Airborne Wind Energy
Short introduction and current status

IEA Wind TEM#102
on
Airborne Wind Energy

23 September 2020

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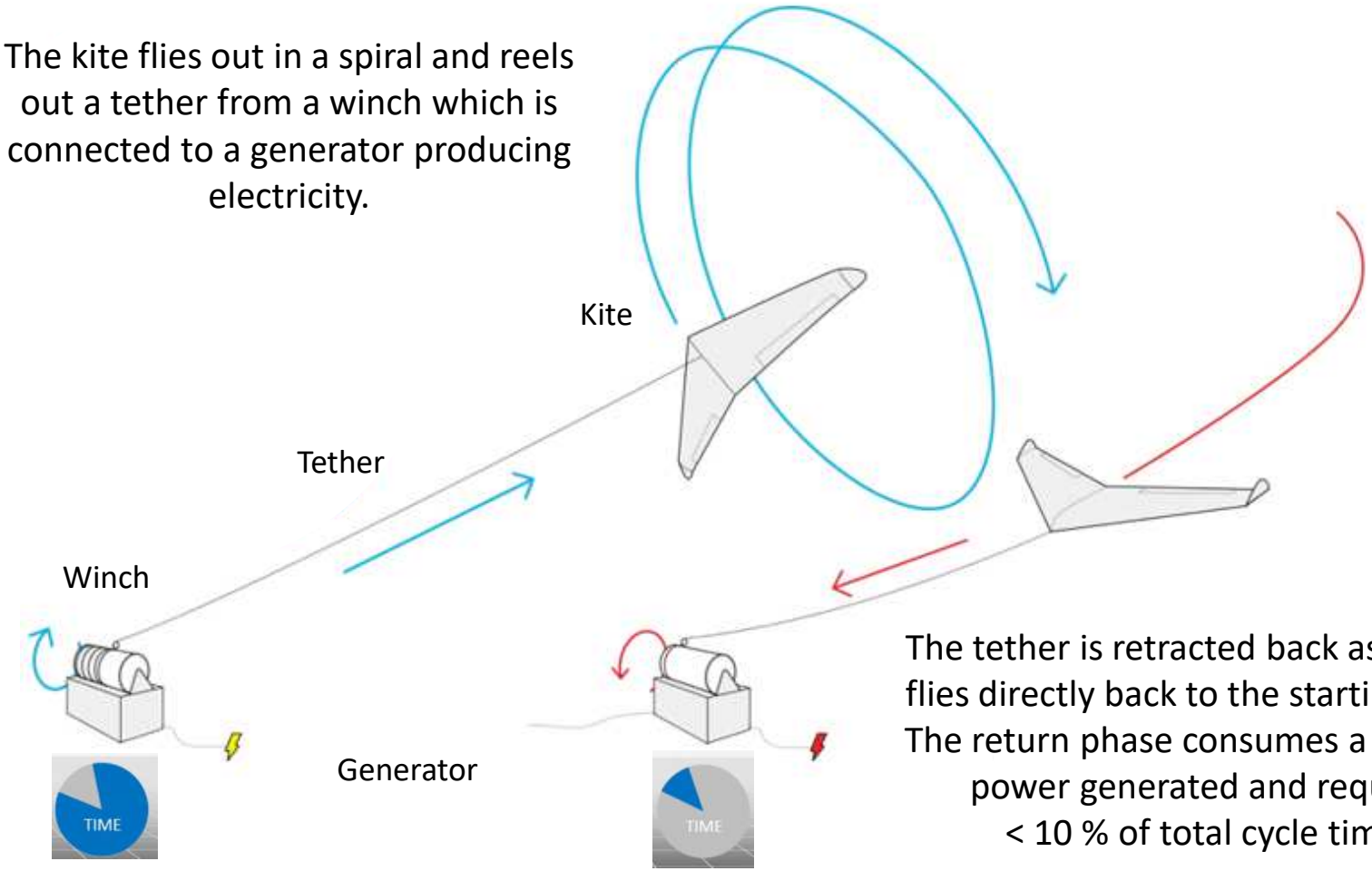
Content

- Airborne Wind Energy – principle and concepts
- Advantages
- Current State of the AWE Industry

Ground generation ("ground gen") or yo-yo principle

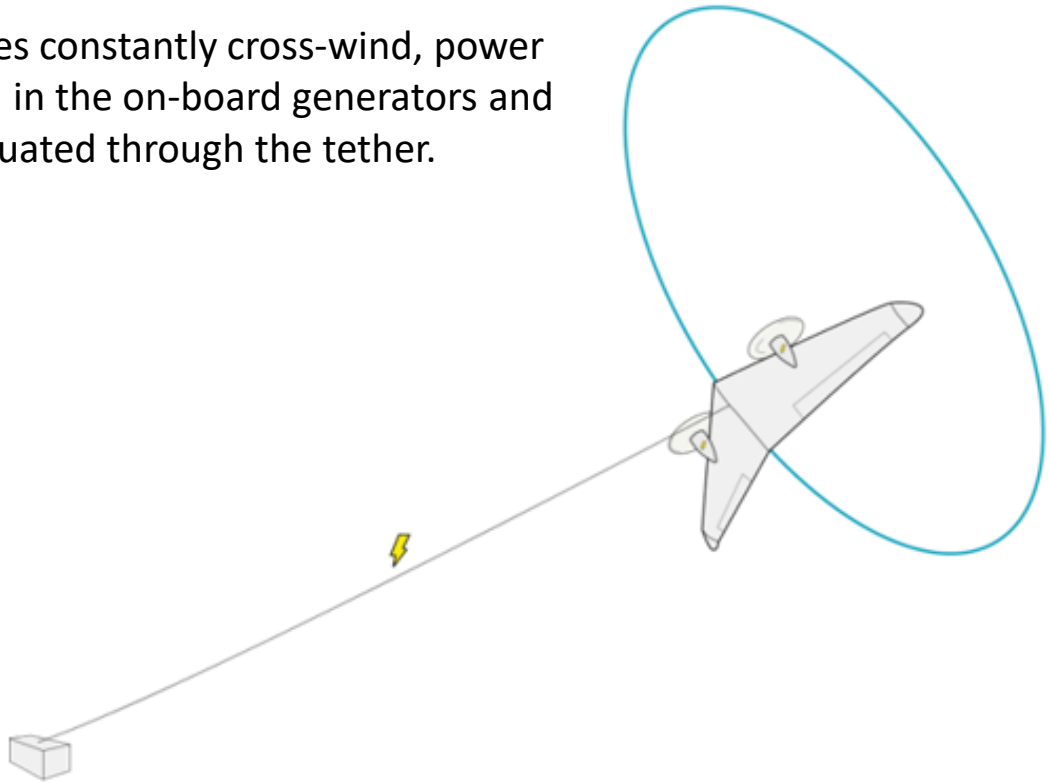
The kite flies out in a spiral and reels out a tether from a winch which is connected to a generator producing electricity.



