AIRBORNE WIND ENERGY CONFERENCE 2015

Wind Fisher - Autonomous Kite Towed Submarine for Airborne Wind Energy Capture and Storage

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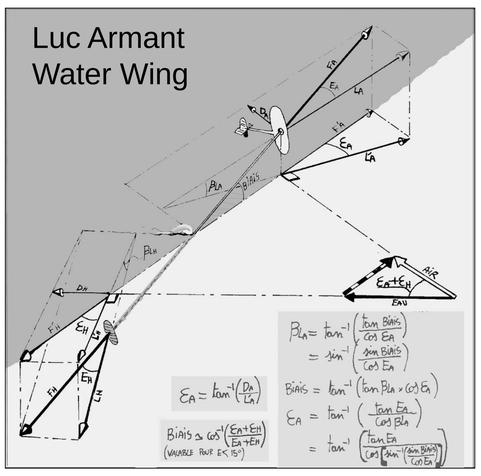
Abstract – **Wind Fisher is a new start-up project, based in France, designing and developing an autonomous maritime platform, consisting of a Magnus effect, lighter-than-air kite, pulling a submarine with marine current turbines for electrical generation and with a chemical synthesis plant for energy conversion and storage. Wind Fisher submarines are designed to operate in the Southern Ocean around Antarctica, isolated from other human activities, to chase the persistent winds in this region. The system is forecast to produce renewable ammonia fuel at $50 per barrel of oil equivalent.**

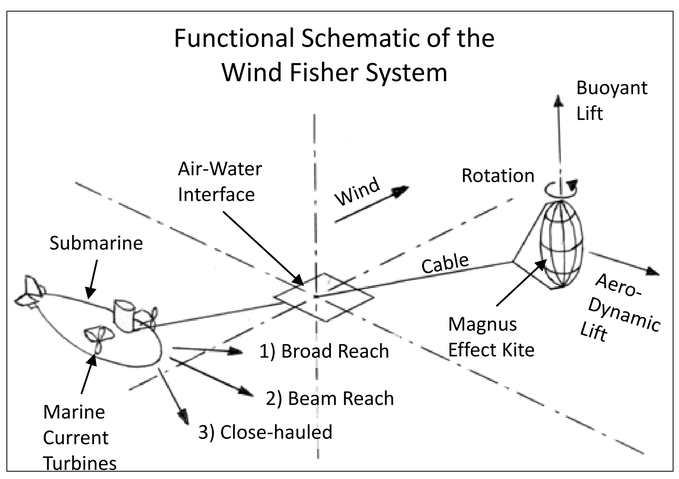
1- Context / System Architecture

Wind + Air + Water = Energy

Key Features:

- ✓ Magnus effect kite – dynamic flight, excellent gust response, durable textiles
- ✓ Solid State Ammonia Synthesis (SSAS) – converting wind to storable fuel
- ✓ Water wing architecture – tested & proven by Luc Armant in 2000



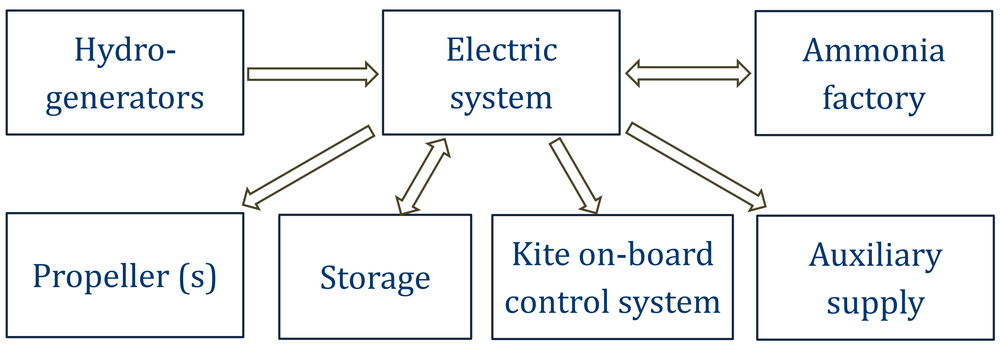


Problems solved:

- ✓ Airspace is free of air traffic over the high seas at 500-1500m altitude.
- ✓ Visual pollution & NIMBY are resolved due to operations over-the-horizon.
- ✓ Limited launch & recovery operations due to lighter-than-air solution.
- ✓ Regular maintenance in port under controlled conditions means lower cost.

3- Electric System

Objective: Use marine current turbines to convert kinetic energy to electricity to supply the kite, SSAS and submarine systems.



- ✓ Autonomous system, remotely monitored via satellite link.
- ✓ Design trades for life-cycle cost optimization should be made.
- ✓ An MTBF>2 months and fail-safe degraded operating modes.
- ✓ Two main modes of operation:
  - **Hydro generators supply the submarine: Dominant operation mode.** The electric system supplies the Ammonia factory, and the other parts of the system. Excess power is stored in batteries.
  - **The Ammonia factory supplies the submarine: Navigation against the wind and in port.** Ammonia is burned in spark-ignition generators to provide electric power to drive the propeller(s) and auxiliary systems.

