Introduction to
Airborne Wind Energy

Airborne Wind Europe

2 February 2022

IEA Wind Task 51 Kick-off Meeting

Kristian Petrick

Airborne Wind Europe

Interreg North-West Europe MegaAWE

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Airborne Wind Europe – members and collaboration

Our members are leading AWE companies, universities, research centers, suppliers, customers and supporters of the AWE industry.

Member of:

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Airborne Wind Europe

Concepts: Soft, semi-rigid and rigid wings; ground-gen vs. fly-gen

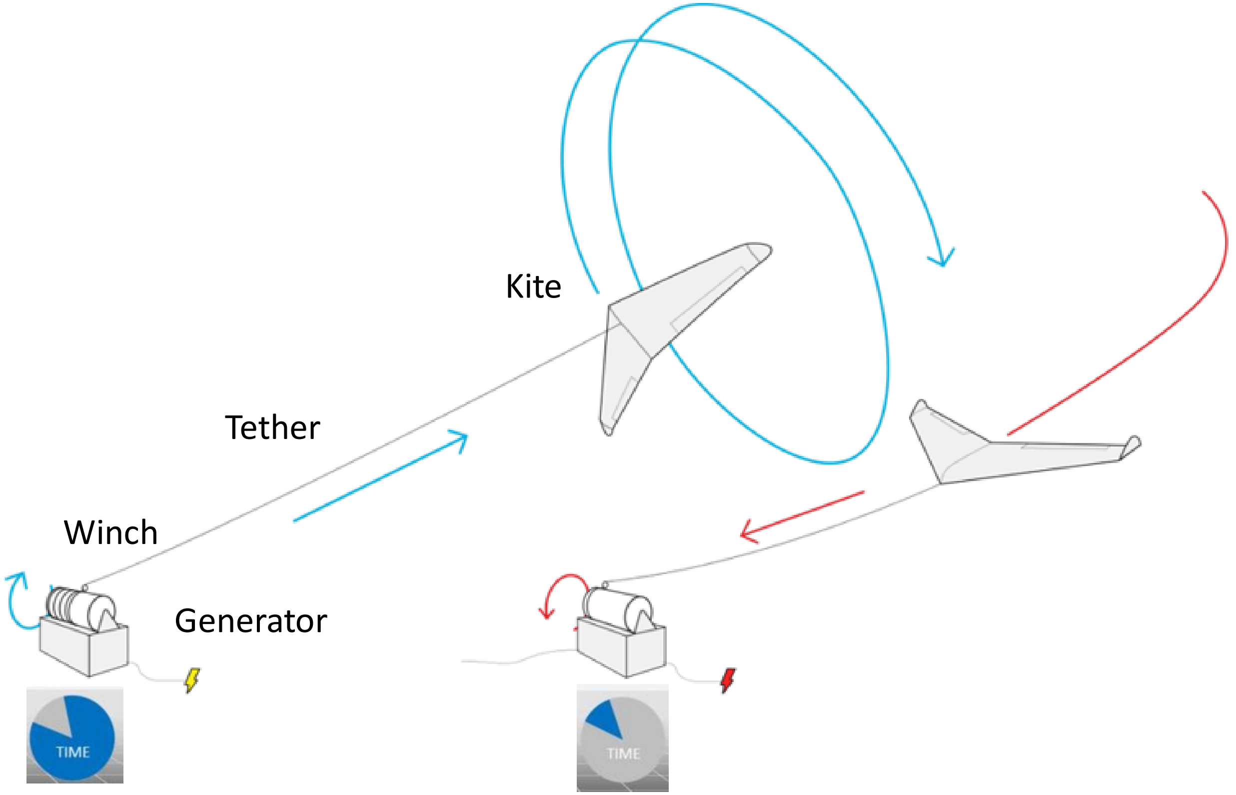
KITEPOWER™ EnerKite ampyx power KITEMILL TWINGTEC WIND ENERGY 2.0

SkySails SKYPULL WIND FOR ENERGY RWTH AACHEN UNIVERSITY KITE//KRAFT Windswept & Interesting

Two main generation principles for cross-wind AWE systems

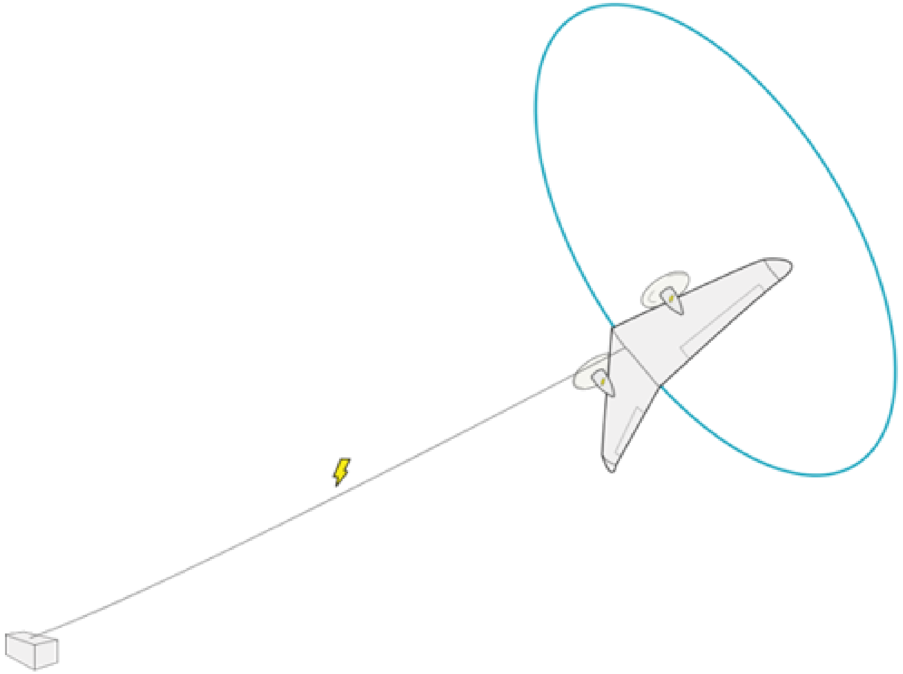
Ground-gen (or yo-yo principle)