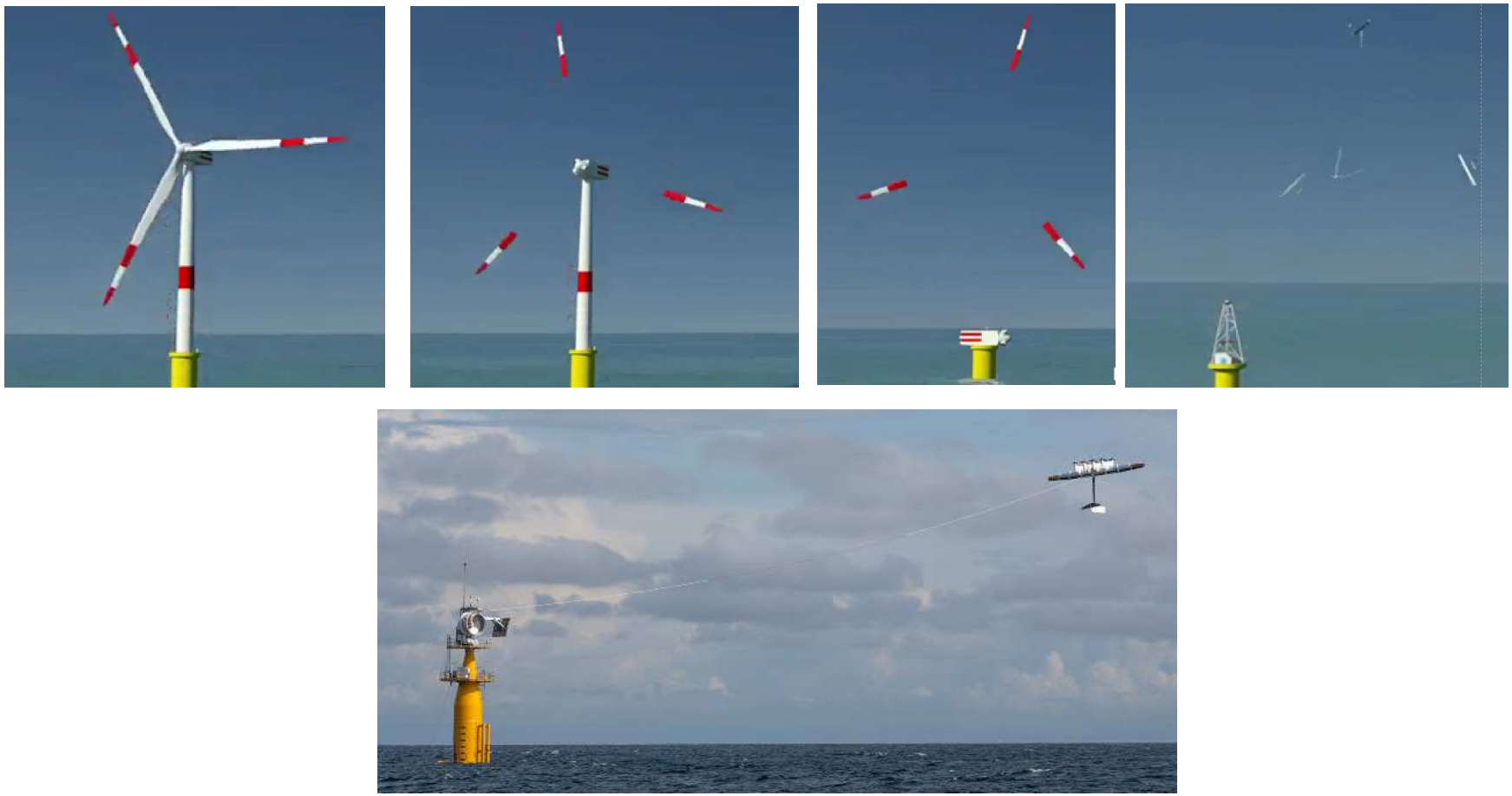
The tether is retracted back as the kite flies directly back to the starting point. The return phase consumes a few % of power generated and requires < 10 % of total cycle time.

On-board generation (“fly-gen”)

The kite flies constantly cross-wind, power is produced in the on-board generators and evacuated 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

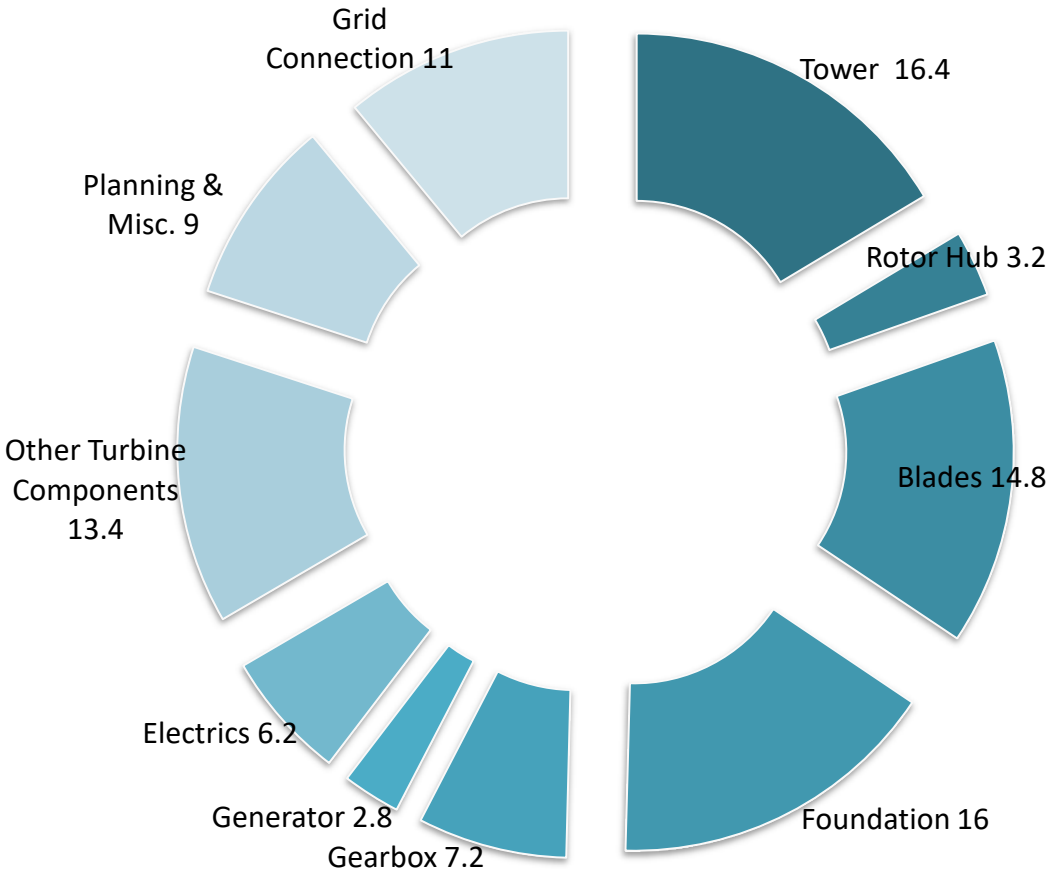
Concepts – soft, semi-rigid and rigid wings

