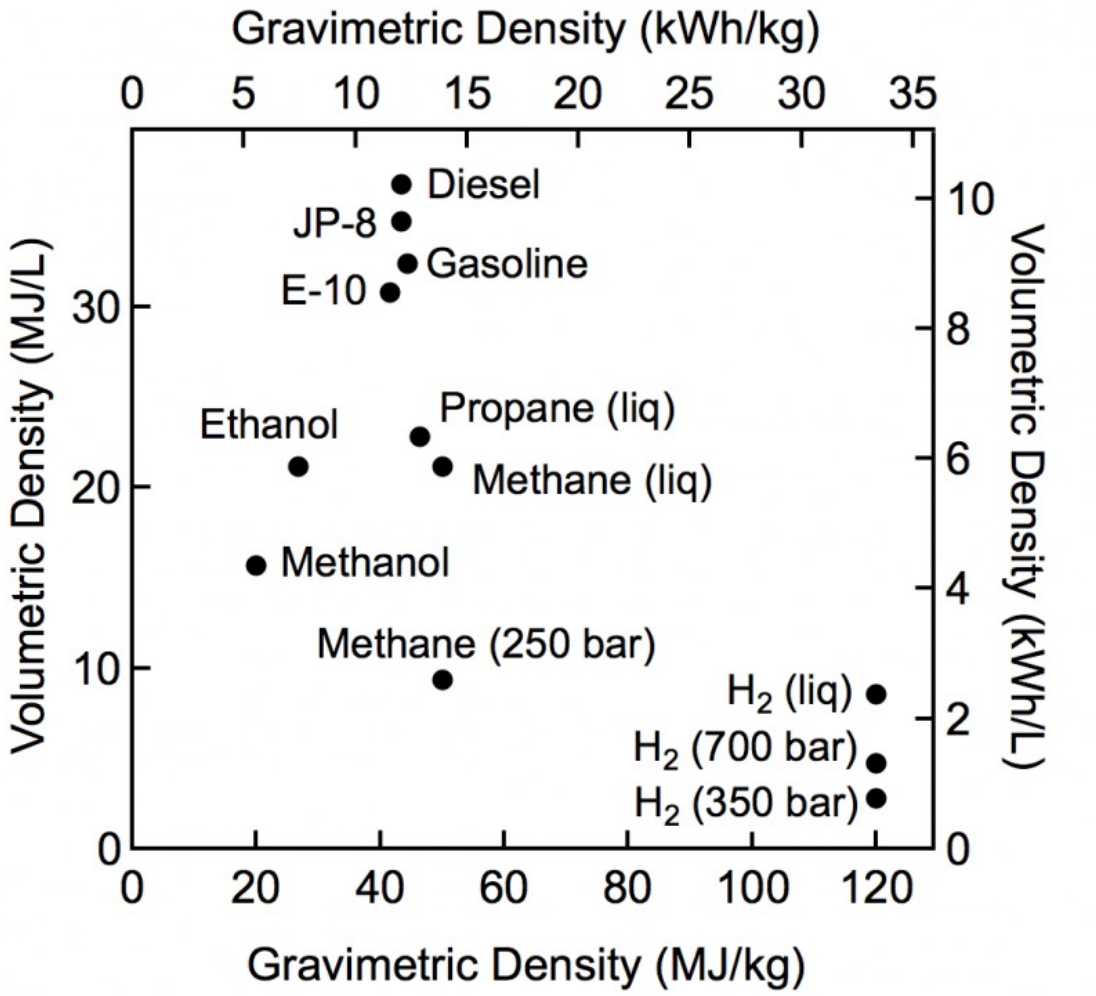


Hydrogen as the basis of Remote Renewable Energy Hubs

Authors: Victor DACHET, Bardhyl MIFTARI, Guillaume DERVAL and Damien ERNST

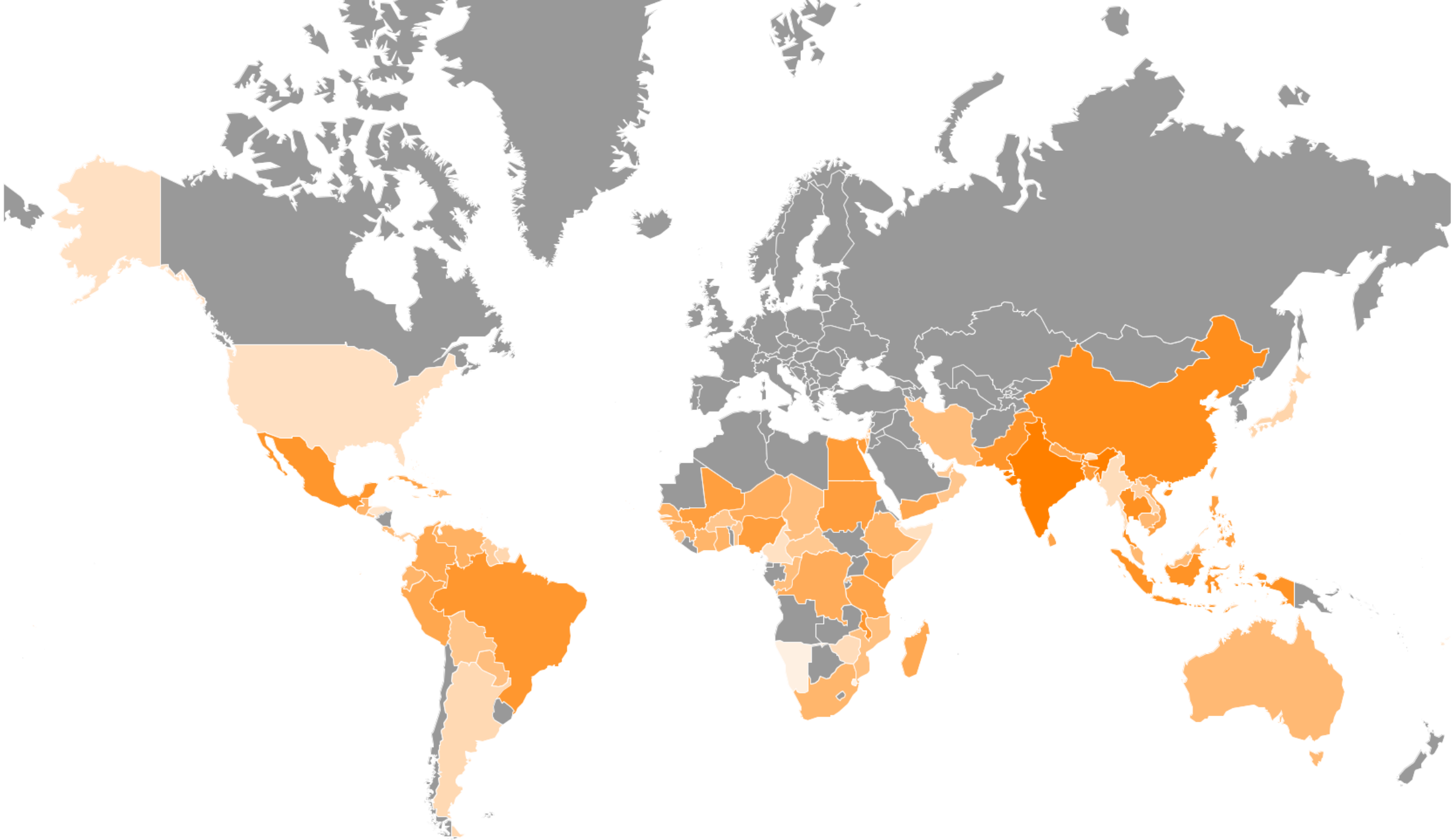


Source: US energy dept.