With reel-out and retraction phase

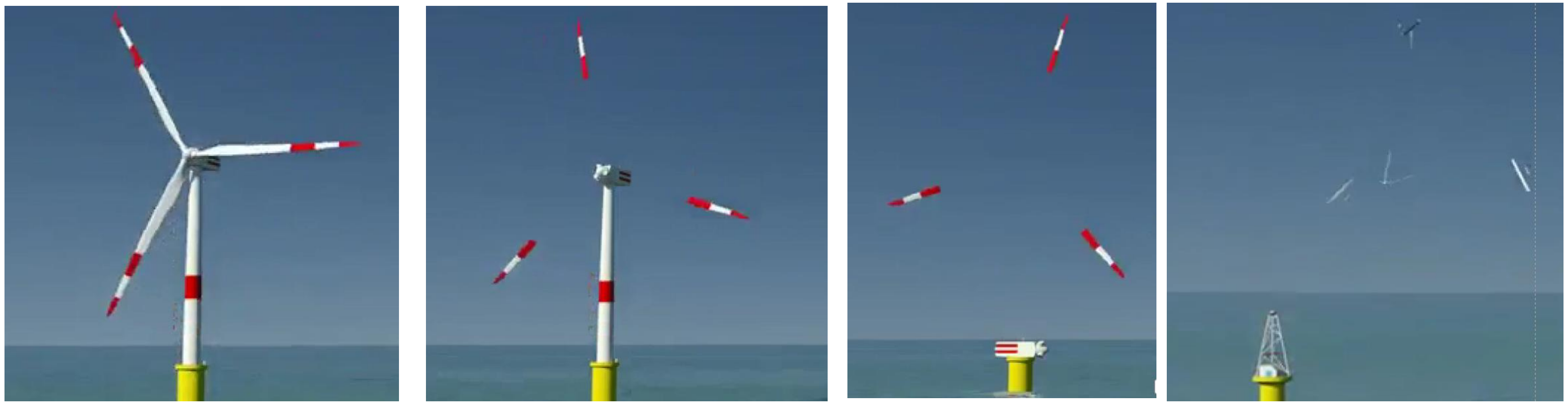


Fly-gen

On-board generation and
power evacuation through the tether

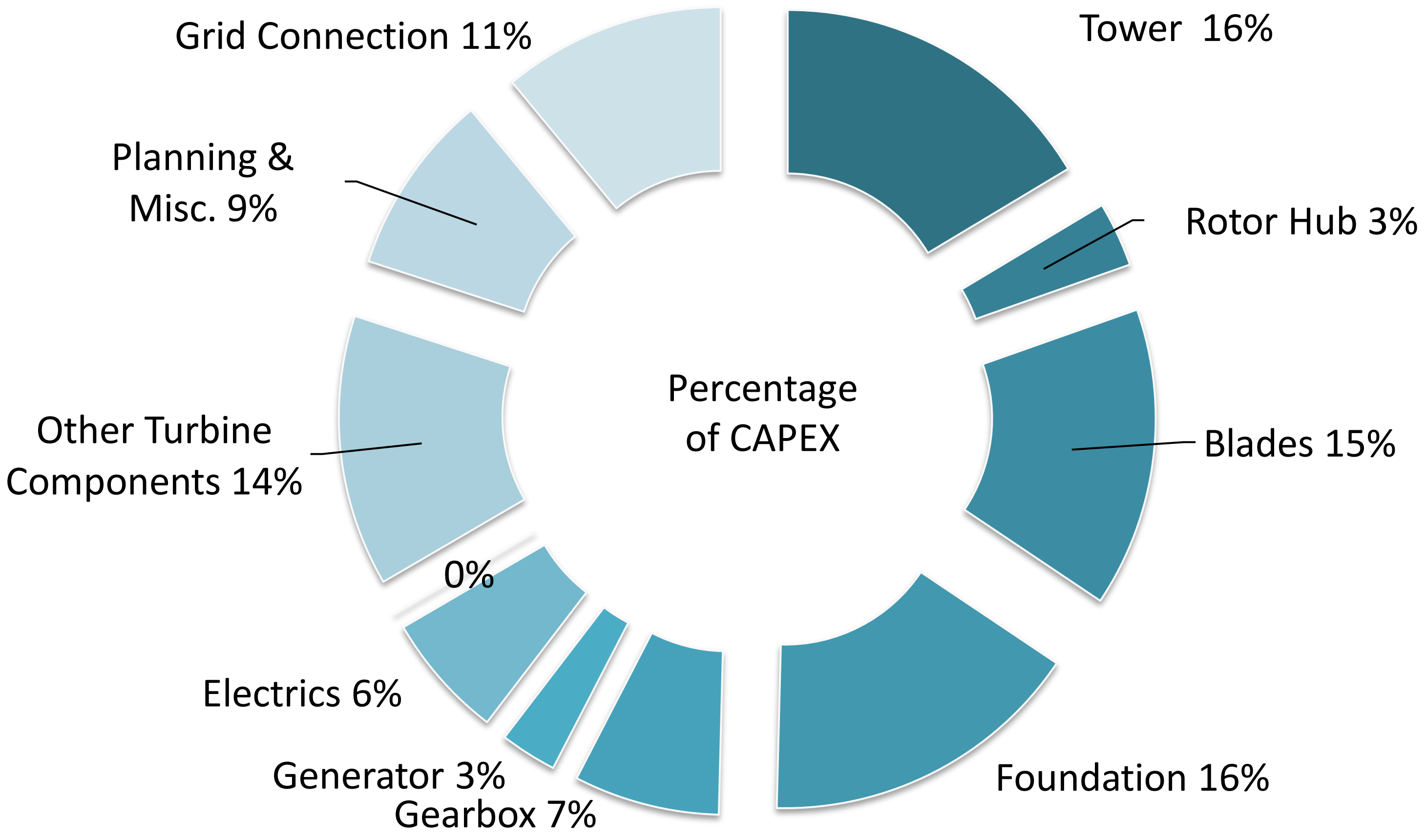


The general idea: Emulating the movement of a blade tip but at higher altitudes



Source: Erc Highwind https://www.youtube.com/watch?v=1UmN3MiR65E Makani