Content

- Airborne Wind Energy
- AWE Advantages
- Challenges
- Airborne Wind Europe

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

Percentage of CAPEX

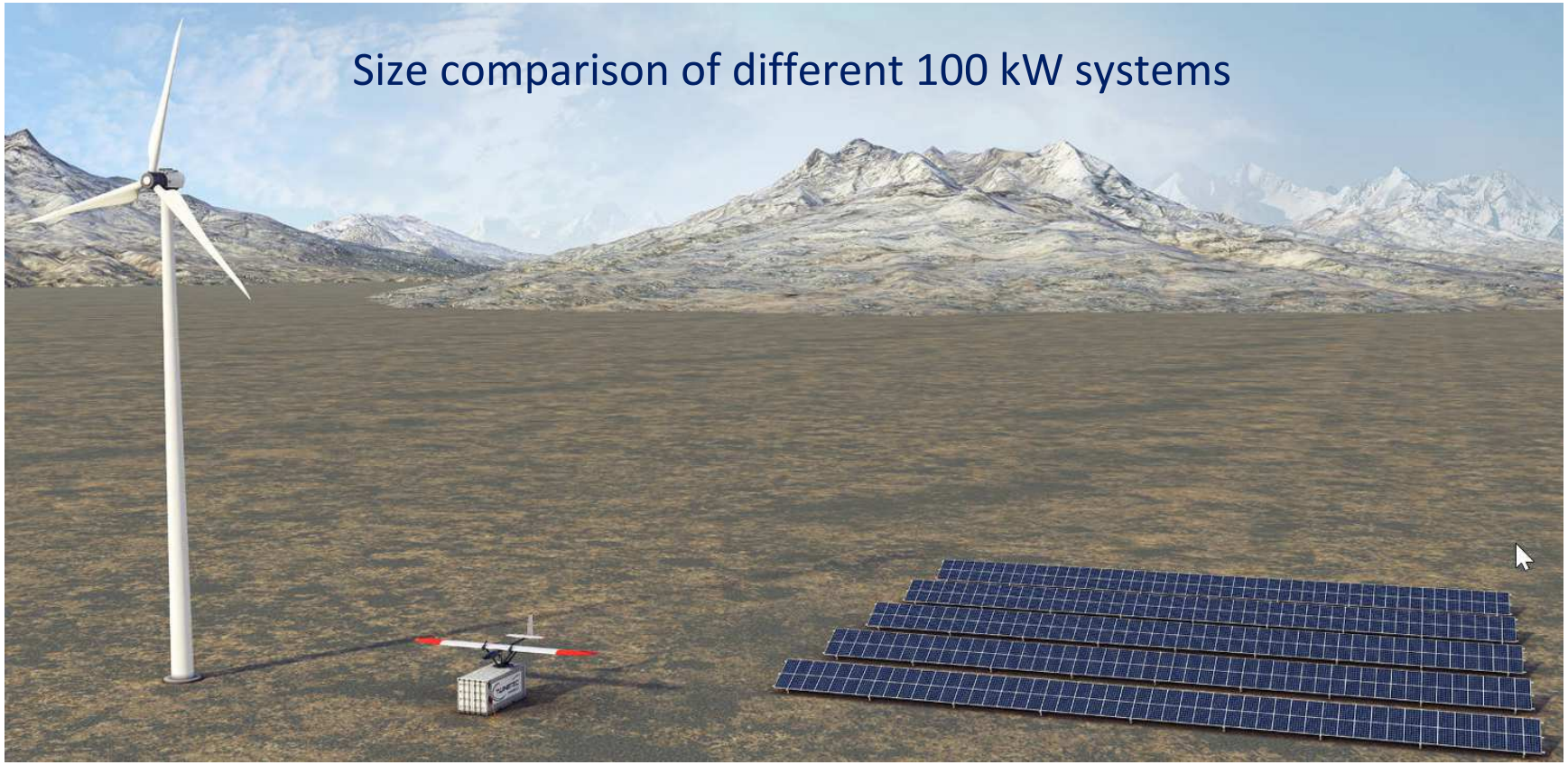


source: IRENA

Less material, lower carbon footprint

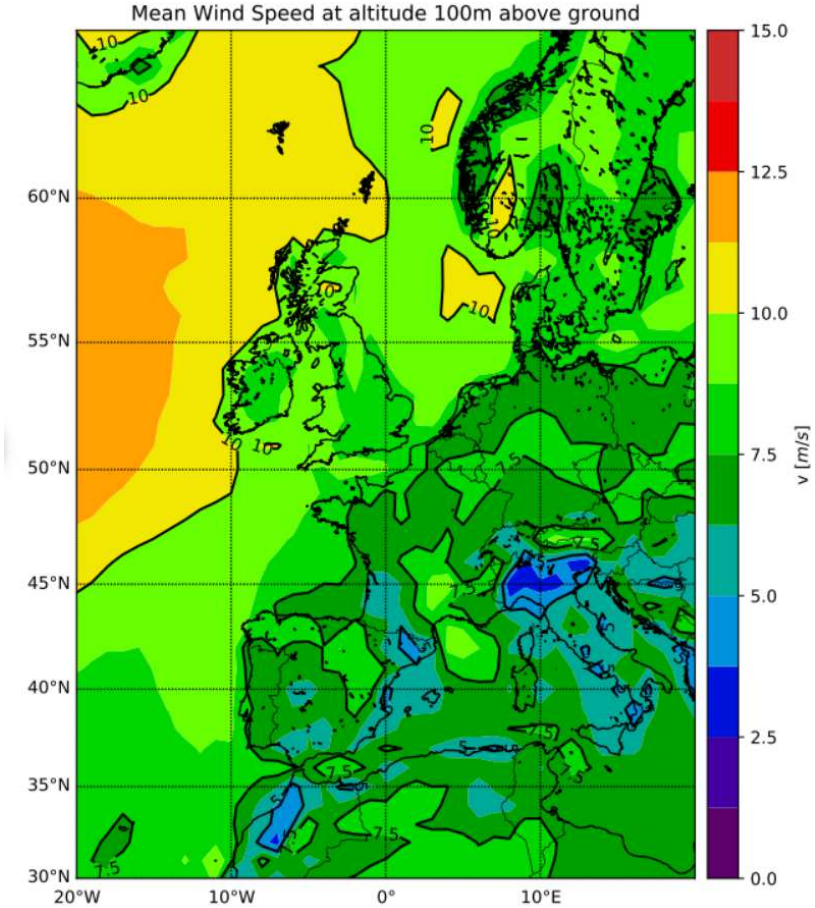
- 7 MW wind power plant: nearly 5,000 tons of material.