- H2 is hard to store (high pressure/low temperature)
- Low volumetric density
- Losses in storage/transport

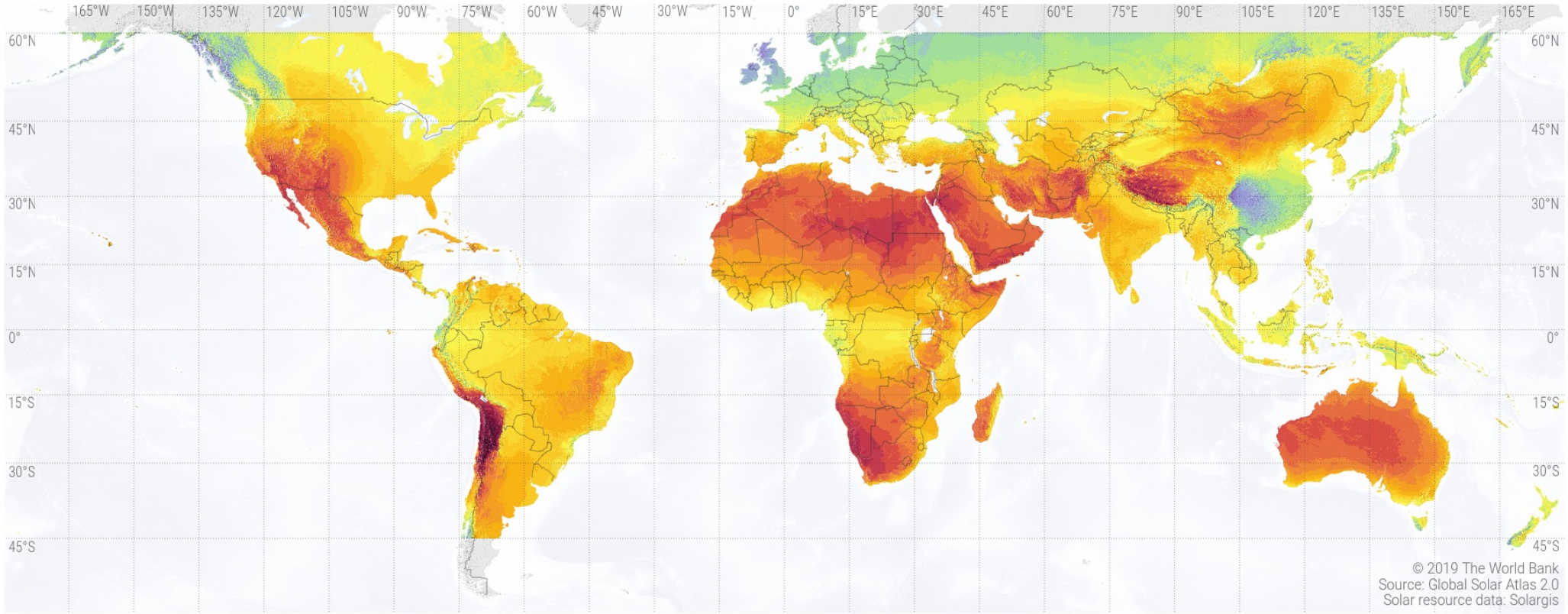
Hydrogen will probably not reach the last steps of the energy usage (mobility, home heating, electricity generation, …).

What are the other usages?



