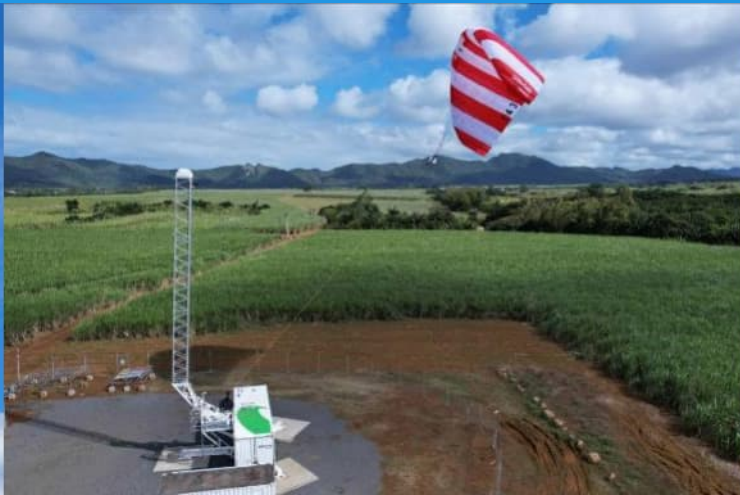


# Airborne Wind Energy

Tapping into the vast potential of high-altitude winds



Airborne Wind Europe 

27 October 2023

EUFORES 23<sup>rd</sup> Inter-Parliamentary Meeting, Stockholm

**Kristian Petrick**

Secretary General, Airborne Wind Europe



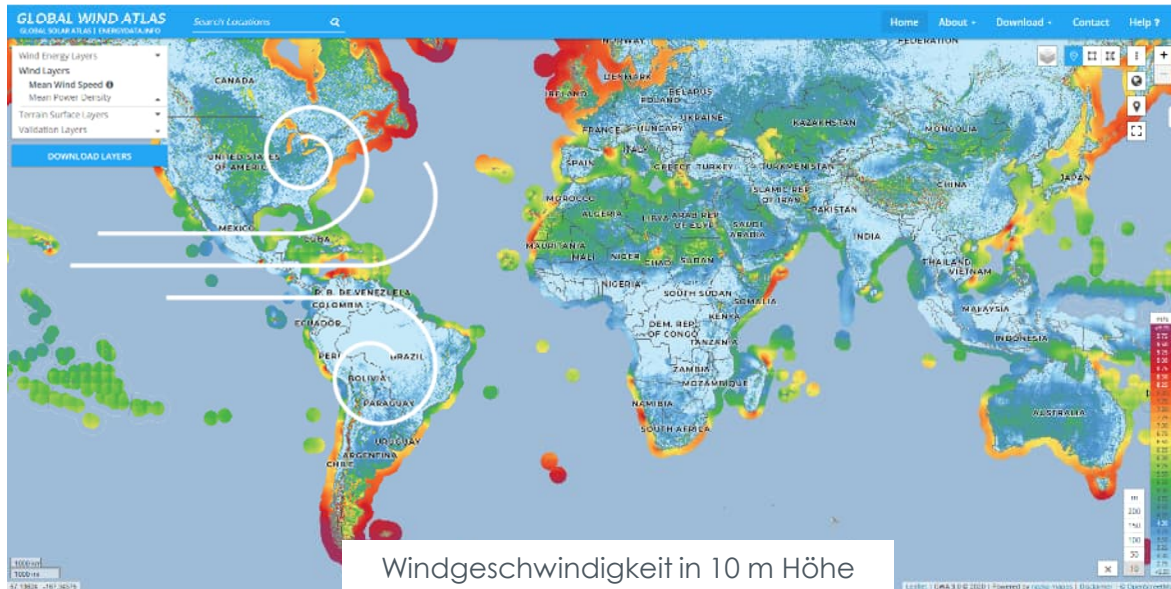
**iea wind**

Task 48

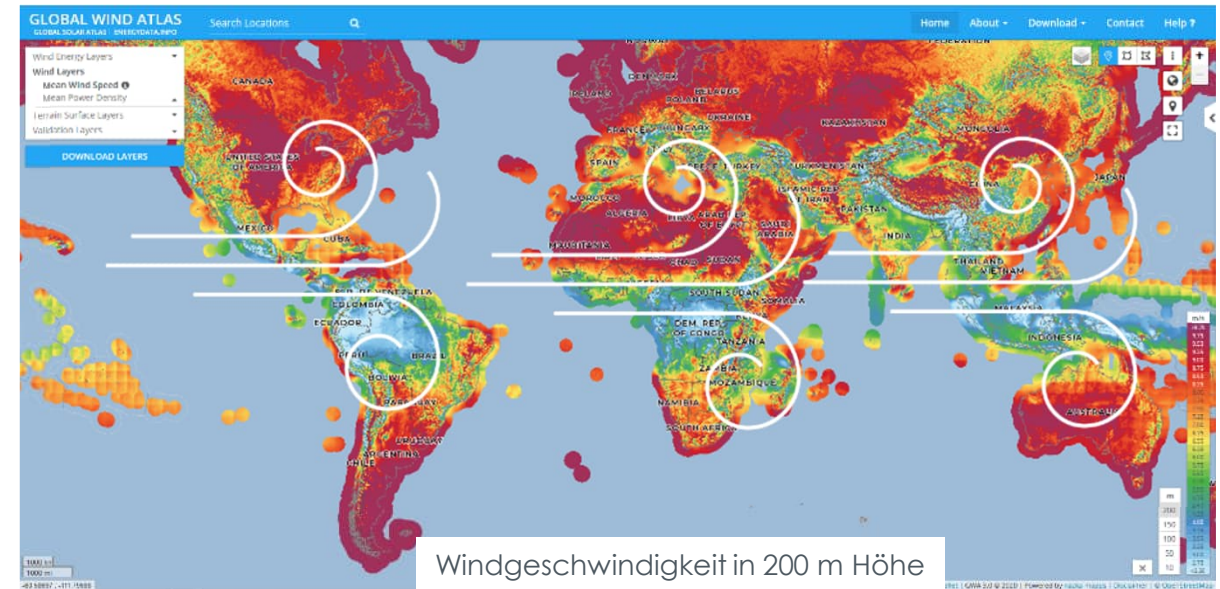


Funded by the  
European Union

# High-altitude wind energy: The largest untapped renewable energy resource



Windgeschwindigkeit in 10 m Höhe

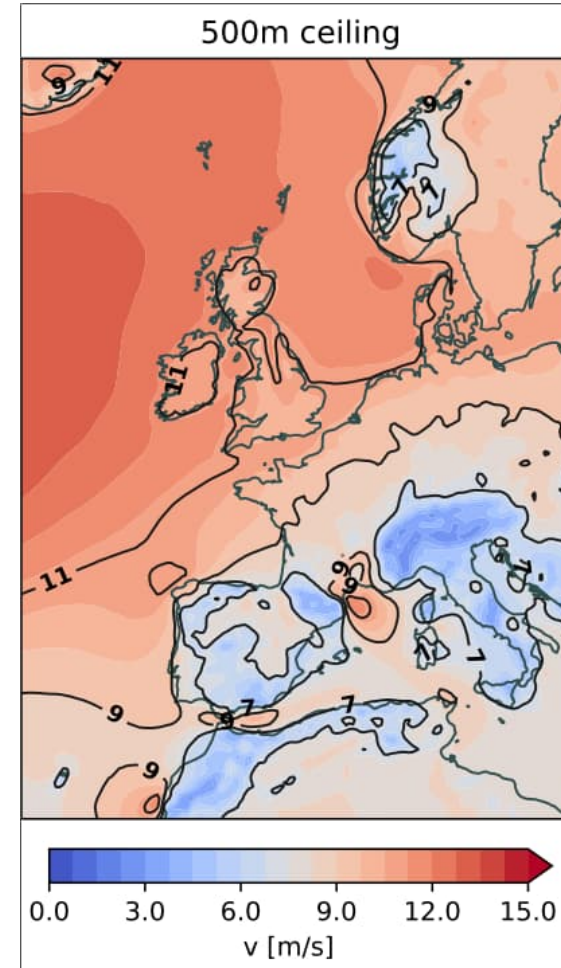
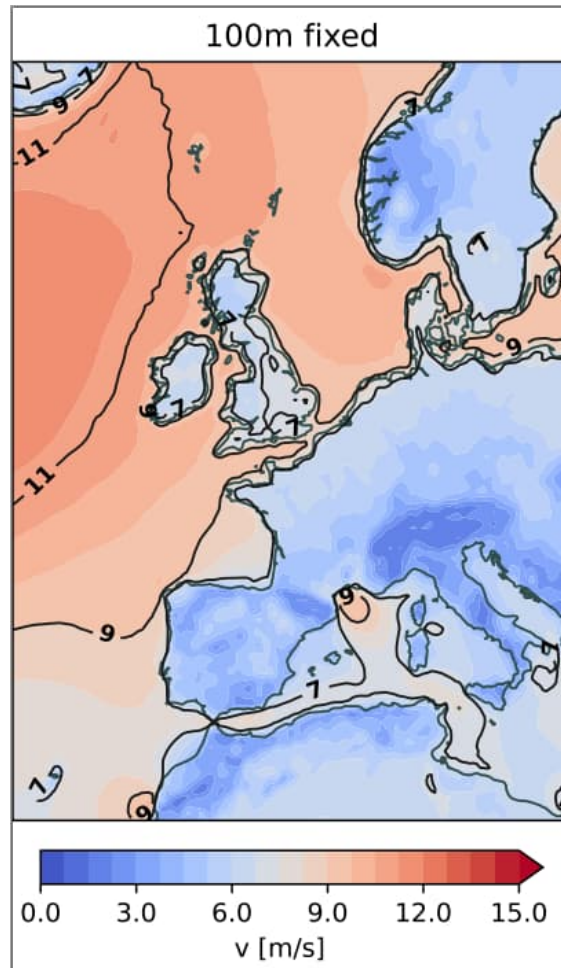