- AWE systems require about 90% less material than conventional wind turbines
- “AWE is substituting hardware with software”

Less material (lower CO2 footprint), more compact, lower visual impact

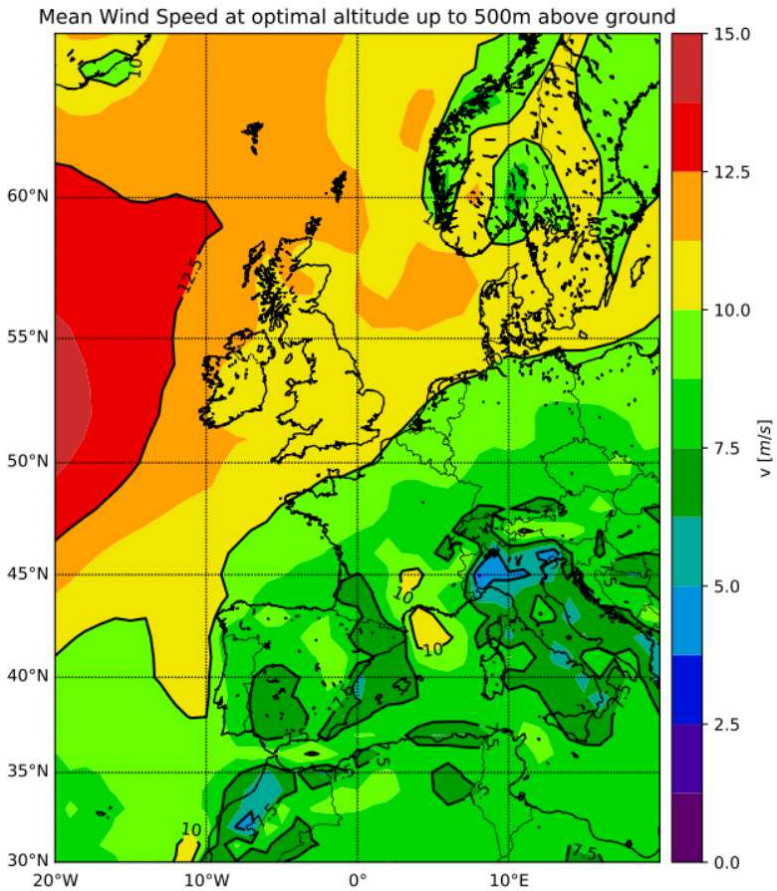


Source: TwingTec

More available wind resources in Europe



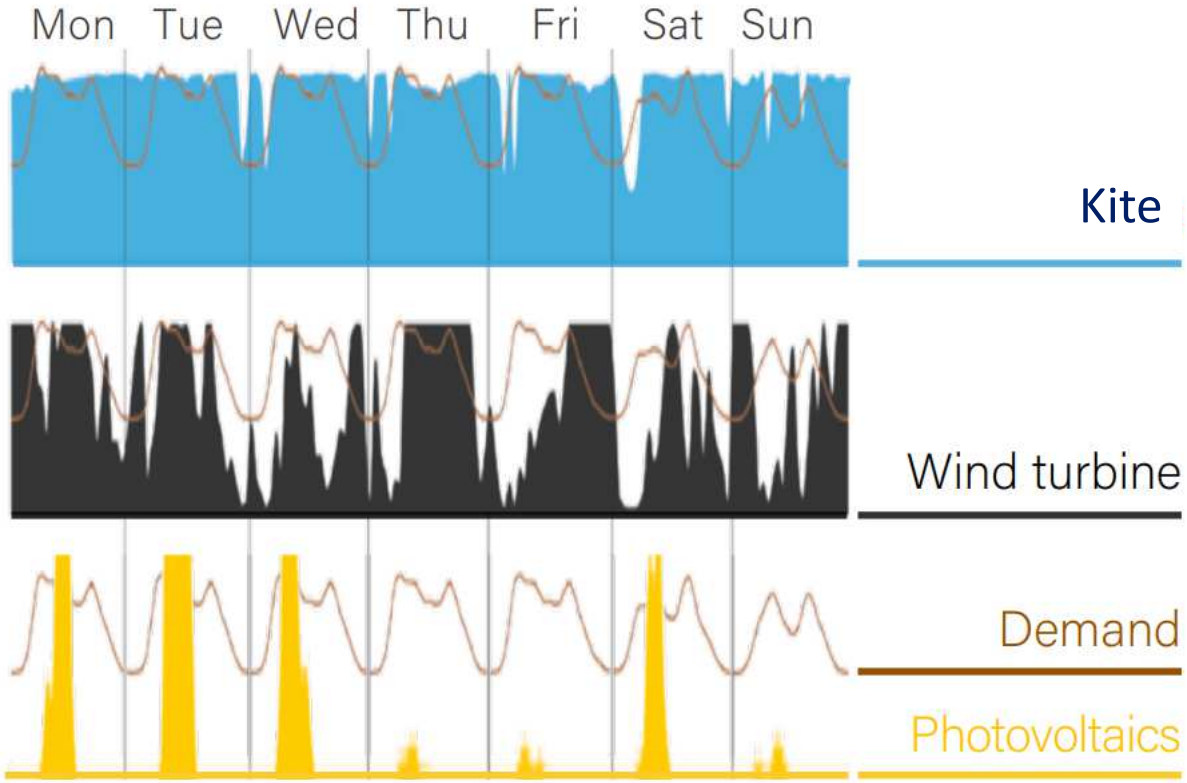
Source: Bechtle et. al., wind data: ERA5