2- Renewable Fuel Synthesis

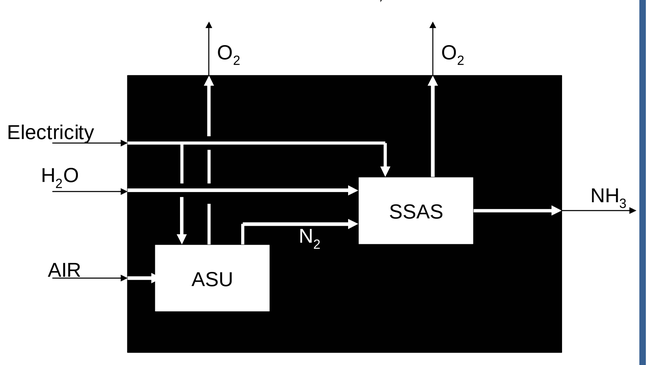
Employment of solid state ammonia synthesis (SSAS) for renewable energy conversion and storage.

Benefits:

- ✓ Ensure the availability of energy despite the discontinuity of the renewable energy resource.
- ✓ Provide an affordable carbon free, hydrogen-based fuel: NH3.
- ✓ Ammonia transportation & storage is a well-established technology.
- ✓ Ammonia can be used directly as a fertilizer, be cracked to generate Hydrogen, or supply an ICE Genset and produce electricity.

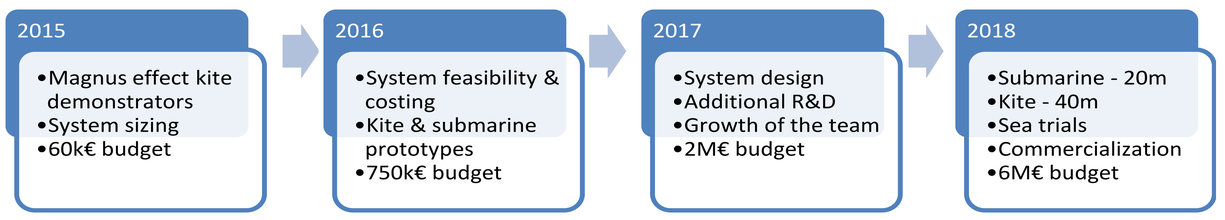
Solid state ammonia synthesis (SSAS)

$$6\ H_2O + 2\ N_2 \Rightarrow 3\ O_2 + 4\ NH_3$$

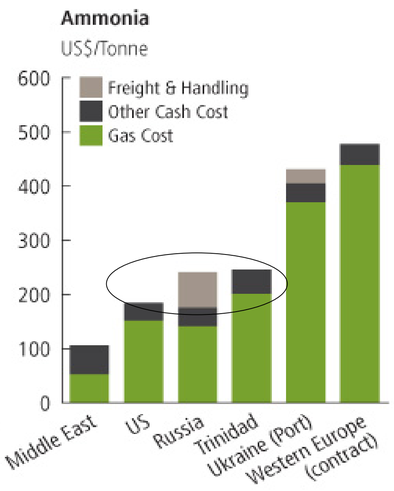


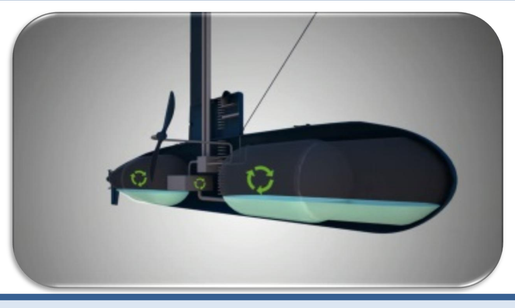
Energy consumption 7,000 – 8,000 kWh per ton NH_3

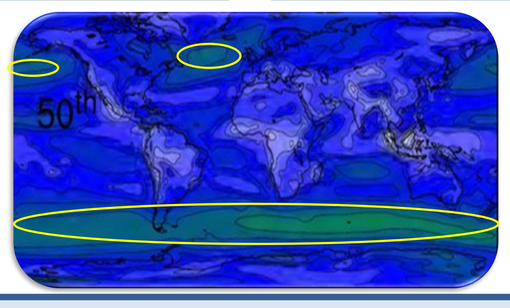
4- Business Development

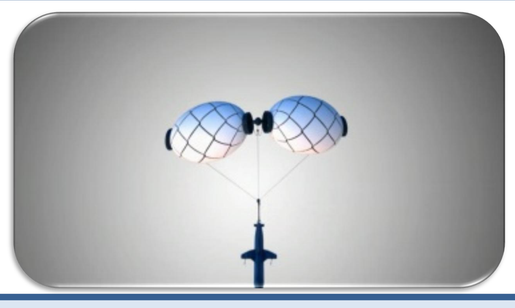


- ✓ Spin-off new company from Cosmica Spacelines
- ✓ Ammonia market is robust, 200Mt/year, with forecast capacity growth of 10Mt ($10B) per year.
- ✓ NH3 market pricing is between $400-$600/ton
- ✓ $ 3M for 1MW system → LCOE $400/ton NH3
- ✓ $10M for 5MW system → LCOE $260/ton NH3
- ✓ Renewable NH3 fuel creates local jobs for island nations seeking complete energy independence.
- ✓ 10,000 submarines will occupy less than 0.2% of ocean surface between 40°-60° south latitude.









Work status

- Literature review complete and preliminary theory shows clear technical feasibility
- Economic model developed to validate economic feasibility based on manufacturing costs, capacity factor and operations/maintenance costs. NH3 produced at $150-300 per ton.
- Wind resource evaluations done at multiple island locations showing capacity factor of 65-85%

Perspectives

- Small scale kite & submarine prototypes, exploratory flight/tow testing, and feasibility study to be finished by end 2015. IP protection in process.
- Opportunities for partnerships to promote concept & advance technology.
- Grant applications in progress. 2nd investment round for end 2015.

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Collaboration

- GIPSA-Lab
- Airstar
- NHThree
- Impulse Partners