Lower material costs – a large share of a conventional turbine‘s cost structure is for tower, blades and foundation

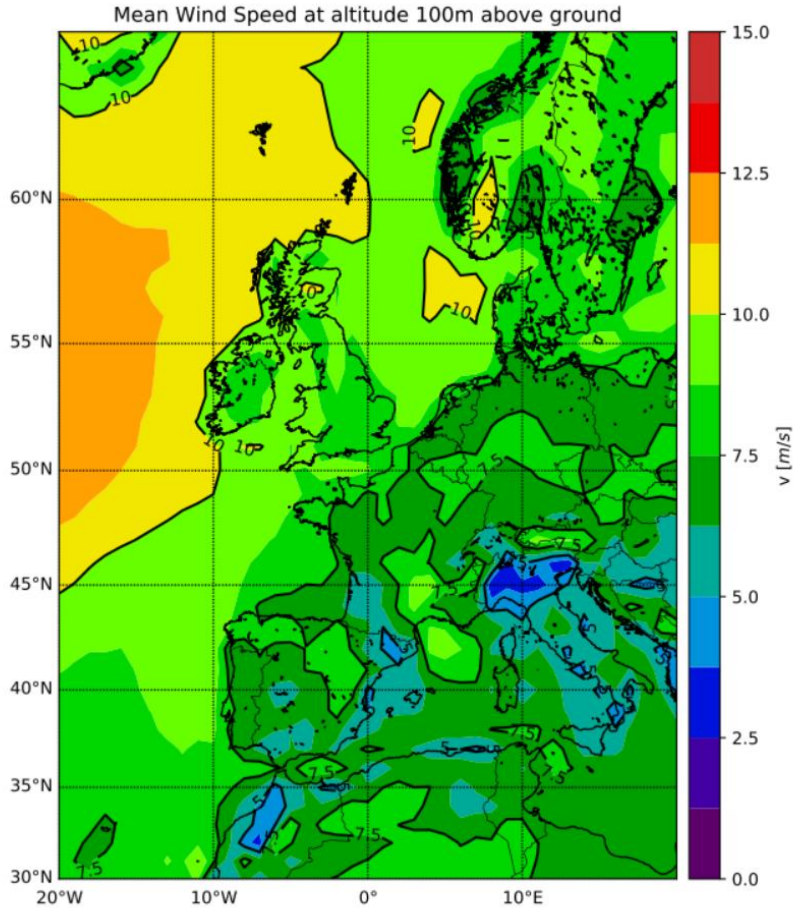


Source: IRENA

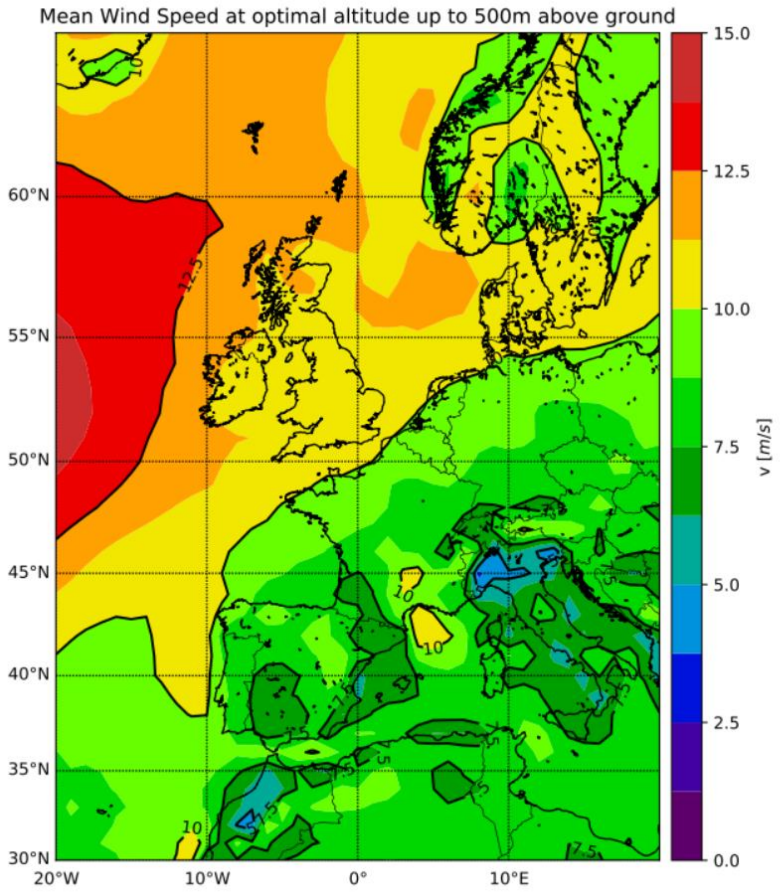
AWE systems require about 90% less material than conventional wind turbines.