Windgeschwindigkeit in 200 m Höhe

Airborne Wind Energy (AWE) technology is the **only** technology that can harvest this energy potential – **with 90% less material input.**

## More available wind resources in higher altitudes: offshore conditions become available onshore

Red colours:  
Wind speed > 7.5 m/s  
-> Excellent conditions



25% higher wind speed  
-> doubling of wind power

Higher capacity factors  
facilitate system  
integration

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

# Our technology: Convergence towards soft-kites and fixed-wing systems – all flying cross-wind

Soft-wing systems



SkySails



KITEPOWER™



kitenrg



OCEANERGY

Fixed-wing systems



KITEMILL



TWINTEC  
WIND ENERGY 2.0



KITE//KRAFT



EnerKite

## Airborne Wind Energy (AWE): Supporting Europe's climate targets and renewable industry

1

**AWE may be the single most important new renewable energy technology**

2

**AWE is reality.**

3

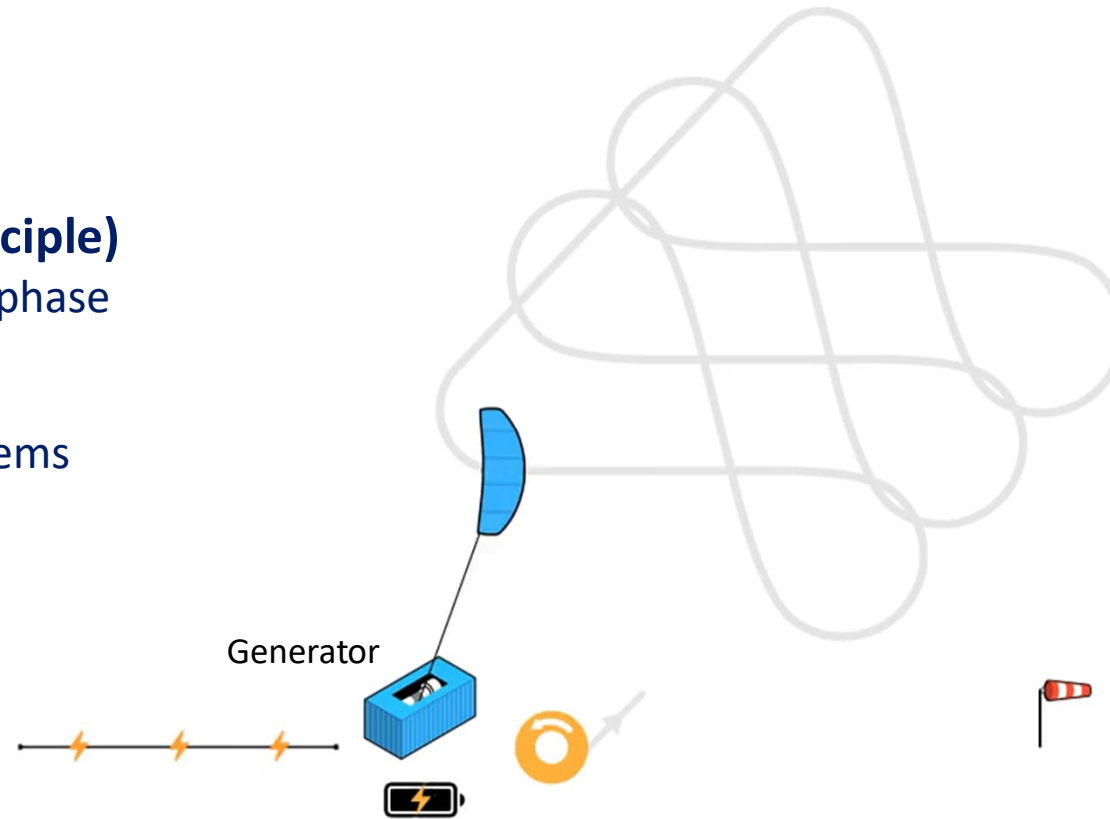
**Political support speeds up the unlocking of AWE potential.**

**A European Airborne Wind Energy Strategy is needed**  
Jointly developed by EU, governments and AWE sector

## Power generation on the ground

**Ground-gen (or yo-yo principle)**  
With reel-out and retraction phase

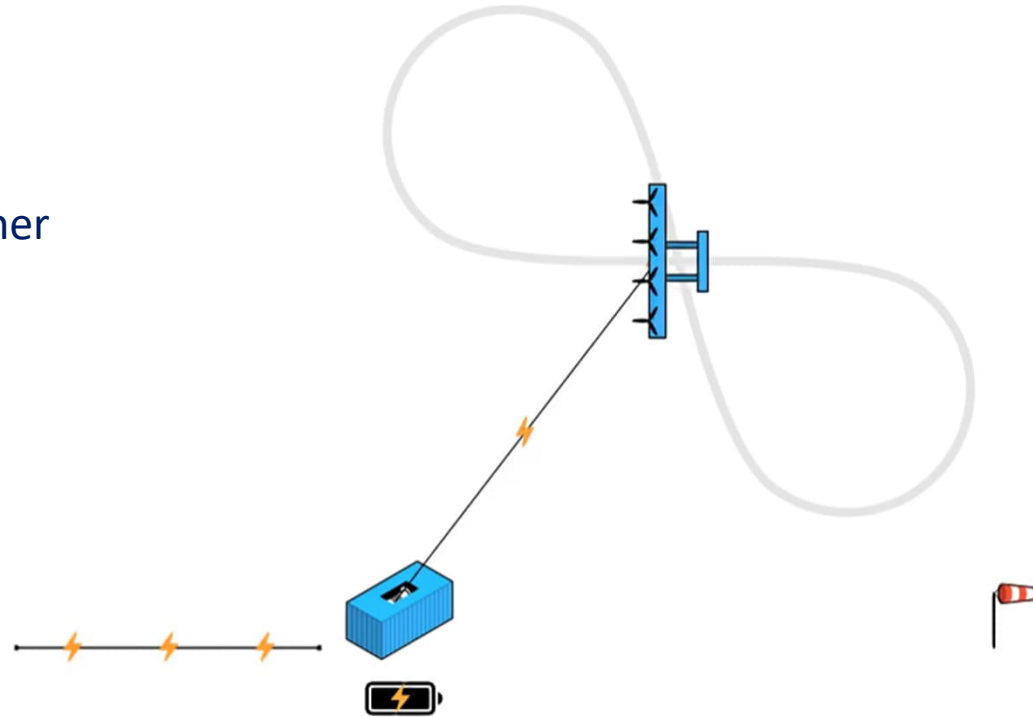
Soft-wing and fixed-wing systems



## Power generation in the air

### Fly-gen

On-board generation and power evacuation through the tether



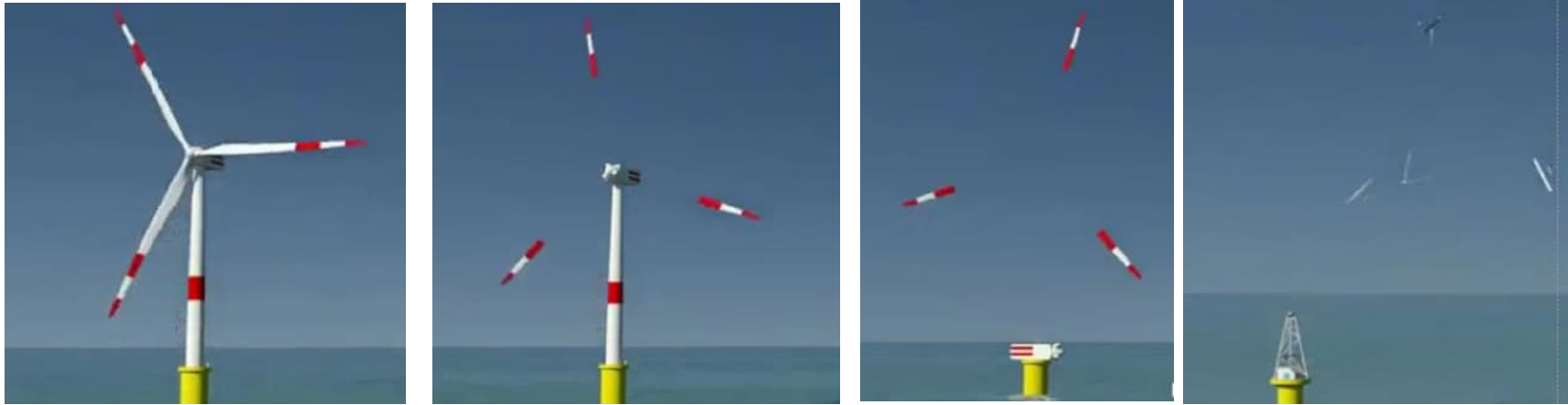
## Video: Skysails Power system (~150 kW) on Mauritius