Light green means 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

Overview

- **Less material:** lower environmental impact: CO_2 footprint, visual, resources
- **Additional wind resources:** capturing more renewable potential globally
- **High full load hours:** more constant electricity production
- **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 and floating offshore

Agenda

- Airborne Wind Energy
- Advantages
- Current State of the AWE Industry

Agenda

- Flight Video

Achievements of the AWE Sector – selected examples

Automatic flight

2008 – Makani
2008 – SkySails – 1 MW*
2012 - TU Delft – 1h – 20 kW
2012 – Enerkite (05/2008 ≤ 1hr)
2012 – Ampyx – 15 kW
2016 – Kitepower – 25m^2
2019 – skypull – 1 kW

Automatic operation in major operational phases

2008 – Makani – x kW (soft kite)
2008 – SkySails – 1 MW*
2012 – Enerkite – 30 kW, 3d
2015 – Ampyx – 15 kW
2016 – SkySails – 50 kW
2018 – Kitepower
2019 – Kitepower – 100 kW
Until 2020 – Ampyx – 500+ L&&
2020 – skypull – 1 kW

Full proof-of-concept

2015 – ampyx – 15 kW
2016 – SkySails – 50 kW
2018 – TwingTec: Rigid Wing -VTOL – Groundbased Generation – 2 kW
2020 – Ampyx – SORA compliant flight ops
2020 – skypull – 1 kW

Operational hours

2018-20 – Kitepower – ~180 – 100 kW (> 1000 hours overall)
By 2020 – Ampyx - ~100h
By 2020 – SkySails – >10.000 h

< 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020

Commercial systems in operation

2008 SkySails 1 MW*

Operation for multiple days

2008 – SkySails – 1 MW*
2013 – Enerkite – 30 kW 3d
2014 – Enerkite in Winter 3d
2020 – SkySails – 200 kW

Automatic operation during night

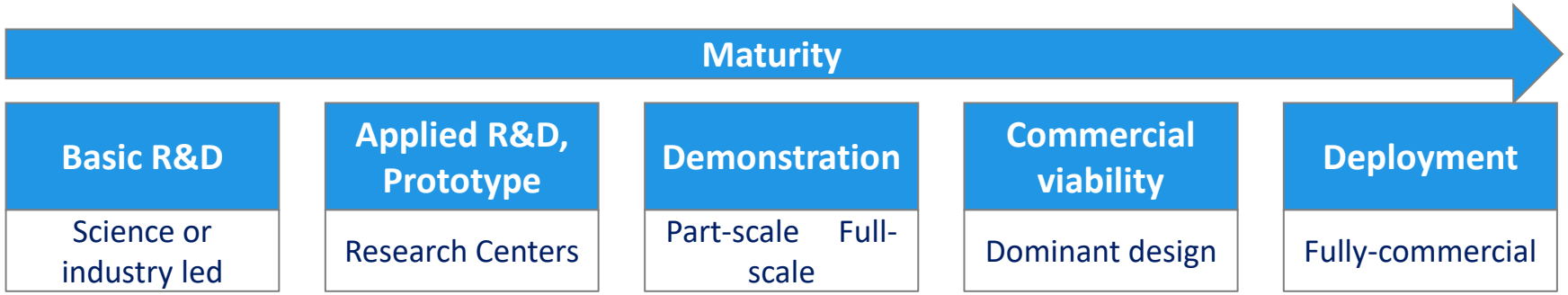
2008 – SkySails – 1 MW*
2013 – Enerkite – 72 hours
2018 – Kitepower – x kW
2019 – Makani – 600 kW
2020 – SkySails – 200 kW