“AWE is substituting hardware with software”.

More available wind resources (example: Europe)



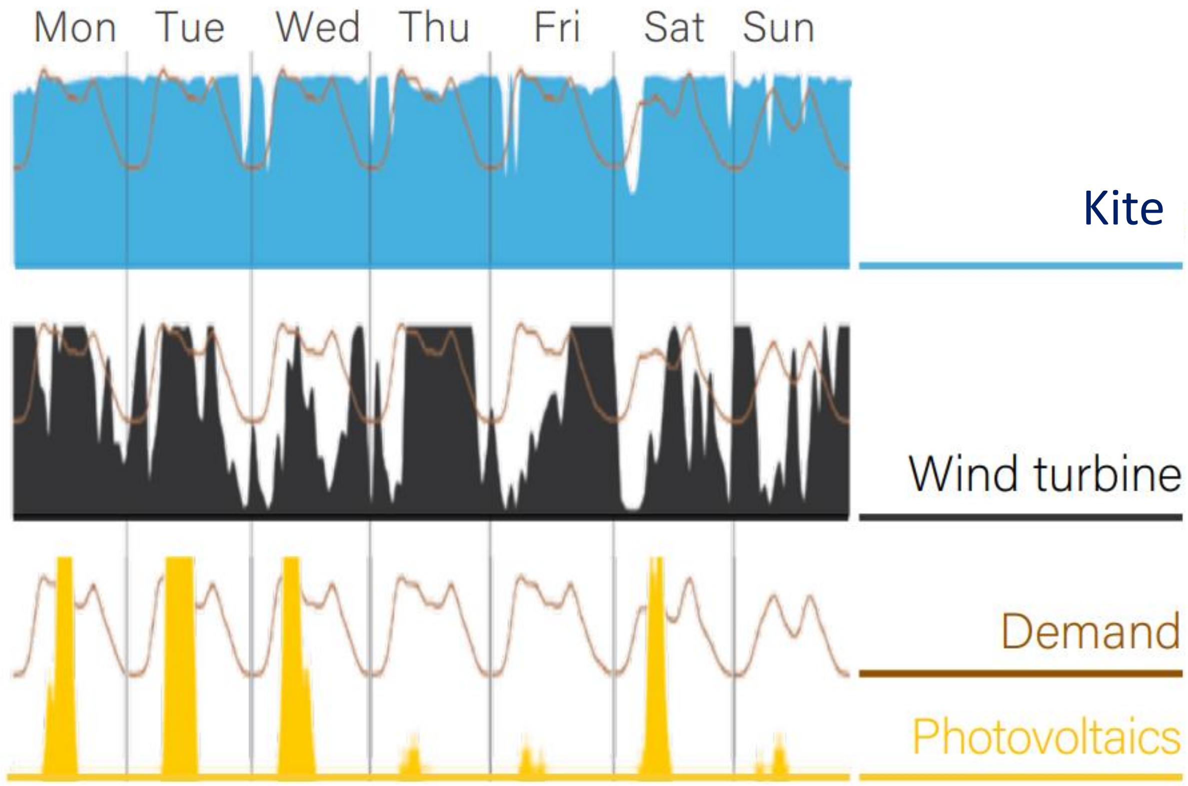
Source: Bechtle et. al., wind data: ERA5



> 7.5 m/s: Excellent conditions

More full load hours, more constant electricity production, less intermittency, better system integration

Higher capacity factor (60%-80% or beyond) compared to conventional wind (30-60%) and solar (15-25%)



