Autonomous Roaming Offshore Wind Turbines: Unlocking the Vast Energy Resources of the High Seas

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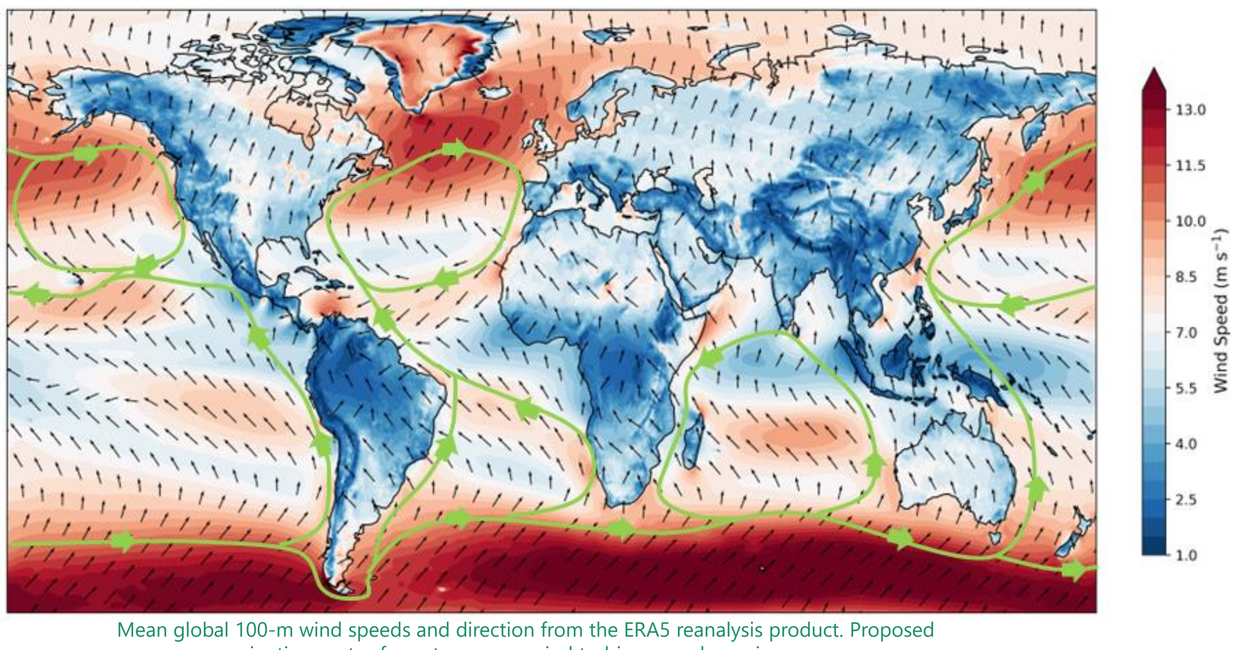
Background and Motivation

- Decarbonizing all energy sectors will require 10x more wind turbines
- Land-based and offshore coastal wind resources may not be sufficient
- Many sectors needs green fuels to decarbonize
- The wind resources on the high seas are enormous and less constrained
- Costs of mooring, anchors, and export cables are avoided
- No wake impacts and minimal permitting

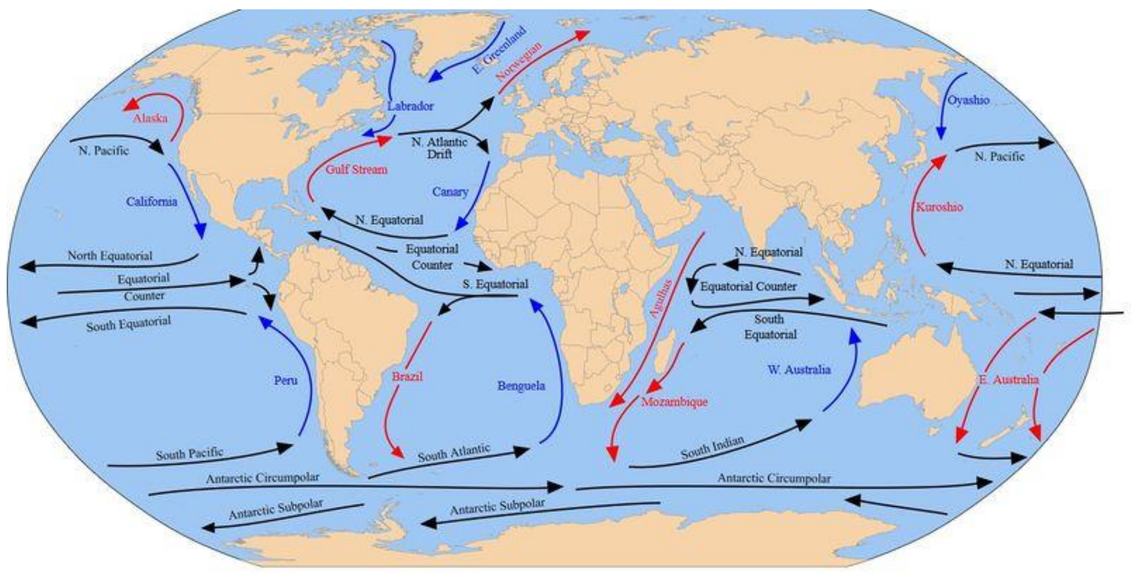
Synergy of Global Winds and Ocean Currents

Global wind circulations favor the circumnavigation of roaming wind turbines:



Mean global 100-m wind speeds and direction from the ERA5 reanalysis product. Proposed navigation routes for autonomous wind turbines are shown in green.