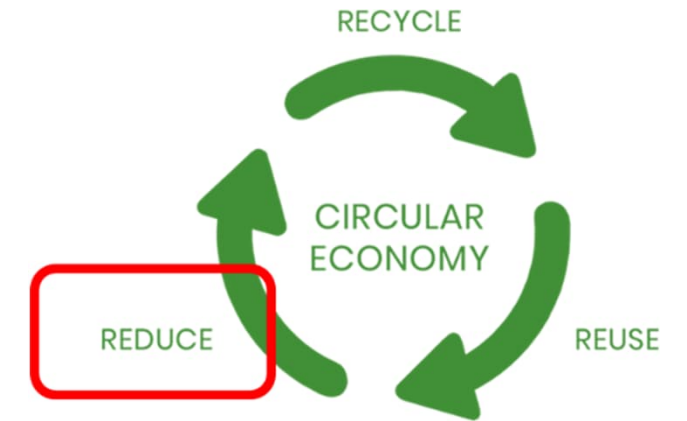
<https://skysails-power.com/media-material/>



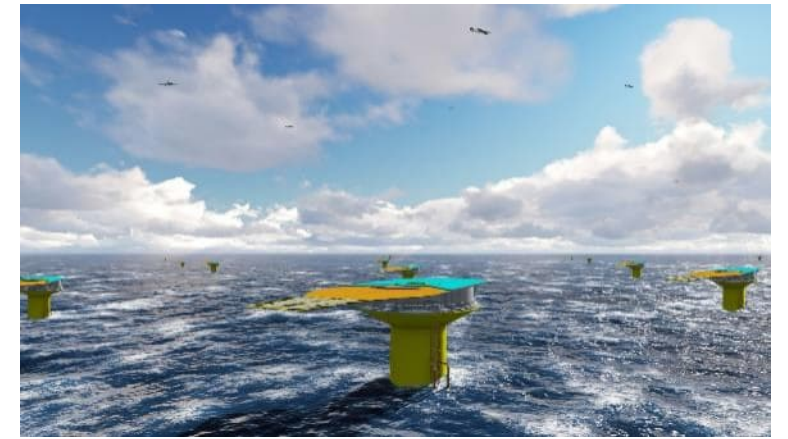
# AWE-Systems need up to 90% less material than wind turbines, therefore reduced supply risks for concrete, steel, aluminium and rare-earth materials



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



# AWE systems can be scaled from kW to MW; onshore and offshore floating; distributed on- and off-grid installations and large-scale farms



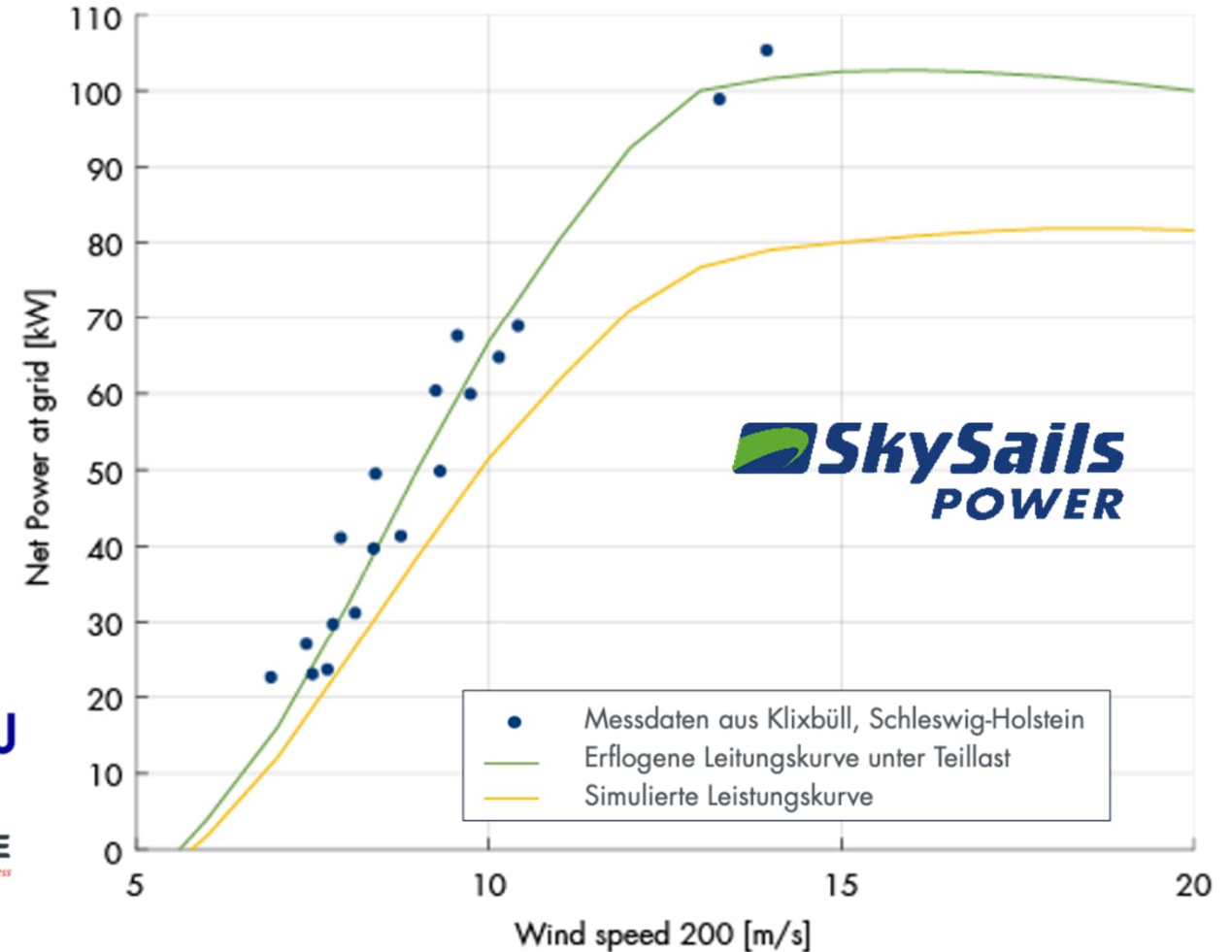
# New RWE test site in County Mayo, Ireland. Kitepower has started tests in 09/2023

# RWE



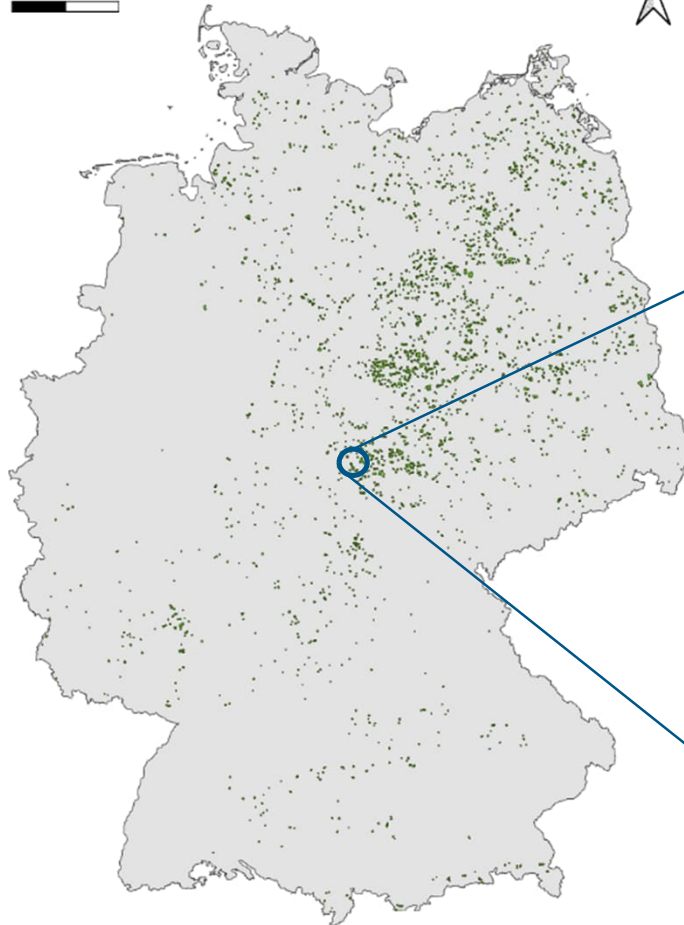
## With costs around 20 ct€/kWh, the first commercial AWE systems are already today competitive in markets with diesel-based power generation

- Power curve available
  - Official validation by Q1 2024)
- >1,500 hours of flight time
- Uptime of 74% at Mauritius site
- High market interest:
  - >7 projects with >20 systems in project development
  - Letters of intent >1,000 systems



# Germany has an AWE potential of at least 12 GW – there is a multitude of suitable sites

0 50 100 km



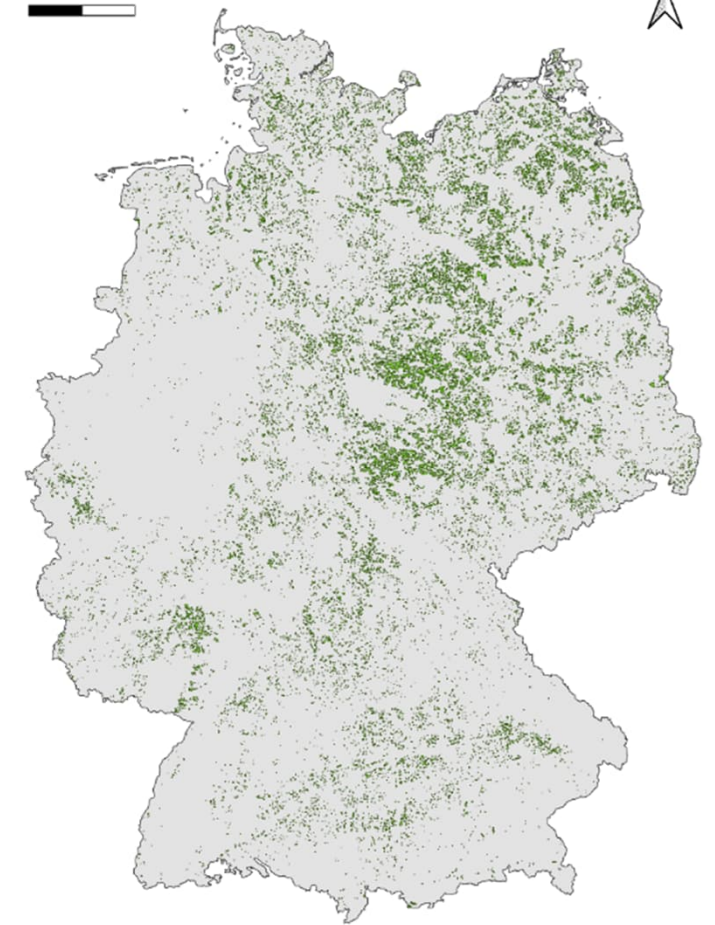
**850m tether length**  
Sites = ~ 3.500  
Systems = ~ 8.500  
1.7 – 12.7 GW