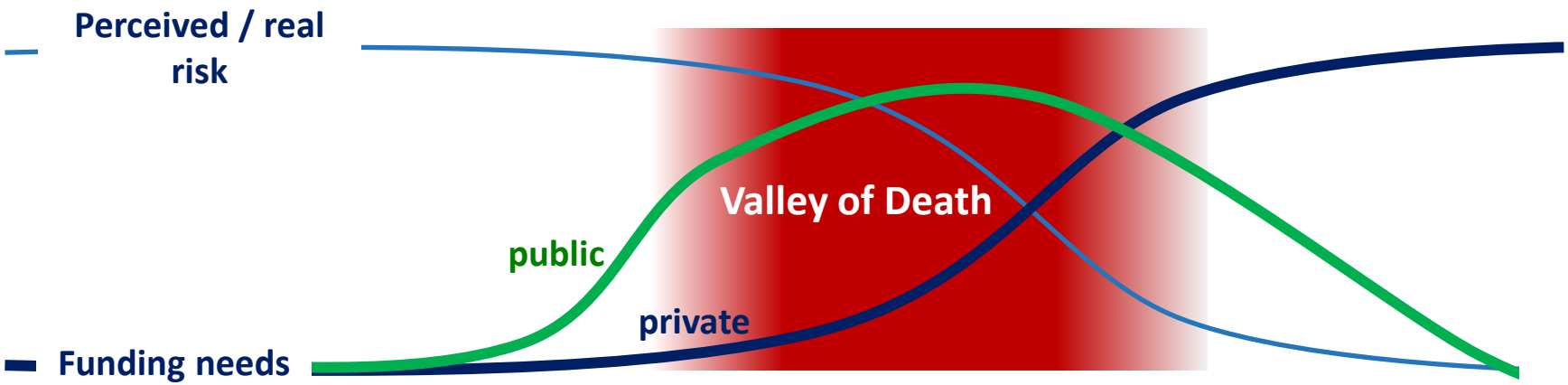
Flight in offshore conditions

2003 – SkySails – 40 kW*
2019 – Makani – 600 kW

*: vessel propulsion system

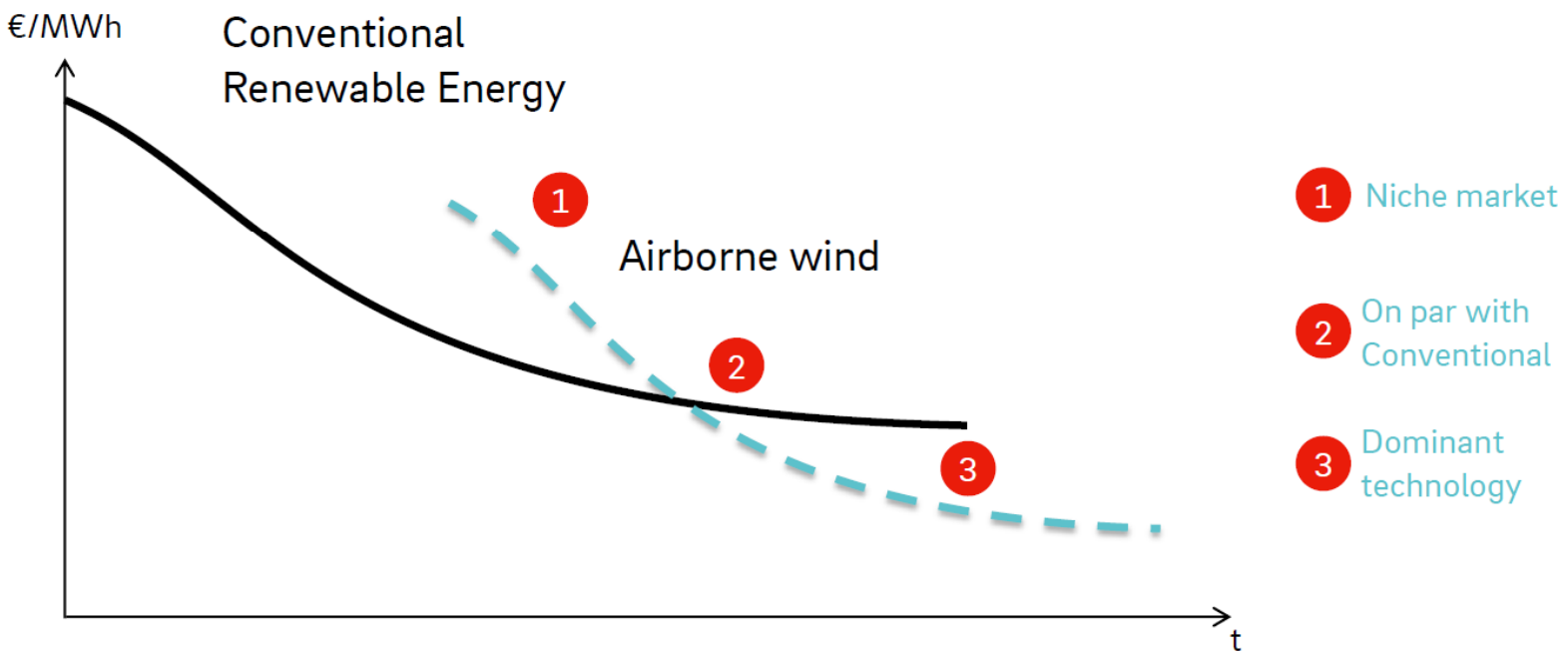
AWE companies will face "Valley of Death": Still high risk and high funding needs (especially public funding)





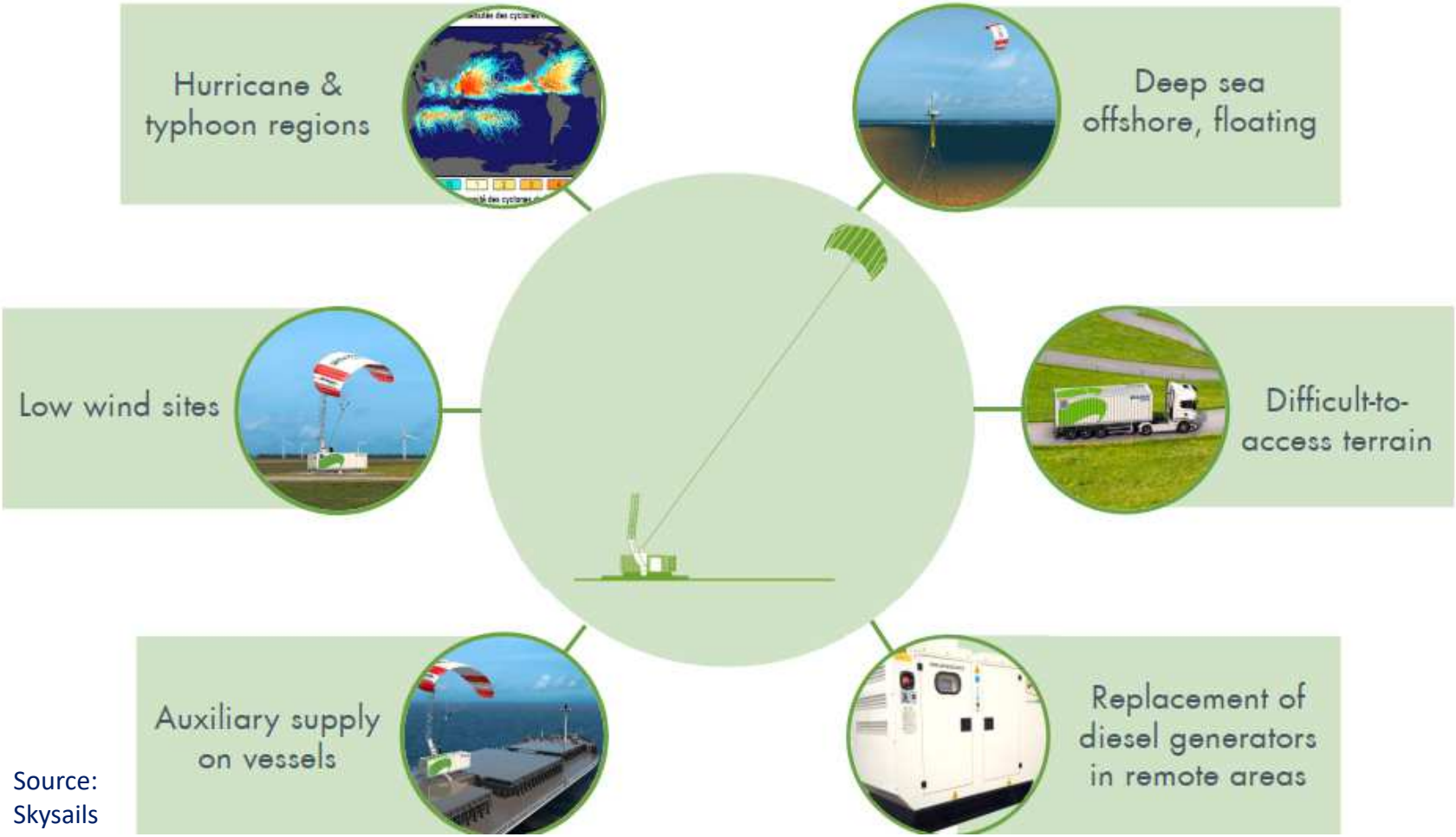
Current State of the AWE Industry

Great cost reduction has been achieved for conventional renewable energy, AWE has the potential to make the next jump in the curve