Graph: Enerkite

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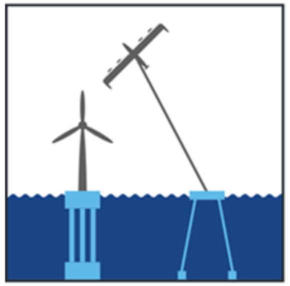
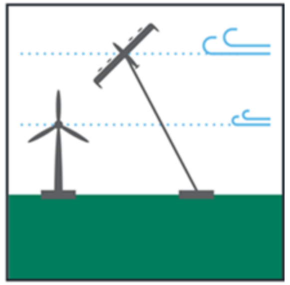
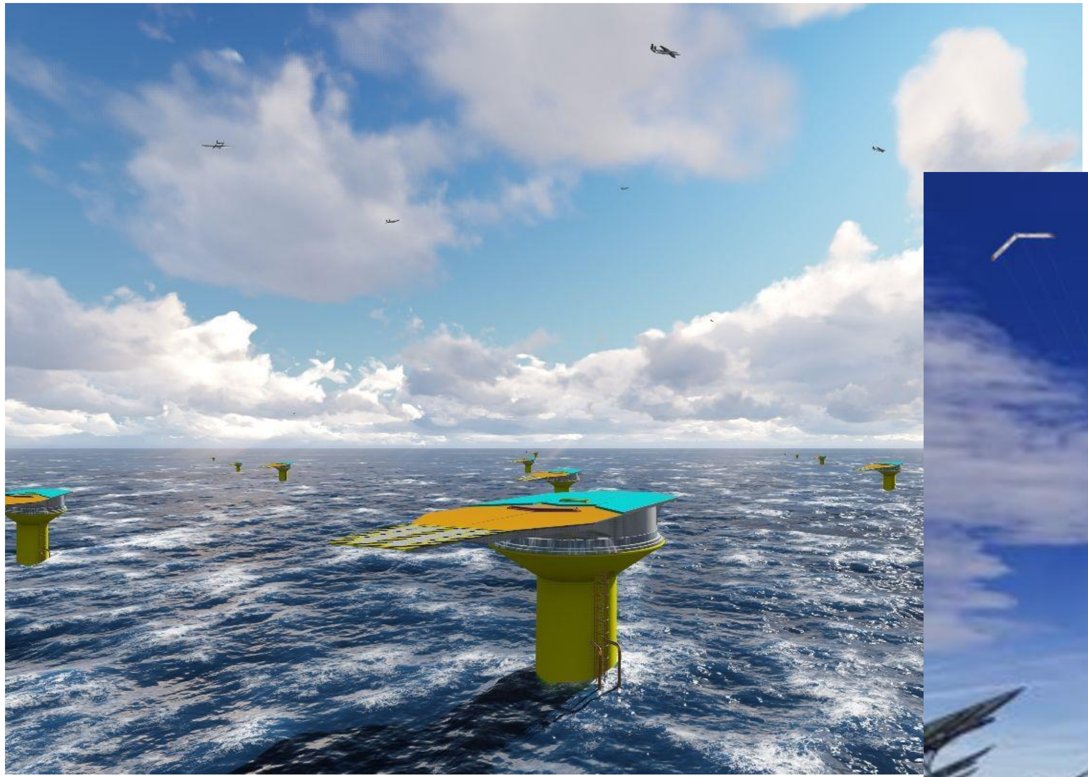
Airborne Wind Energy is a promising technology with a large potential

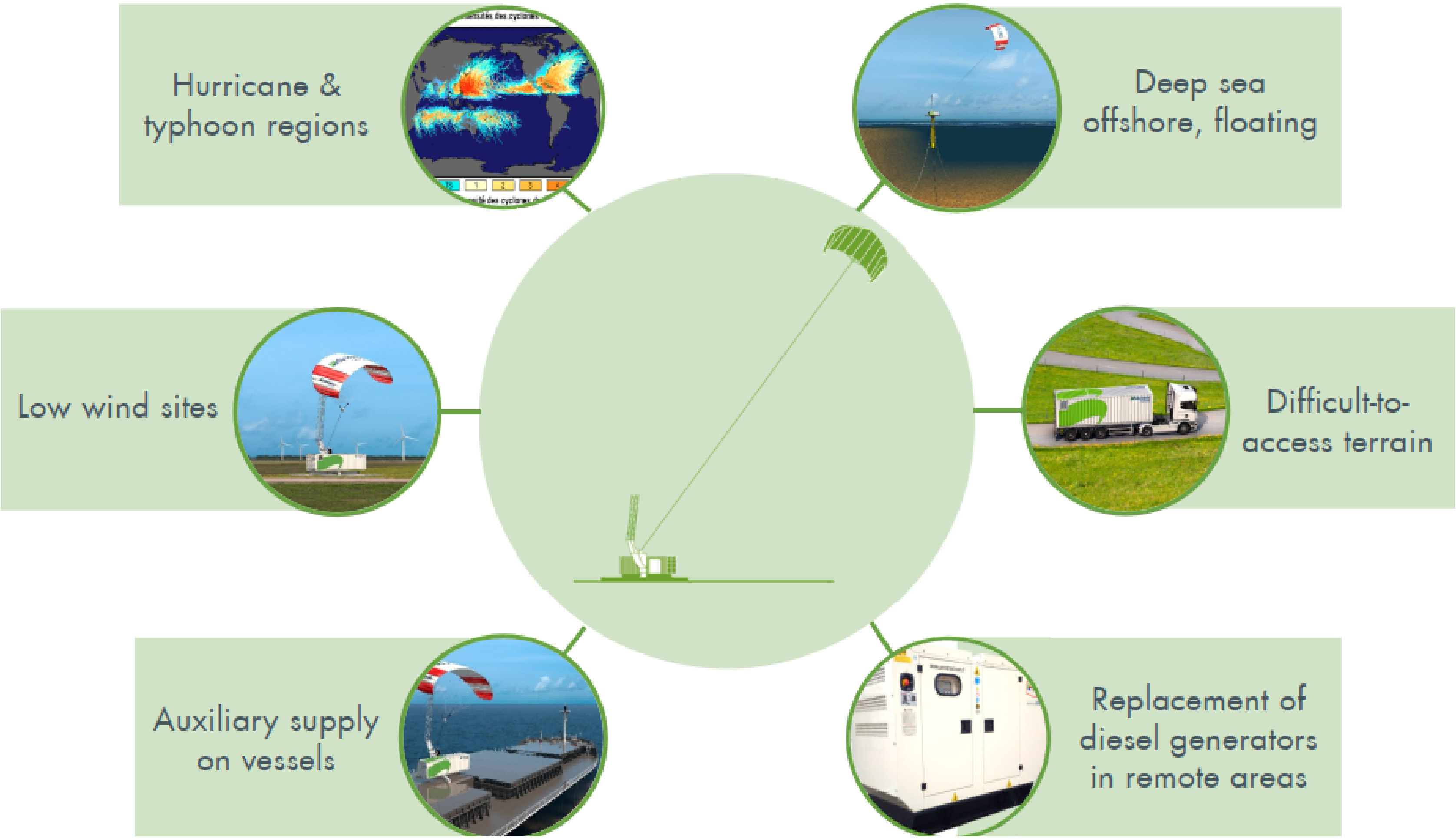
- **Less material:** small carbon footprint, low visual impact, less use of resources
- **Additional wind resources:** increasing global renewable energy potential
- **High capacity factor:** more constant electricity production for system integration