SOLAR RESOURCE MAP

PHOTOVOLTAIC POWER POTENTIAL

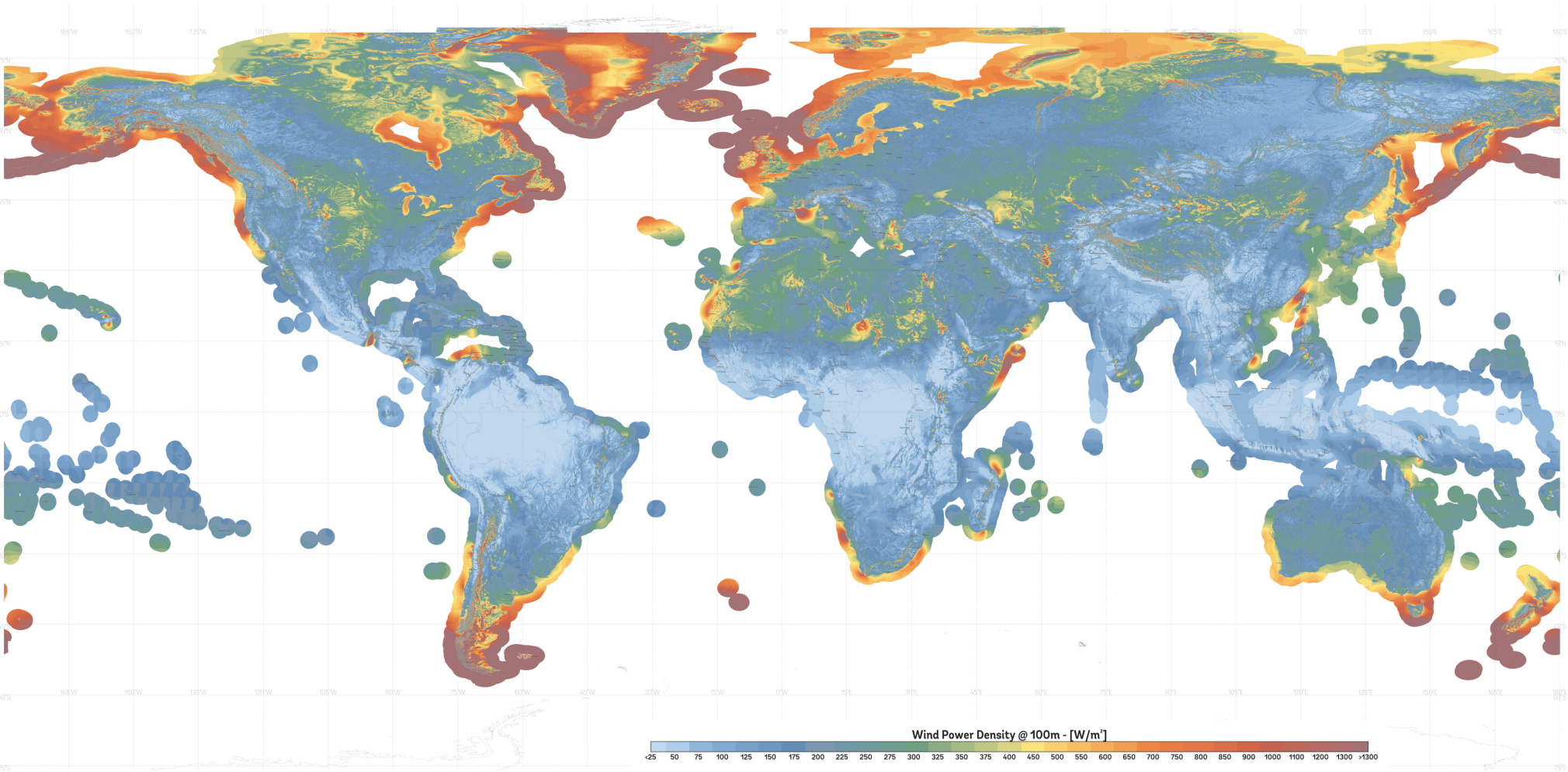


Long-term average of photovolaic power potential (PVOUT)

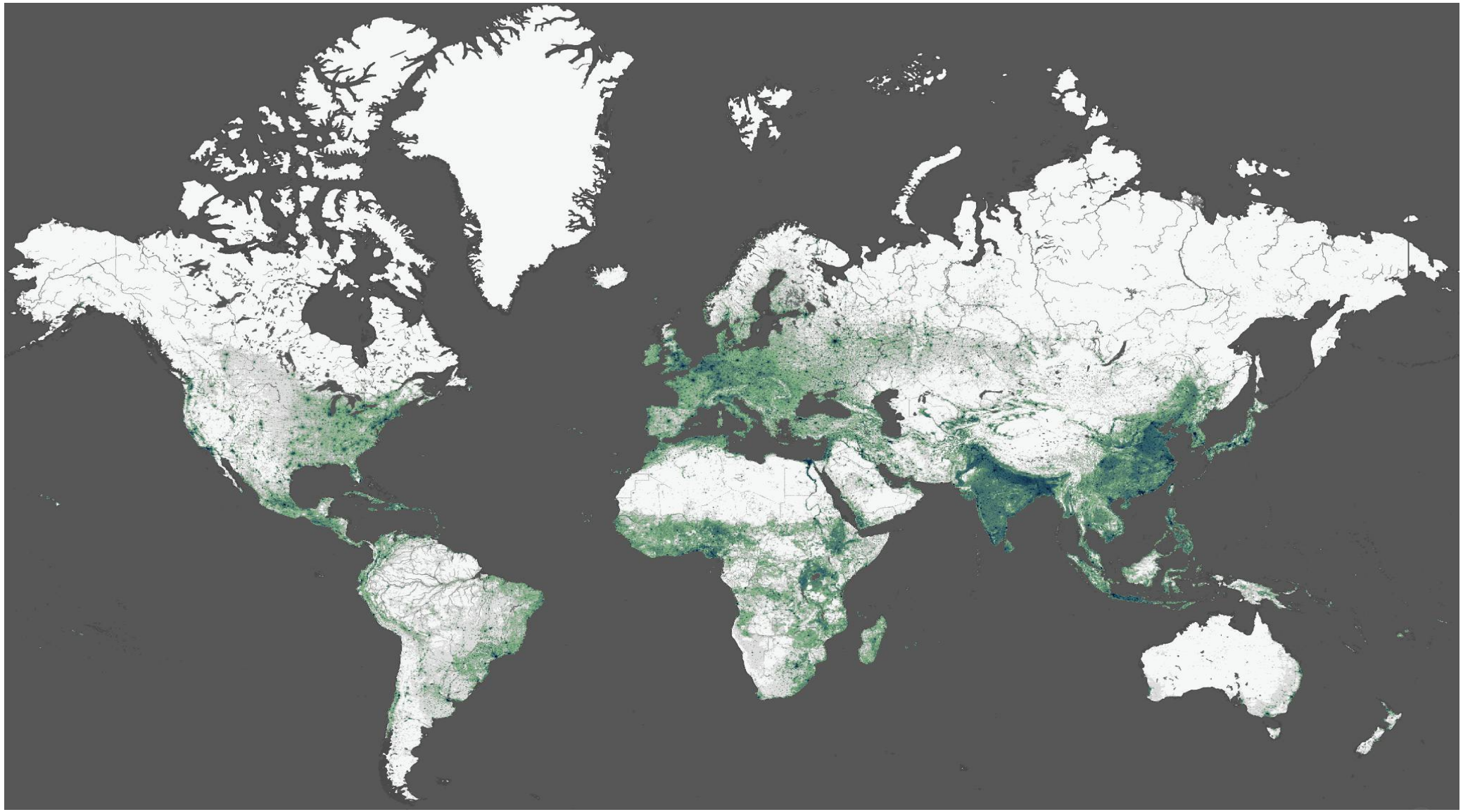
Daily totals:	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4
												kWh/kWp
Yearly totals:	730	876	1022	1168	1314	1461	1607	1753	1899	2045	2191	2337