**BLUEWISE  
MARINE**

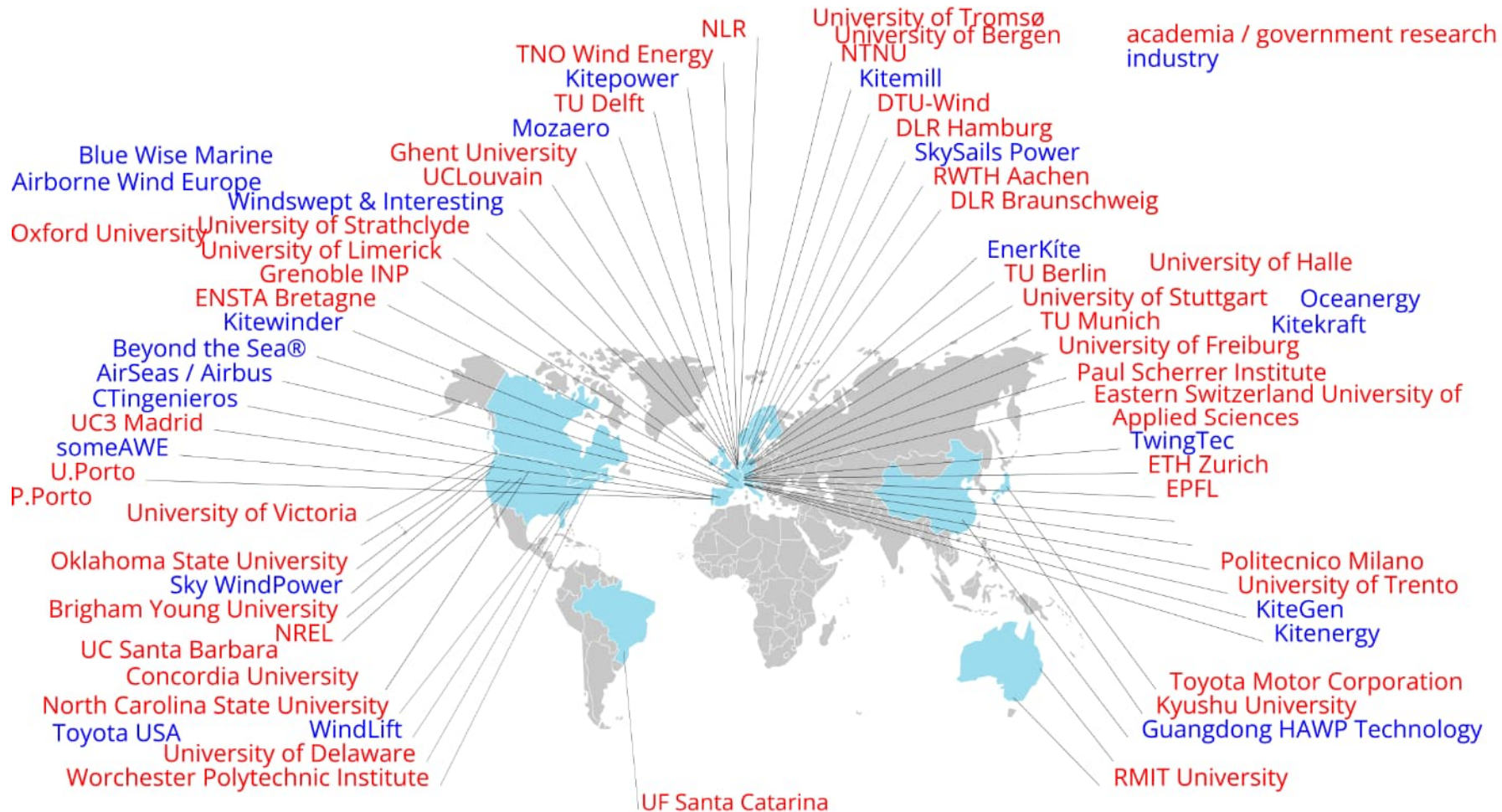
**435m tether length**  
Sites = ~ 22.000  
Systems = ~ 72.000  
14,3 – 107,8 GW

0 50 100 km



Capacity in GW calculated for  
200kW and 1.5MW AWE systems

# The AWE sector is global – Europe is (still) leading



**iea wind**  
Task 48

11 countries:  
BE, CH, DE, DK, ES, IE,  
IT, NL, NO, UK, US

Source: TU Delft

## Airborne Wind Europe – members and collaboration

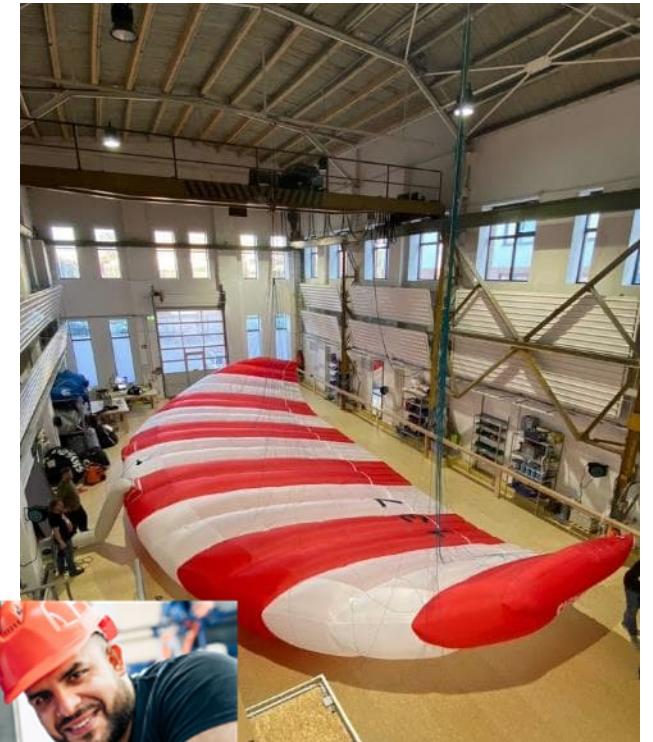
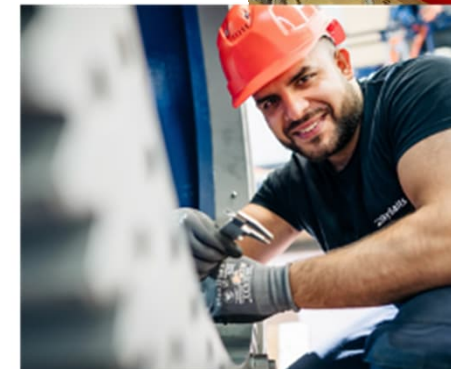


Our members are leading AWE companies, universities, research centers, suppliers, customers and supporters of the AWE industry.



## AWE can provide long-term impetus for the economy and make Europe a pioneer for innovative renewable technologies

- **High-tech made in Europe** - "AWE replaces hard- with software"
- **High value creation** involving existing European industry
- **Creation of jobs** in Europe
- **Export potential** thanks to scalable systems
- **Expansion of existing R&D landscape** in energy & aerospace sectors



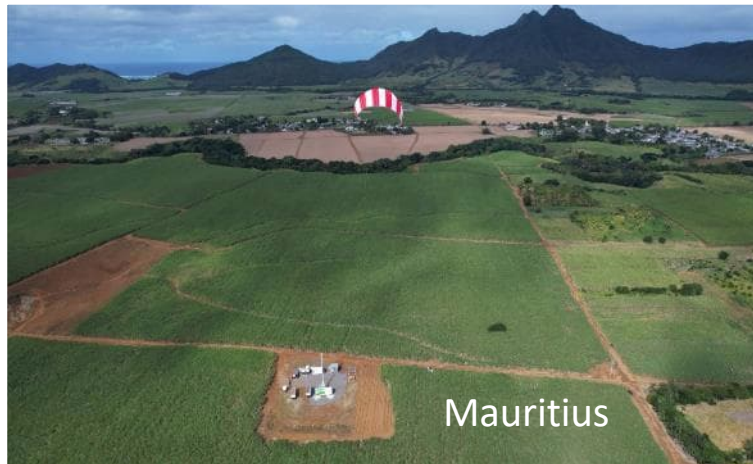


## The AWE sector faces mainly policy/regulatory and financial challenges – political support is required.

The AWE sector needs:

- 1. EU and national policies and energy strategies that recognize the importance of AWE**
  - Include in NECPs: AWE to support 5% target for “innovative RETs” by 2030
  - Give signal to energy industry and investors; increasing public awareness about AWE
- 2. AWE-specific remuneration support for generated electricity**
  - Incentives (FiTs, CfD, ...) are required for a few years to be able to compete
- 3. AWE-specific R&D funding lines**
  - Include AWE in SET-Plan, Horizon Europe, EIC, Innovation Fund, EIC, IPCEIs, etc.
- 4. AWE-specific regulation on safety and airspace integration**
  - Ideally harmonised on European level
- 5. Sites for 24/7 operation**
  - For testing, demonstration and commercial operation

# The opportunities are huge, the sector is ready – and with political support the uptake can be very fast!



**Thank you for your attention!**



**Kristian Petrick**

Secretary General  
+34 637 710 451

[kristian.petrick@airbornewindeurope.org](mailto:kristian.petrick@airbornewindeurope.org)

**Stefanie Thoms**

Membership, Network, General Inquiries  
+49 173 6027136

[stefanie.thoms@airbornewindeurope.org](mailto:stefanie.thoms@airbornewindeurope.org)

**Jesús Carballo**

Communications and Marketing  
+34 695 957 384

[Jesus.carballo@airbornewindeurope.org](mailto:Jesus.carballo@airbornewindeurope.org)

**Airborne Wind Europe**

Avenue de la Renaissance 1  
1000 Brussels, Belgium

[info@airbornewindeurope.org](mailto:info@airbornewindeurope.org)

[www.airbornewindeurope.org](http://www.airbornewindeurope.org)

## Opportunities are huge, the sector is ready & with political support the uptake can be fast.

### AWE may be the single most important new renewable energy technology

- Access to untapped wind resource, complementary to other RET
- Lowest mass and GWP per MWh
- Major opportunity for Europe's industry

### AWE is a reality

- Major achievements with minimum funding
- First commercial systems and technology convergence
- No technical or other major show-stoppers anymore

### Political support can speed up unlocking the AWE potential

- Public funding required to trigger private investment
- AWE-specific remuneration
- Adequate regulation and sites



## A European Airborne Wind Energy Strategy is needed

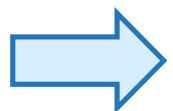
Ideally jointly developed by governments, agencies and the AWE sector

**A significant increase of public R&D support is needed, totalling approx. 1 b€ by 2030. The next years are crucial to get on the planned deployment curve**

Table 8 Scenario of spread of AWE public funding support (€million)

| Funding for                                | 2023      | 2024      | 2025       | 2026       | 2027       | 2028       | 2029       | 2030      | Total       |
|--|-----------|-----------|------------|------------|------------|------------|------------|-----------|-------------|
| EU   | 8         | 15        | 30         | 40         | 50         | 50         | 25         | 13        | 230         |
| Large European States (DE, ES, FR, IT, UK) | 18        | 35        | 70         | 90         | 100        | 100        | 50         | 25        | 488         |
| Other European States                      | 10        | 20        | 40         | 40         | 40         | 40         | 20         | 10        | 220         |
| US   | 4         | 8         | 15         | 25         | 25         | 25         | 13         | 6         | 120         |
| <b>Total</b>                               | <b>39</b> | <b>78</b> | <b>155</b> | <b>195</b> | <b>215</b> | <b>215</b> | <b>108</b> | <b>54</b> | <b>1058</b> |

© BVG Associates 2022



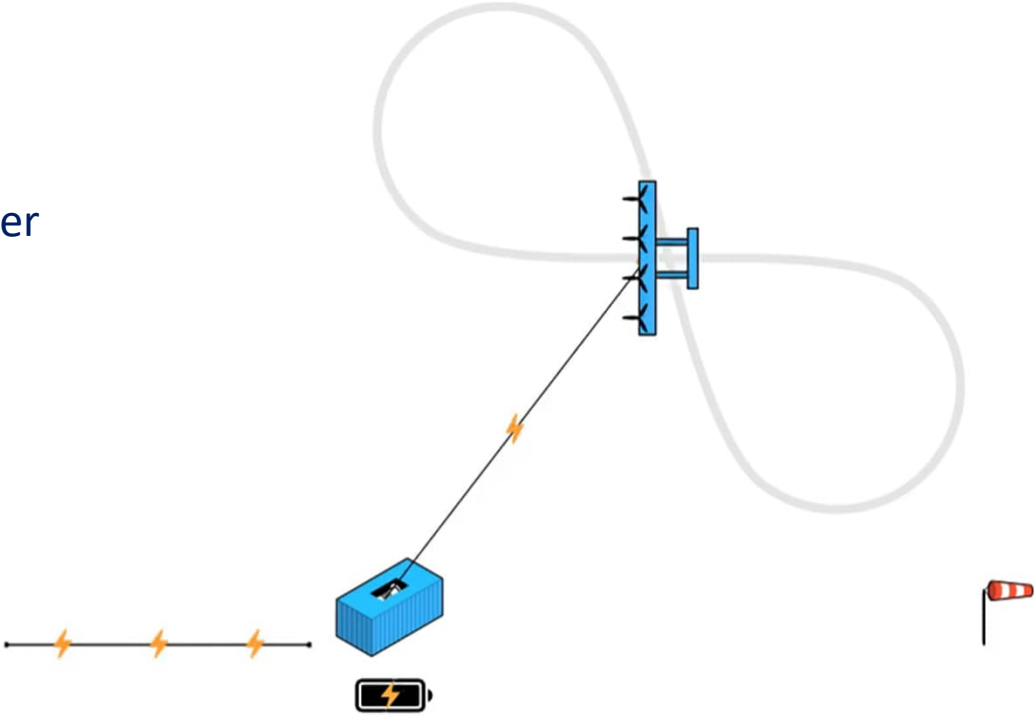
**In 2023 public funding falls short by over 35 m€!**

Total public funding over last 12 years (EU, Member States, US): **75 m€ -> 6.3 m€/year**

# Power generation in the air

## Fly-gen

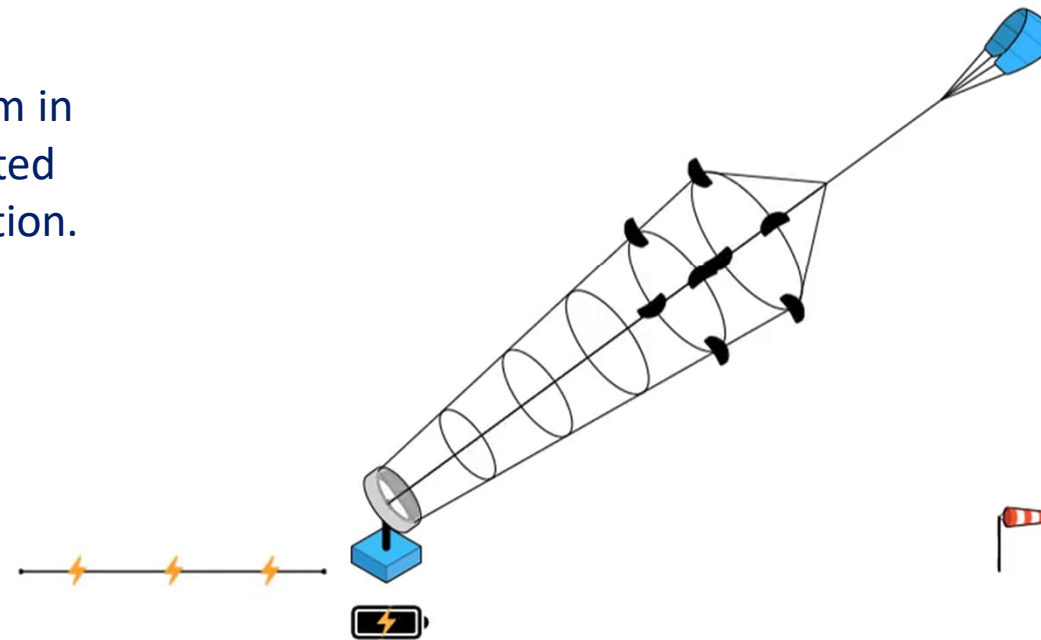
On-board generation and power evacuation through the tether



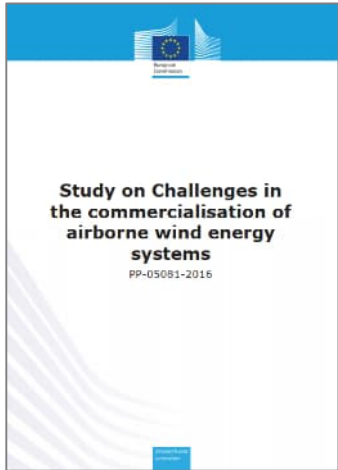
## Power Generation through rotating system on the ground

### Rotary

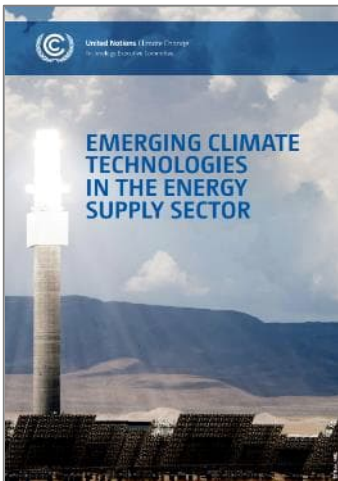
A lifter kite holds the AWE system in the air. Rotary power is transmitted through torque to the ground station.