Source: E.ON AWEC 2017

Niche Markets



Source: Skysails

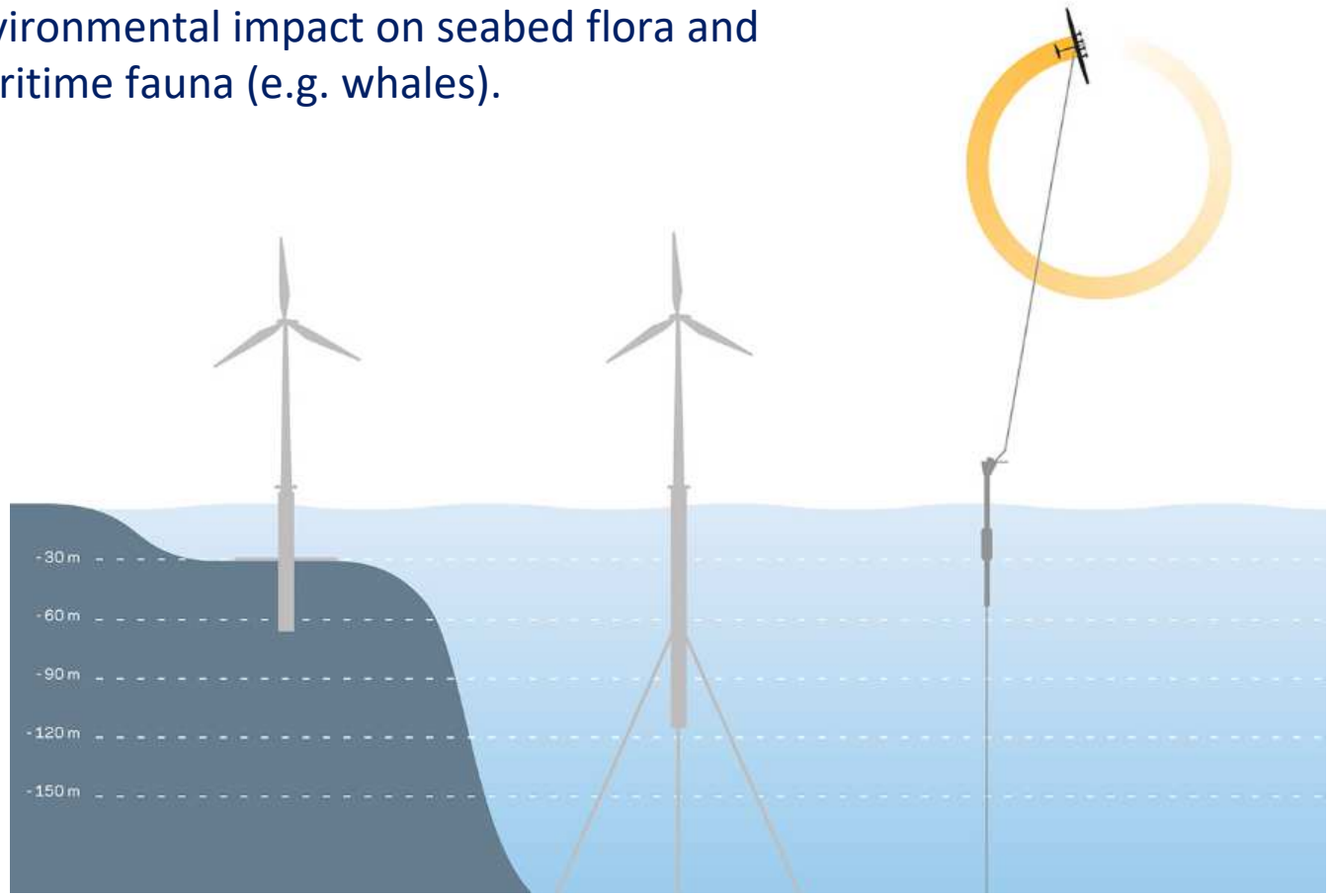
“Spill-over effect” to applications in maritime transport sector

AWE knowledge can help decarbonising maritime shipping

Skysails

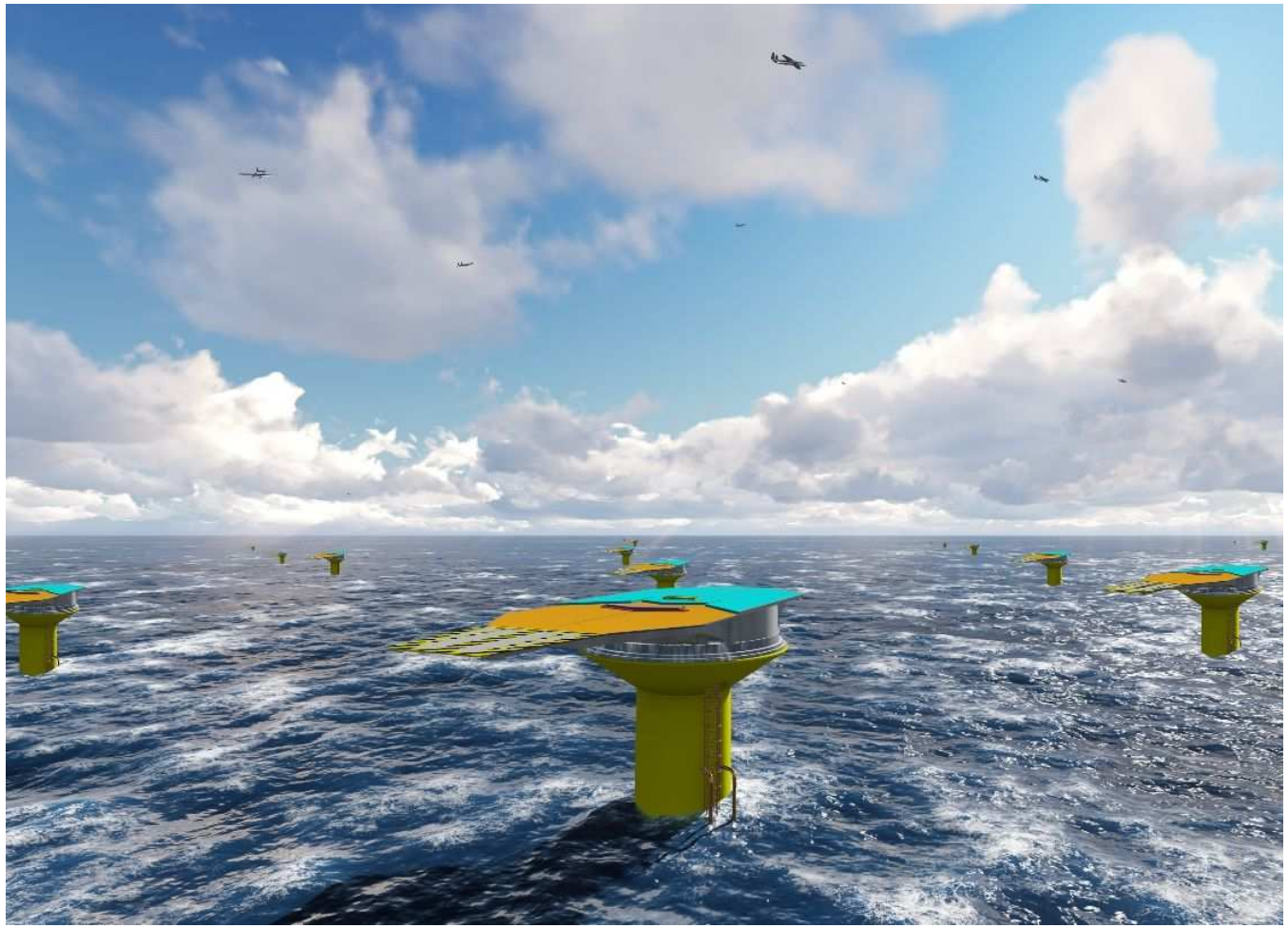
Deep offshore – only small platform required