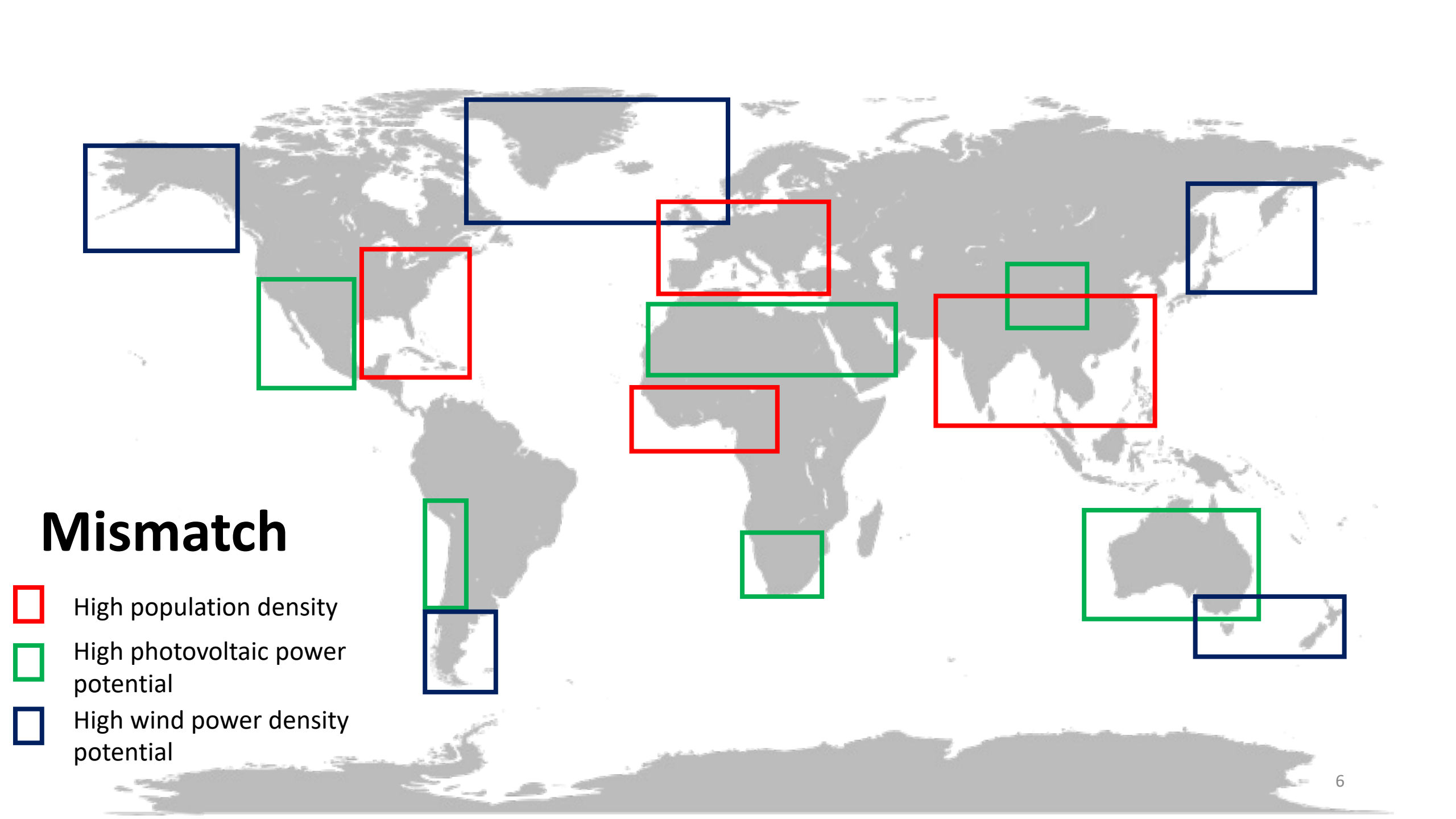
This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit http://globalsolaratlas.info.

WIND POWER DENSITY POTENTIAL



World population density

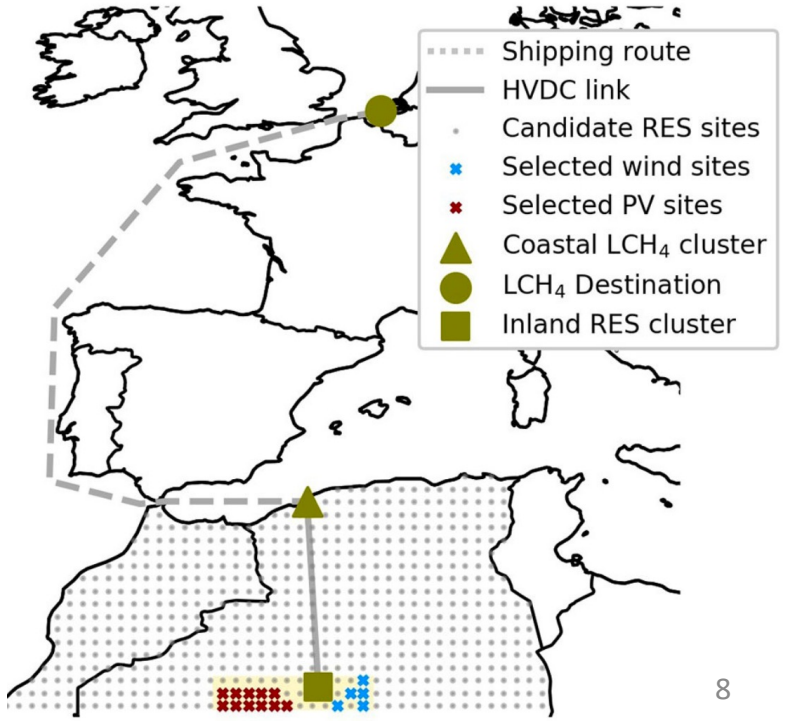



Mismatch
High population density
High photovoltaic power potential
High wind power density potential