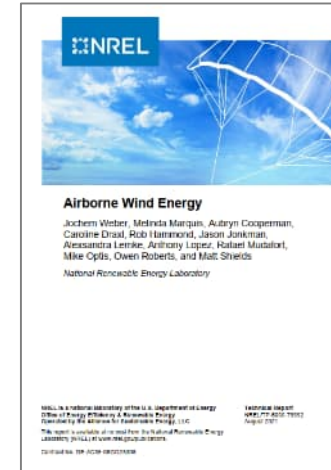
# All major recent reports on AWE recommend to further pursue the AWE technology path.



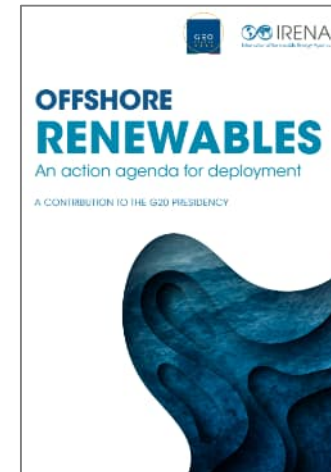
European Commission / Ecorys 2018: *“The case for Airborne Wind Energy Systems from the perspective of EU industrial leadership seems strong. Moreover, **there seems sufficient potential to continue exploring the technology.**”*



UNFCCC 2021: *“**Governments can, if they choose, assist in several key areas, such as providing funding for fundamental research in materials and control systems, expanding the (often very limited) number and size of testing sites, and facilitating future market access through the development of regulatory standards for commercial operations.**”*



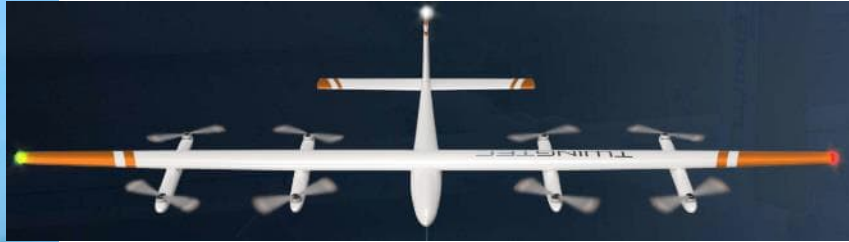
NREL 2021: *“... **we believe it is worth considering a 10-year research plan.**”*



IRENA 2021: *“Invest in RD&D for airborne wind energy [...] policy makers could invest in their advancement through RD&D programmes.”*  
*“**AWE has the potential to become a game changer.**”*

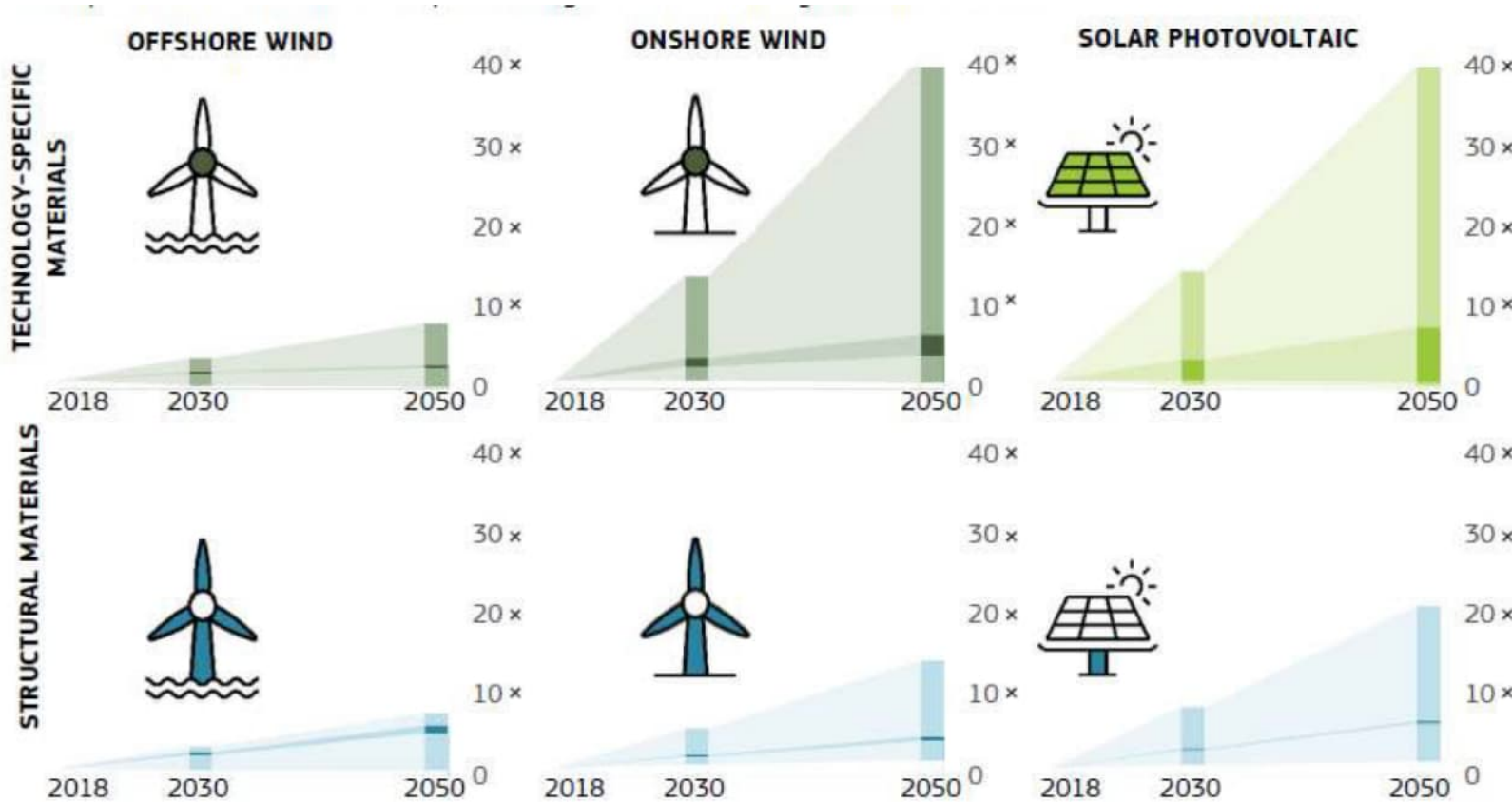


# AWE Components and Supply Chain – Opportunities for various high-tech industries, including mass production in Europe



- Energy
- Aviation / aeronautics
- Textile industry (soft kites)
- Composites (fixed-wing)
- Automotive (gear boxes, etc.)
- Chips
- IT
- Tether / ropes
- Mechanical engineering
- ...

# AWE saves large masses of concrete, steel, aluminium but also rare-earth materials – thus facilitating scaling of renewables and reducing supply chain risks



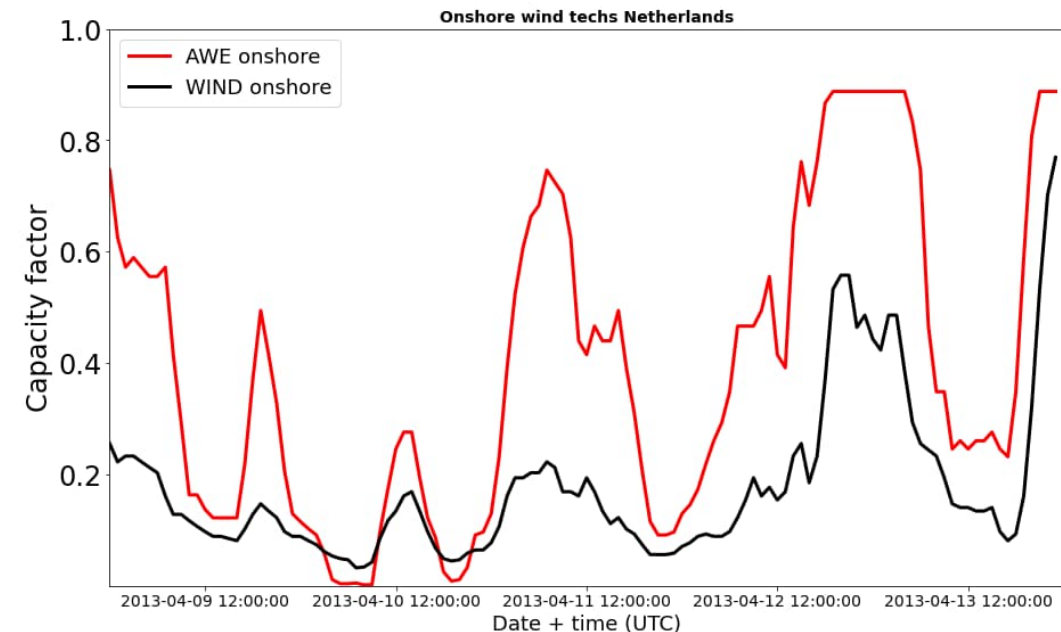
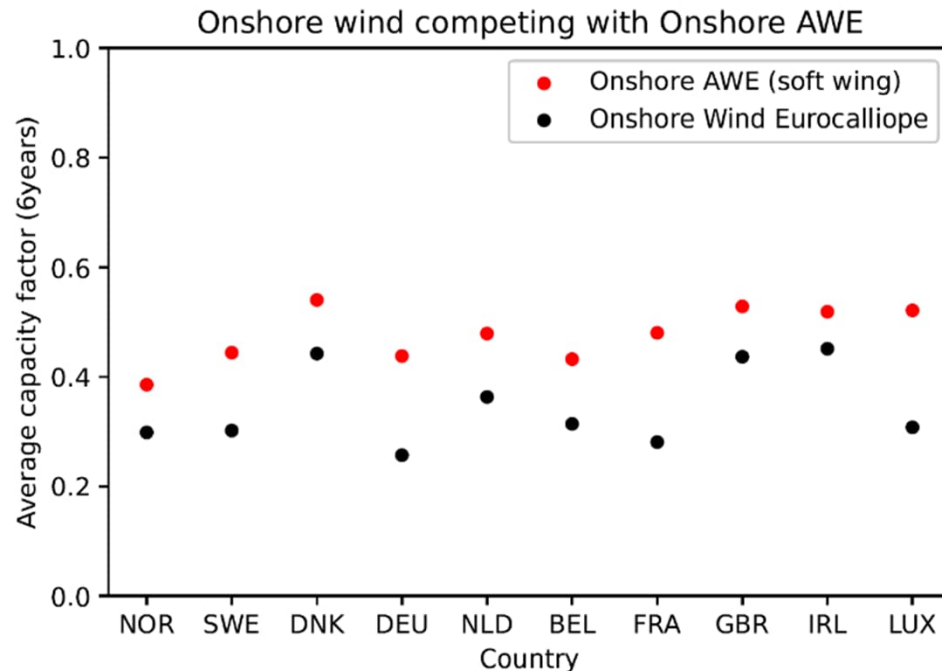
Source: JRC analysis.