- **Low LCOE:** potential for lower cost of energy produced
- **Flexibility:** easier logistics, quick set-up
- **Scalability:** from few kW to several MW
- **New markets:** Repowering, floating offshore, off-grid

On- and offshore AWE applications including repowering; distributed installations and large-scale farms



Niche Markets

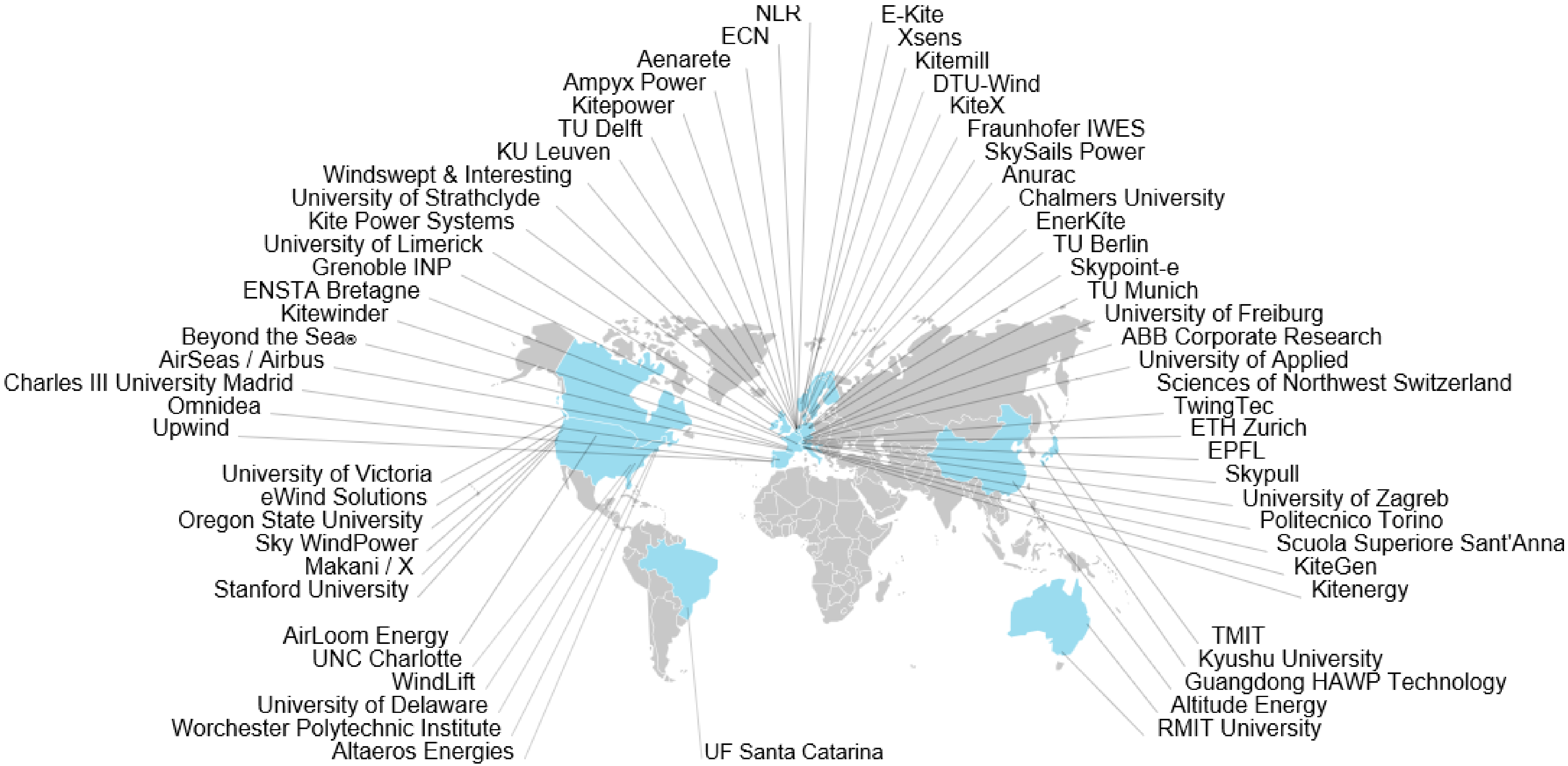


Source: Skysails

The first commercial AWE systems are already today competitive in markets with diesel-based power generation

https://www.skysails-group.com/index.html?artikel=Kite-Power-For-Mauritius

AWE is a global technology



Source: TU Delft

A way to collaborate: the New Task 48 on Airborne Wind Energy of IEA Wind

- The IEA Wind TCP is an international co-operation platform within the IEA framework
- It shares information and research activities to advance wind energy research, development and deployment in member countries.
- Currently 26 contracting parties from 21 countries
- Nine of these countries support Task 48 on AWE
  - BE, CH, DE, DK, ES, IE, NL, UK, US.
- 4-year period: 2021 – 2024
- Kick-off: 27-28 October 2021:
  - 100 participants from 15 countries and over 60 institutions
- https://iea-wind.org/task48/