Remote Renewable Energy Hubs

Remote Renewable Energy Hub: definition

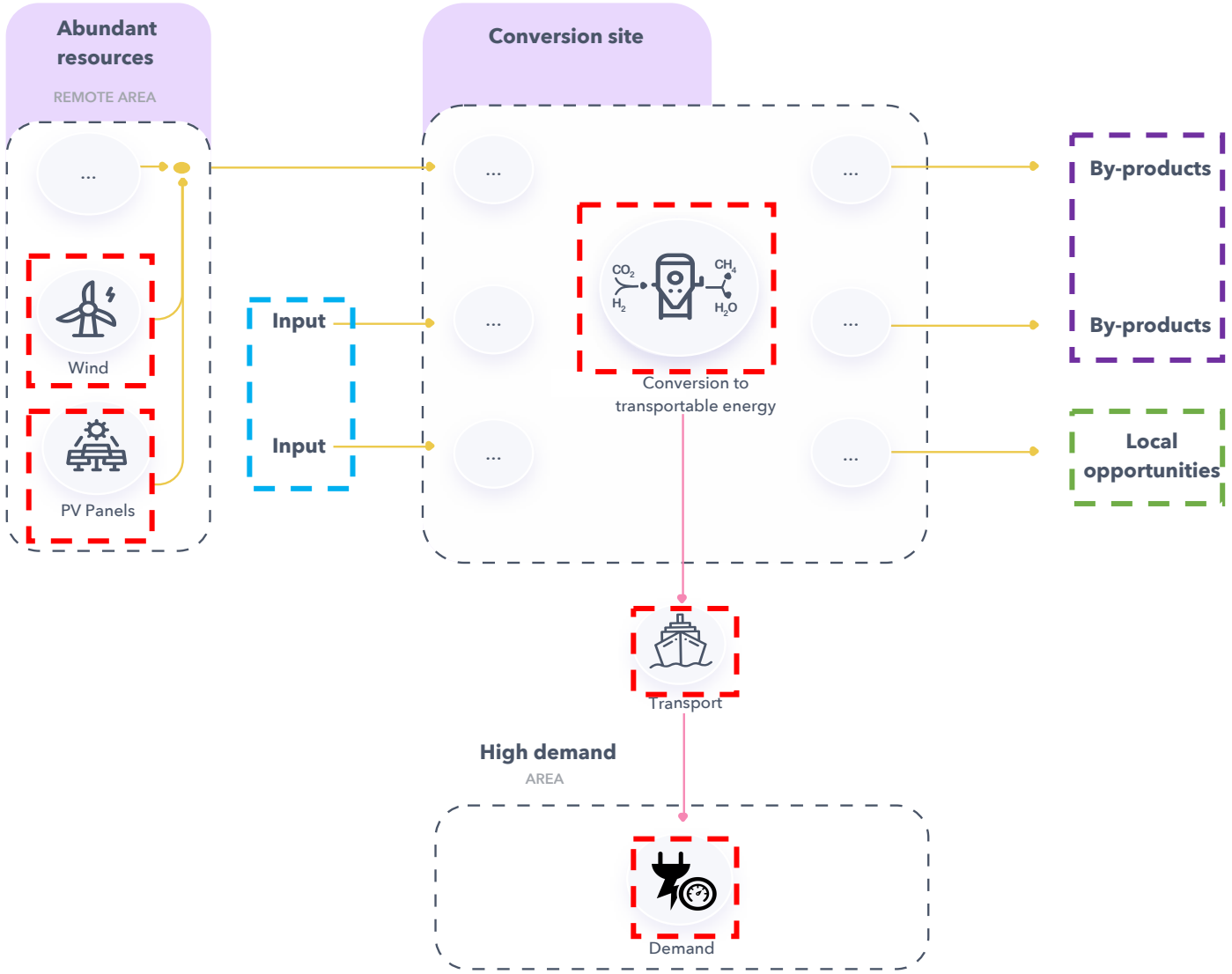
A Remote Renewable Energy Hub (RREH) is an energy hub located far away from large load centres where abundant, high-quality renewable energy is harvested.



Why RREH?

- Energy in load centers is scarce/low quality
- RREHs harvest abundant energy outside load centers
- Production of decarbonized fuel (and export)
- Can be build in parallel
- Benefit to local communities