*“We had designed and realised the generator of the SkyPower100 project **completely rare-earth-free** and achieved very good results with it. There are designs and calculation results for a generator scaled up to the megawatt range.”*

**Prof. Dr.-Ing. Bernd Ponick,  
Leibniz-Universität Hannover**

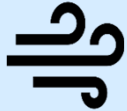




# TU Delft 2023: “Onshore AWE significantly outperforms onshore wind turbines due to higher wind resource availability”

- AWE has the potential to significantly reduce energy system costs
- Onshore AWE is the preferred technology, even at higher costs
  - Spatial capacity density to be further investigated



# Task 48: Five Work Packages – please let us know if you want to participate!

## 11 countries: BE, CH, DE, DK, ES, IE, IT, NL, NO, UK, US

| <b>WP0: Task coordination</b>  | <br><b>WP1: Resource potential and markets</b>  | <br><b>WP2: Reference models, tools and metrics</b>  | <br><b>WP3: Safety and regulation</b>  | <br><b>WP4: Social Acceptance</b>  | <br><b>WP5: AWES architectures</b>   |
|--|--|--|---|---|---|
| <ul style="list-style-type: none"> <li>• Organisation &amp; management of Task</li> <li>• Communication</li> <li>• Website</li> <li>• Dissemination</li> </ul> | <ul style="list-style-type: none"> <li>• AEP prediction for selected sites &amp; toolchain documentation</li> <li>• Global high-altitude wind resource atlas</li> <li>• Recommendation on AWE entry-markets</li> </ul> | <ul style="list-style-type: none"> <li>• Common definition of metrics and KPIs</li> <li>• Joint reference model(s)</li> <li>• Centralized design tool</li> <li>• Simulation vs. test flights comparison</li> </ul> | <ul style="list-style-type: none"> <li>• Concept of operations and risk assessment</li> <li>• Airspace integration concept</li> <li>• Benchmarking concepts for safe automatic operation</li> </ul> | <ul style="list-style-type: none"> <li>• Life-Cycle Analysis</li> <li>• Literatur review</li> <li>• Conducting surveys and studies</li> <li>• Guidelines for site selection, sound measurement and impact mitigation</li> <li>• Circular Economy</li> </ul> | <ul style="list-style-type: none"> <li>• Design space representation</li> <li>• Market specific deployment recommendations</li> <li>• AWES R&amp;D state, trends and needs</li> <li>• Portal for AWES engagement and development potential</li> </ul> |
| <ul style="list-style-type: none"> <li>• Task reporting</li> <li>• Communication outputs</li> </ul>  | <ul style="list-style-type: none"> <li>• AEP prediction toolchain</li> <li>• Economic metrics</li> </ul>   | <ul style="list-style-type: none"> <li>• Definitions</li> <li>• Centralized design tool database</li> </ul>  | <ul style="list-style-type: none"> <li>• Whitepaper on AWES safety</li> </ul>   | <ul style="list-style-type: none"> <li>• LCA of AWE</li> <li>• Repository of surveys &amp; studies</li> </ul>   | <ul style="list-style-type: none"> <li>• Guidelines</li> </ul>  |

## “Getting airborne – the need to realise the benefits of airborne wind energy for net zero”

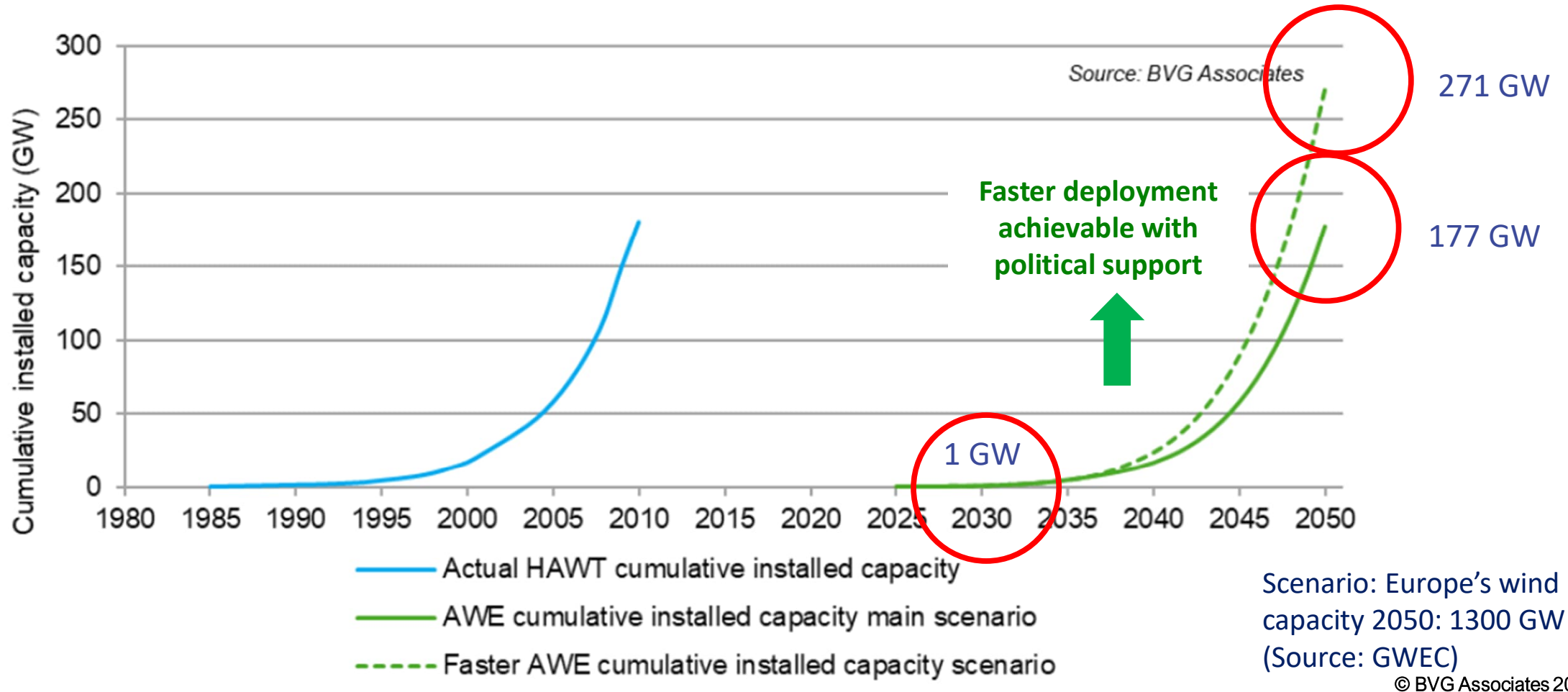
- Report by BVG Associates, UK
- September 2022