International Energy Agency

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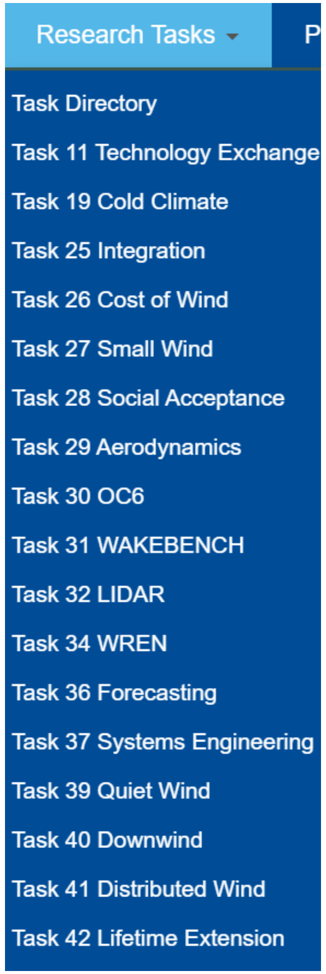
- Other themes/TCPs:
  - Buildings
  - PV, hydro, …
  - Industry
  - Transport
  - Fossil energy
  - etc.



Five Working Groups

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IEA Task on AWE: Enabling the safe and widely supported deployment of AWE by bringing together academia, government & regulators, society and industry

WP0: Task coordination	WP1: Resource potential and markets	WP2: Reference models, tools and metrics	WP3: Safety and regulation	WP4: Public Acceptability	WP5: AWES architectures
• Organisation & management of Task • Communication • Website • Dissemination	• AEP prediction for selected sites & toolchain documentation • Global high-altitude wind resource atlas • Recommendation on AWE entry-markets	• Common definition of metrics and KPIs • Joint reference model(s) • Centralized design tool • Simulation vs. test flights comparison	• Concept of operations and risk assessment • Airspace integration concept • Benchmarking concepts for safe automatic operation	• Life-Cycle Analysis • Repository of survey and studies • Guidelines for site selection, sound measurement and impact mitigation • Circular Economy	• Design space representation • Market specific deployment recommendations • AWES R&D state, trends and needs • Portal for AWES engagement and development potential
• Task reporting • Communication outputs	• AEP prediction toolchain • Economic metrics	• Definitions • Centralized design tool database	• Whitepaper on AWES safety	• LCA of AWE • Repository of surveys & studies	• Guidelines

Overarching goals (from task proposal)

- Goal 1 – Develop a global higher-altitude wind resource atlas for altitudes (up to ~1 km).
- Goal 2 – Create a techno-economic toolchain for AWE that allows developers to assess how expensive a system is expected to be and how expensive it can be to be economically viable, based on the market.
- Goal 3 – Consider AWE systems on individual system and on wind park level and their potential contribution to future energy systems.

- WP 1 Lead: Roland Schmehl, TU Delft, r.schmehl@tudelft.nl

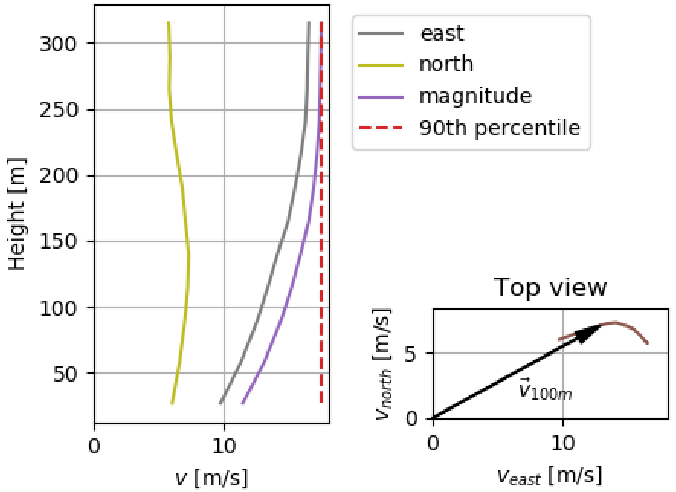
New approach: increase accuracy by using multiple realistic wind profile shapes from data

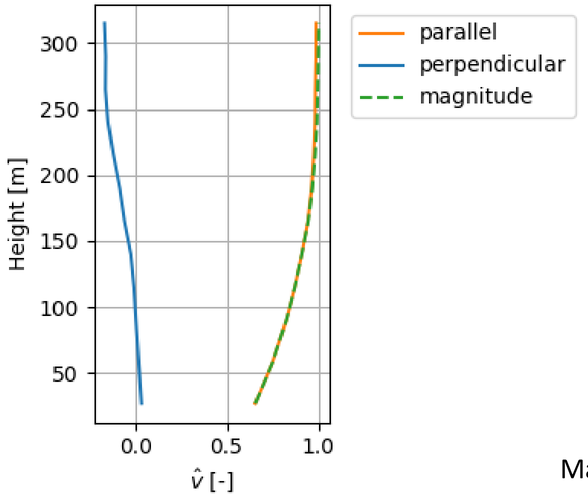
Data should include wind speeds/ directions at multiple heights

- ERA5 reanalysis data
  - 1979 to 3 months of real time
  - 31 km grid
  - Local terrain is not resolved
- LiDAR observations
  - Poor availability
  - Good accuracy