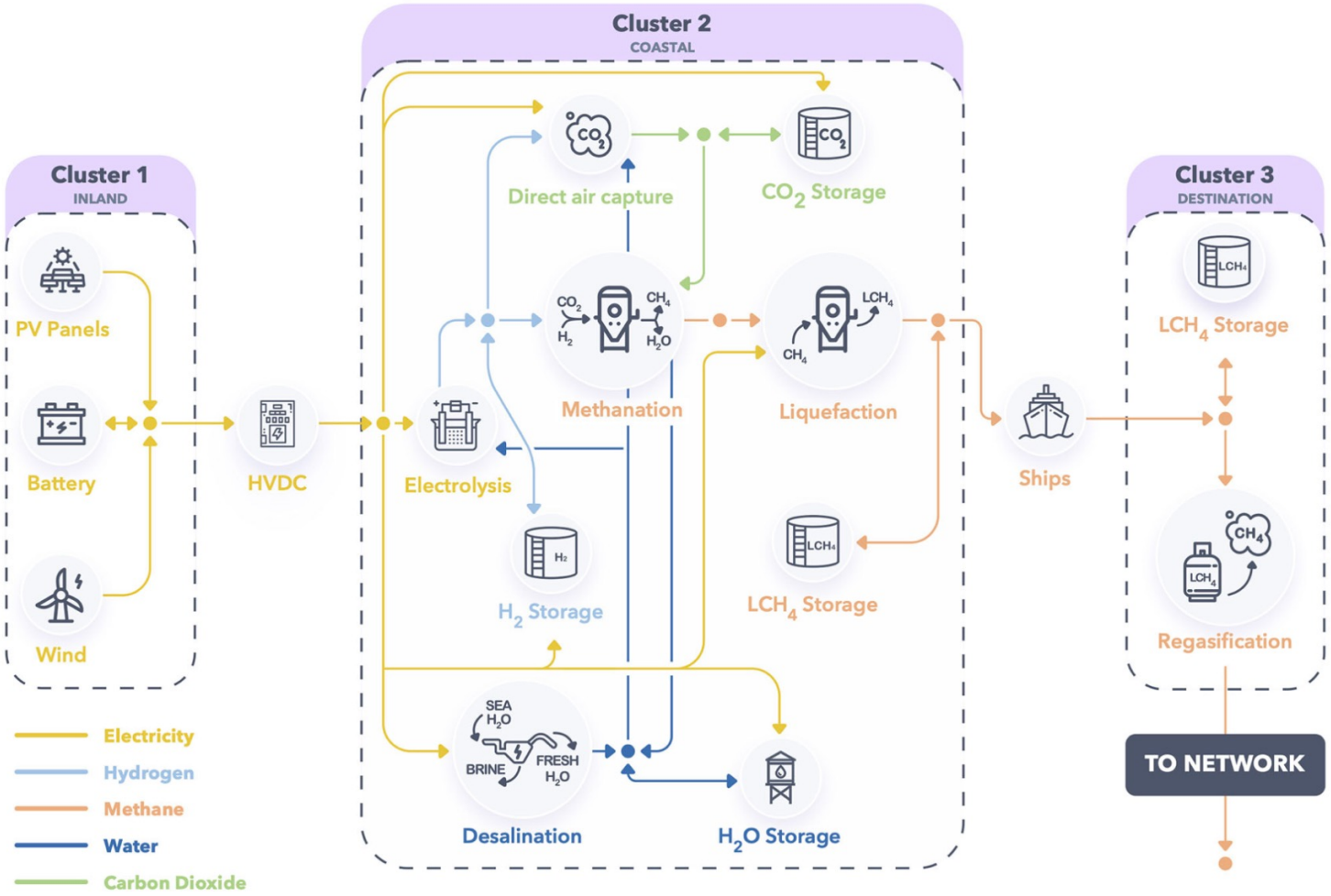
Schematic view of an RREH



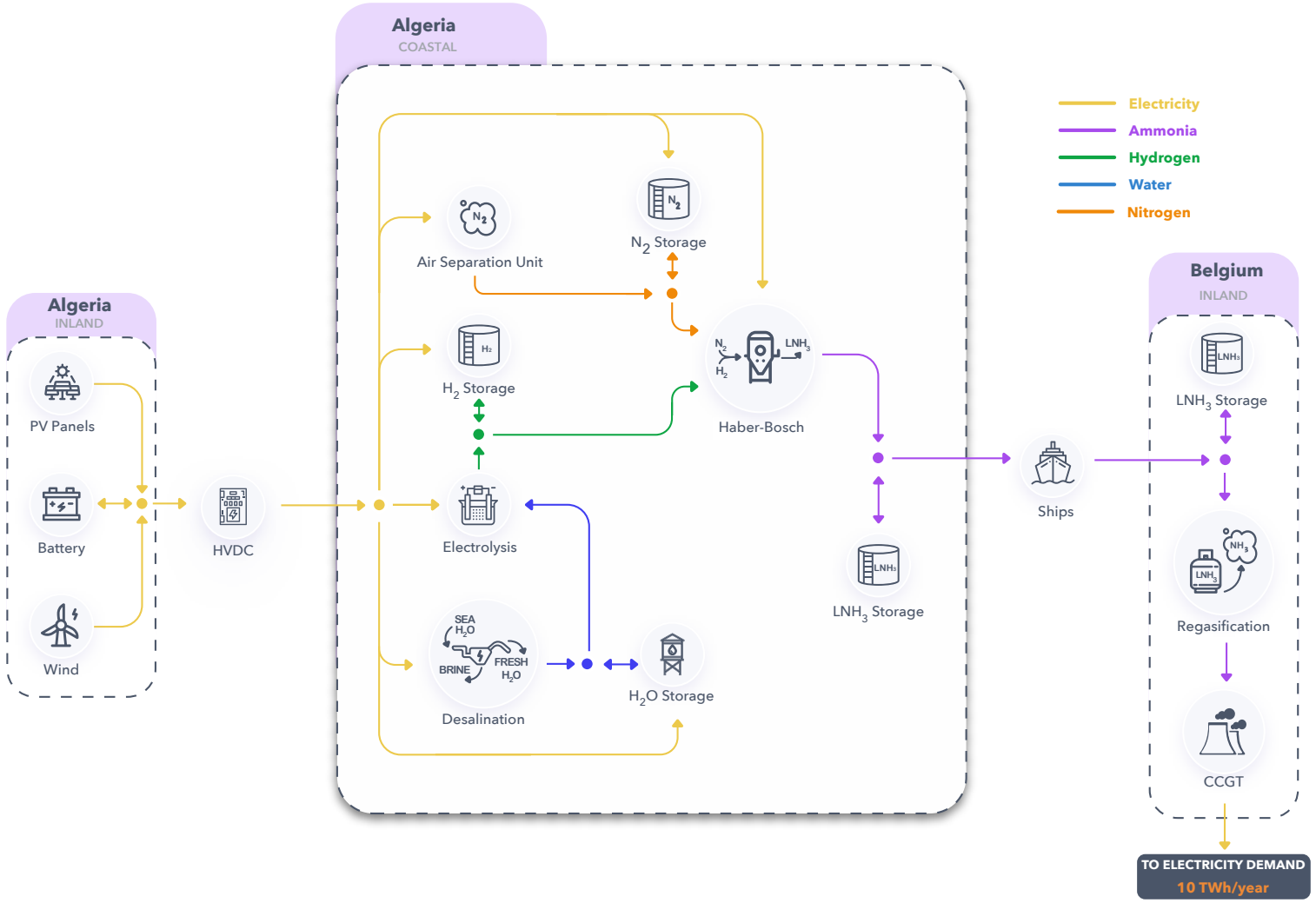
Technologies
Links
Imports
By-products
Local opportunities