Avoiding fixed bottom structures reduces environmental impact on seabed flora and maritime fauna (e.g. whales).

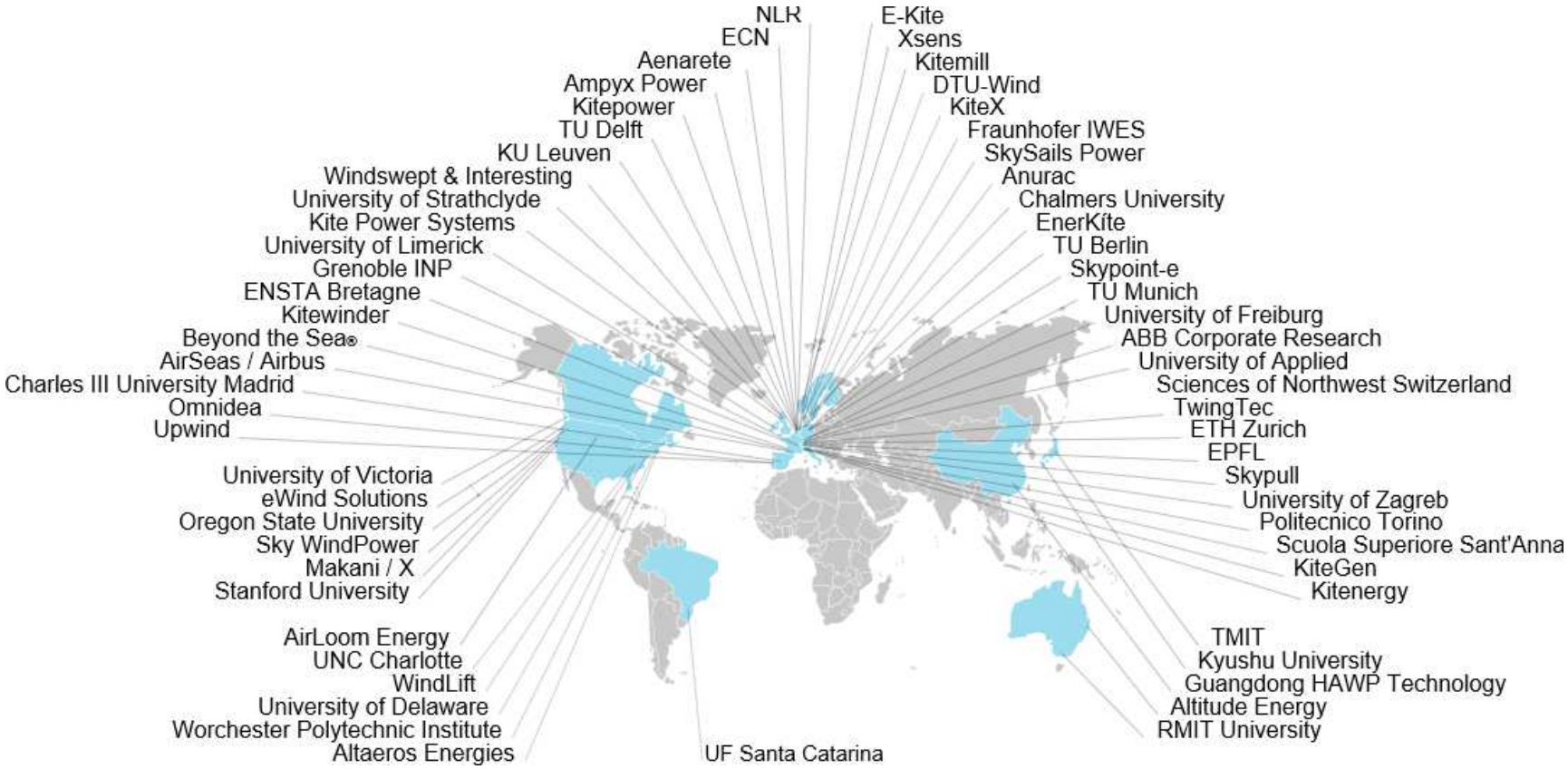


Source: Makani

Repowering of existing off-shore sites



AWE is a global technology



Source: TU Delft

AWE will require co-operation by many stakeholders to become a success

Clients / Investors	Financial Sector	Administration
Utilities, Project developers	Banks, Private investors, funds, public investors and public banks	Grid operators, regulators, airspace authorities, FAA, EASA, local administrations, certification bodies ...

AWE Industry		Countries
AWE companies, suppliers, customers	iea wind	US, Europe (EU Commission and member states), Asia, EMEA, Americas

Research Institutions	Associations	General public
Universities, EUREC, ETIP Wind, other institutes like InnoEnergy, DLR, IRENA	AWEA, WindEurope, GWEC, AWEurope, national associations	Citizens (final electricity consumers, tax payers), civil society, NGOs

Thank you for your attention!

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