Obtaining **wind profile shapes**

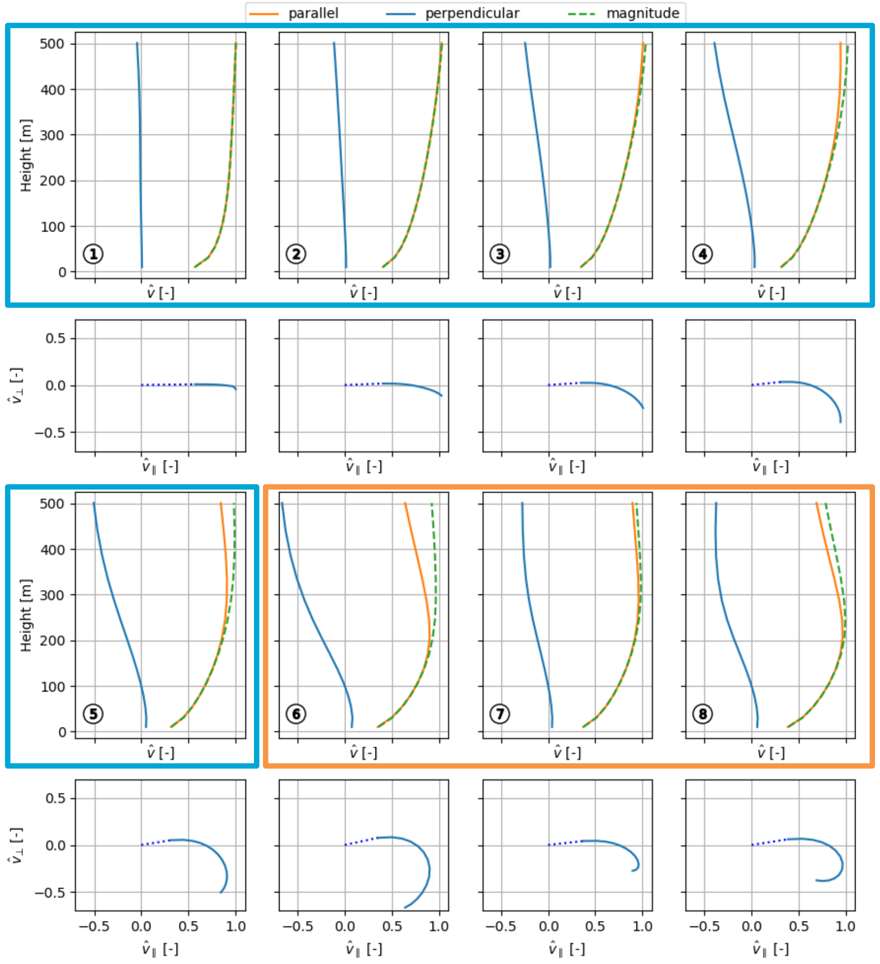
- LiDAR data is hourly averaged
- Wind speed variation is expressed by parallel & perpendicular components w.r.t. 100 m wind speed
- Wind profiles normalised using 90th percentile of wind speed magnitudes





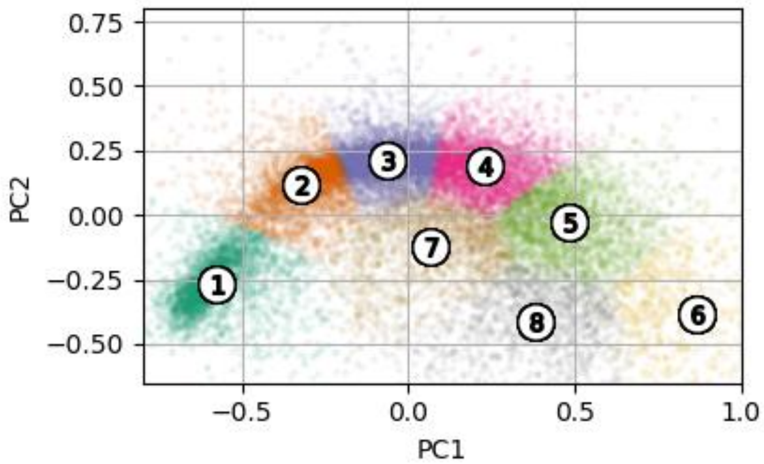
Mark Schelbergen, TU Delft

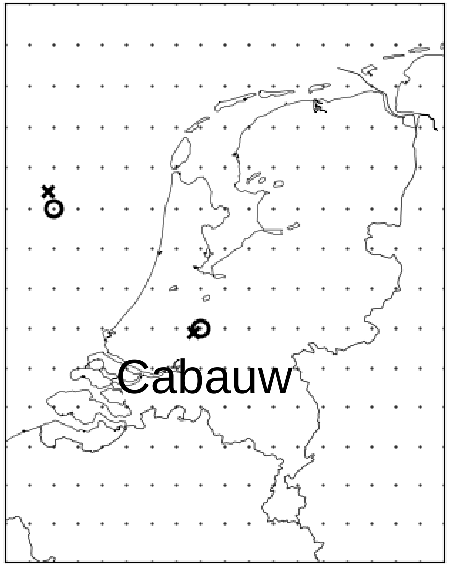
Example: eight cluster profiles for Dutch onshore location



Cabauw:

- #1-5: Log profiles (blue)
- #6-8: Low level jets (orange)





Mark Schelbergen, TU Delft

Value driven system design

- Necessity of designing systems **beyond LCoE**
  - Time dependent revenue generation capability is not captured
  - Contribution to grid stability is not captured
- Drivers like **LPoE** (Levelized Purchasing of Electricity)**, capacity factor, frequency and voltage regulation** will become more relevant in future
- Different markets will have **different design drivers**
  - Utility-scale (>10MW)
  - Off-grid/micro-grid (<1MW to multiple MW)
  - Frequency and voltage regulation
  - Power to gas (e.g. Hydrogen)

Rishikesh Joshi, TU Delft

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Please consider AWE in wind forecasting, i.e. up to 500m – 1000m altitude.
We look forward to a future collaboration with Task 51!

Thank you for your attention!

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