Example: A hub in the desert for carbon-neutral fuel

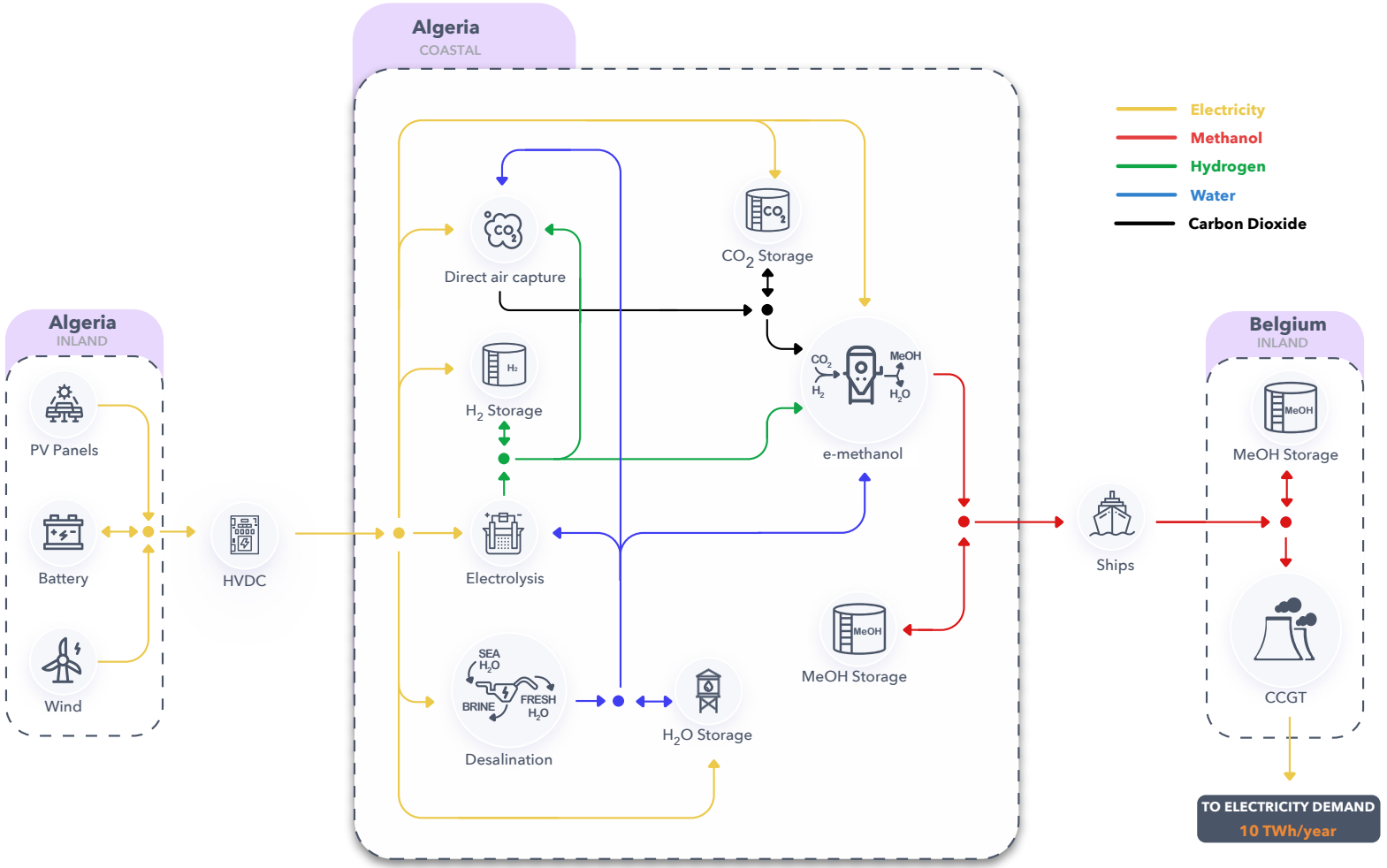
CH4 from the Algerian desert



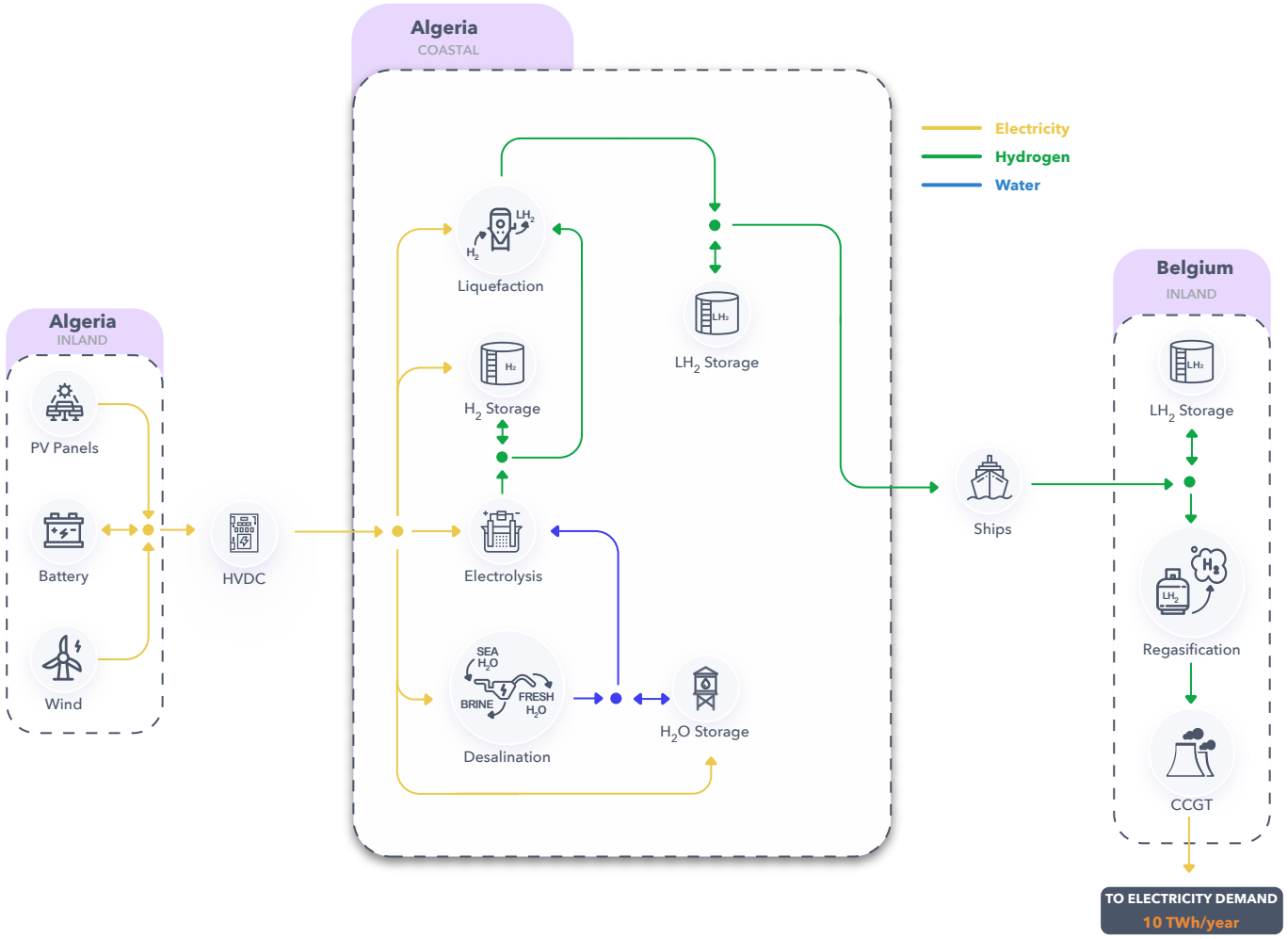
But also ammonia…

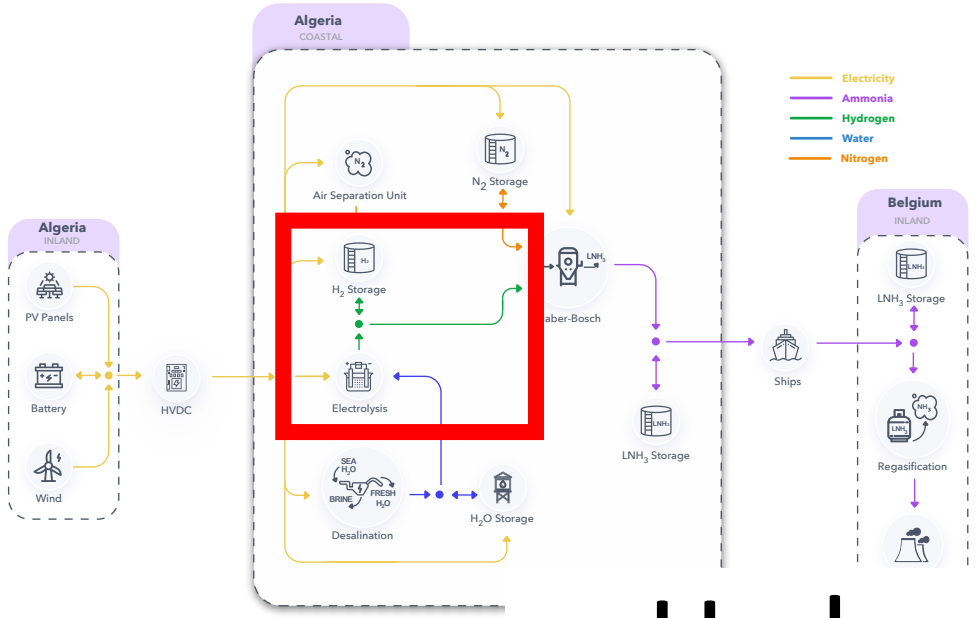


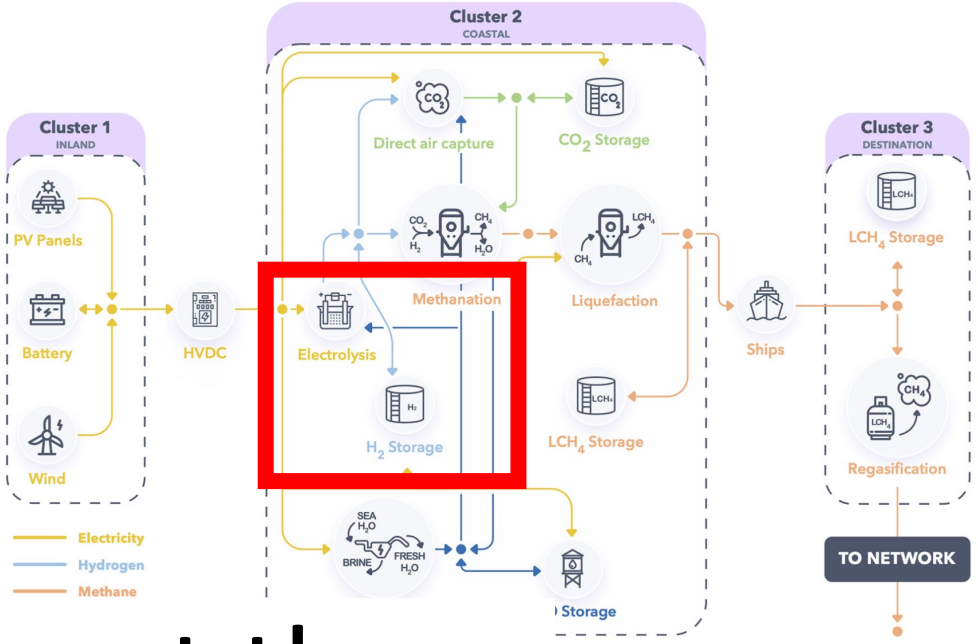
Or methanol…


Algeria
COASTAL
Algeria
INLAND
PV Panels
Battery
Wind
HVDC
Direct air capture
CO_2 Storage
H_2 Storage
e-methanol
Electrolysis
SEA H_2O
BRINE
FRESH H_2O
Desalination
H_2O Storage
MeOH Storage
Ships
Belgium
INLAND
MeOH Storage
CCGT
TO ELECTRICITY DEMAND
10 TWh/year
Electricity
Methanol
Hydrogen
Water
Carbon Dioxide

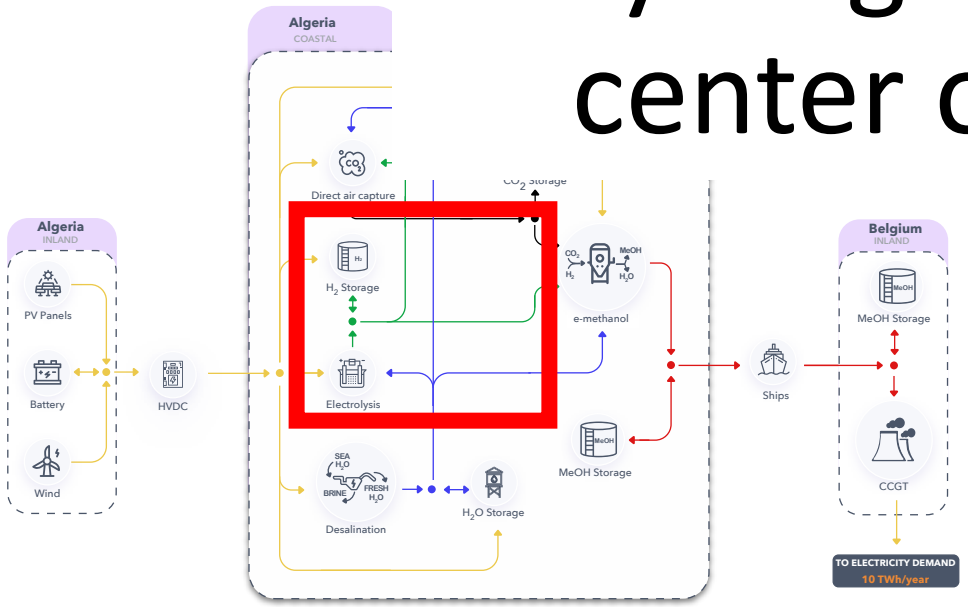
Or hydrogen directly!

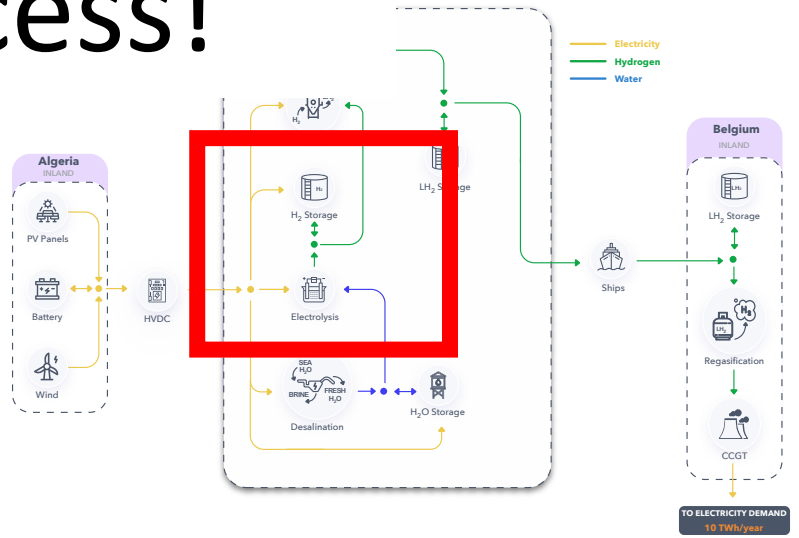






Hydrogen always at the center of the process!





Artistic representation of a ‘Dubai of Greenland’ which would emerge thanks to the significant wind resources of the country, see e.g. Radu et al. (2019).

Irrigation carousel in the Wadi Rum desert in Jordan.

Optimization of the Hubs

Two existing challenges for optimizing a hub

1. **Uncertainty:** how to take into account uncertainty related, for example, to the cost of commodities, the renewable energy profiles, the cost of technologies.

2. **Optimizing the technology:** how can we determine what improvements should be made to the technology to optimize the economy of hubs? For example, designing windmills with higher cut-out speed and rated output speed may significantly improve the economics of an RREH located in windy Greenland; see Radu et al. (2019).*

* We are currently using Reinforcement Learning (RL) techniques as a way to solve these challenges, see e.g. Boland et al. (2022).

Conclusion

- **RREHs offer magnificent opportunities for rapidly transitioning to low-carbon economies.**
- Possibility to take advantage of local opportunities for farming and water.
- Identifying the optimal hubs is a complex optimization task, especially if multi-energy vector hubs are considered.