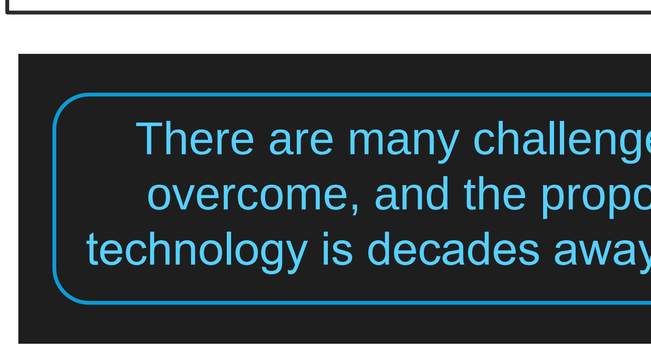
Synergy of global currents further enhances these navigation routes:



Mean global ocean currents.
http://www.coastalwiki.org/wiki/Ocean_circulation

Autonomous Navigation and AI

- Fleet of roaming wind turbines would ingest real-time weather forecasts,
- Use swarm intelligence to avoid storms, reduce wakes, find better winds, and,
- Leverage rapid advancements in autonomous sailboats



Autonomous sailboat technology is developing rapidly
https://www.geospatialworld.net/blogs/autonomous-sail-boats/

Swarm intelligence at work in a school of fish.
Credit: Thinkstock

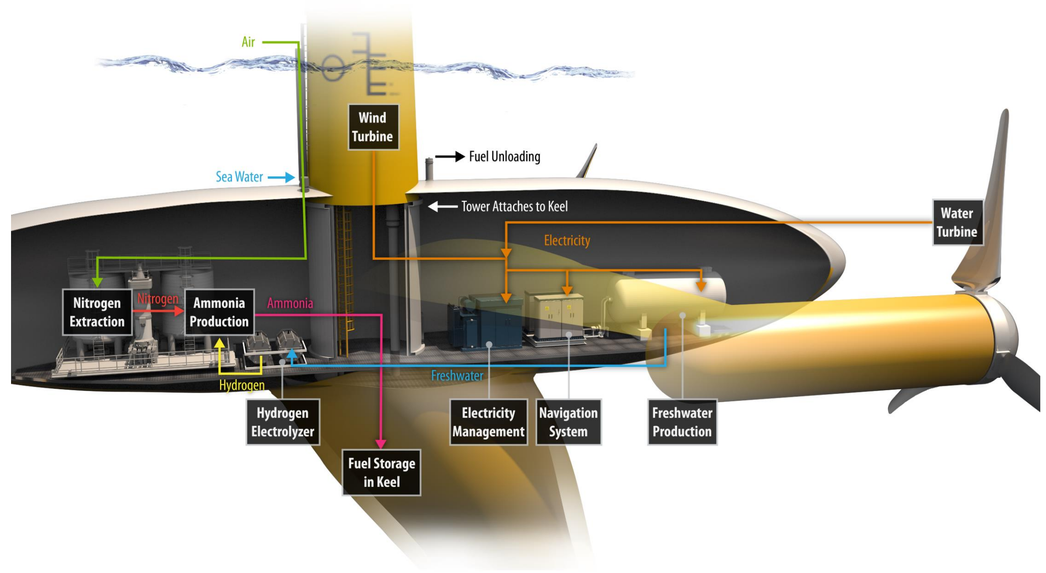
Major Technology Challenges

- Cost and uncertainty of a mobile, small-scale green ammonia production plant
- Reliability and maintenance of autonomous systems
- Federal and international permitting uncertainty
- Security issues (e.g., piracy)
- Damage from storms, obstacles, etc.
- Logistics of fabrication and launching, fuel transfer at ports, and maintenance

Artistic rendering of an autonomous roaming offshore wind turbine. Copyright: NREL.

Making and Unloading Fuel

- Produce green ammonia inside hull and store in keel
- Unload at ports or energy islands around the world



Artistic rendering of the inner-hull ammonia production facility. Copyright: NREL.

Global ammonia terminals as of 2020
Valentini et al., Argus Media, 2020

Source: https://currentaffairs.adda247.com/worlds-first-energy-island-to-be-built-by-denmark/

Could roaming wind turbines unload fuel at future energy islands?

There are many challenges to overcome, and the proposed technology is decades away, but…

…Many of the required R&D efforts are independently underway and rapidly advancing, and…

…If we are going to decarbonize the global economy, we are likely going to need these winds