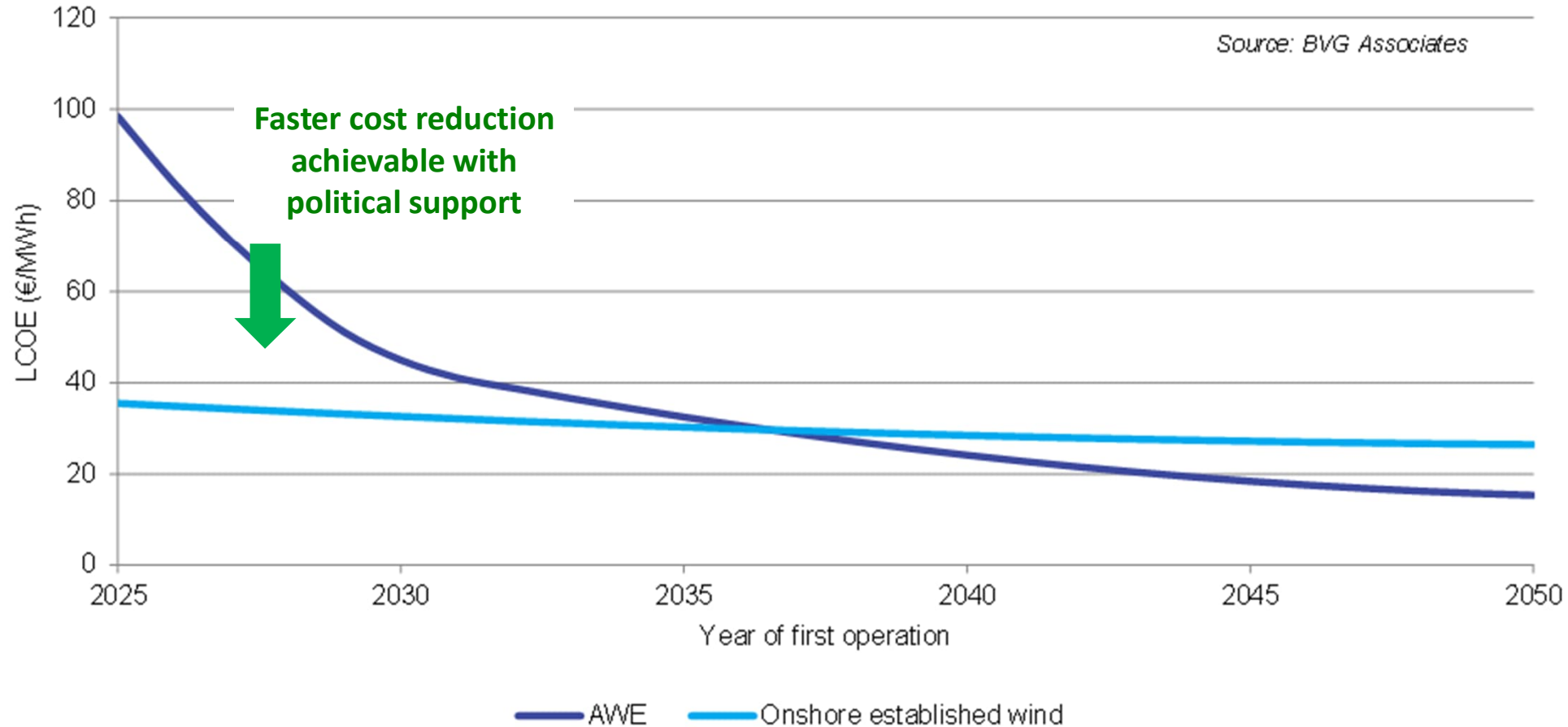
[BVGA-Getting-Airborne-White-Paper-220929.pdf \(airbornewindeurope.org\)](https://www.airbornewindeurope.org/BVGA-Getting-Airborne-White-Paper-220929.pdf)

Several hundred GW by 2050 are realistic.

The uptake can be higher and faster with the right support instruments.

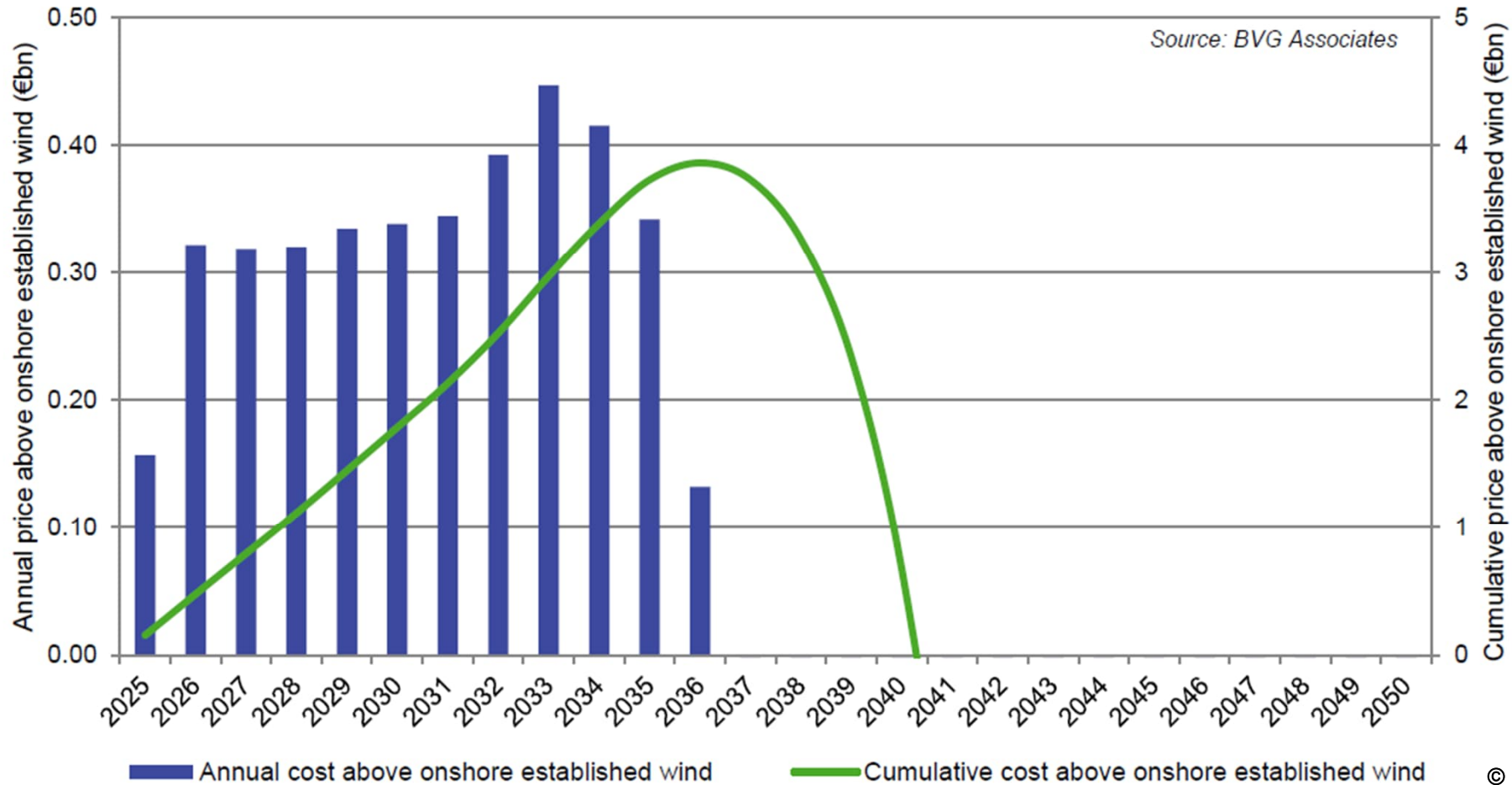


**AWE is at less than 20 ct€/kWh already today. LCOE will reach break-even with established wind in the 2030s – and even earlier with political support.**



© BVG Associates 2022

# About €4 billion of public support required to cover cost difference, ideally through FiT

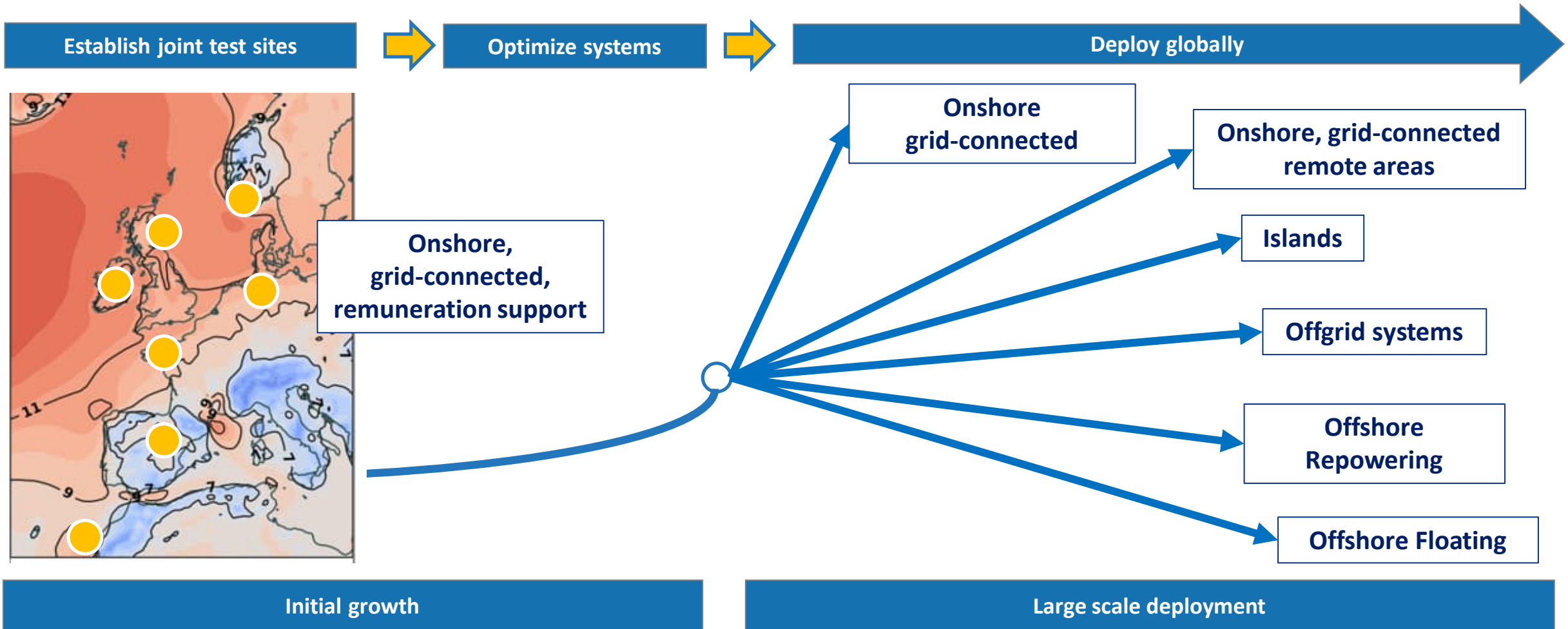


© BVG Associates 2022

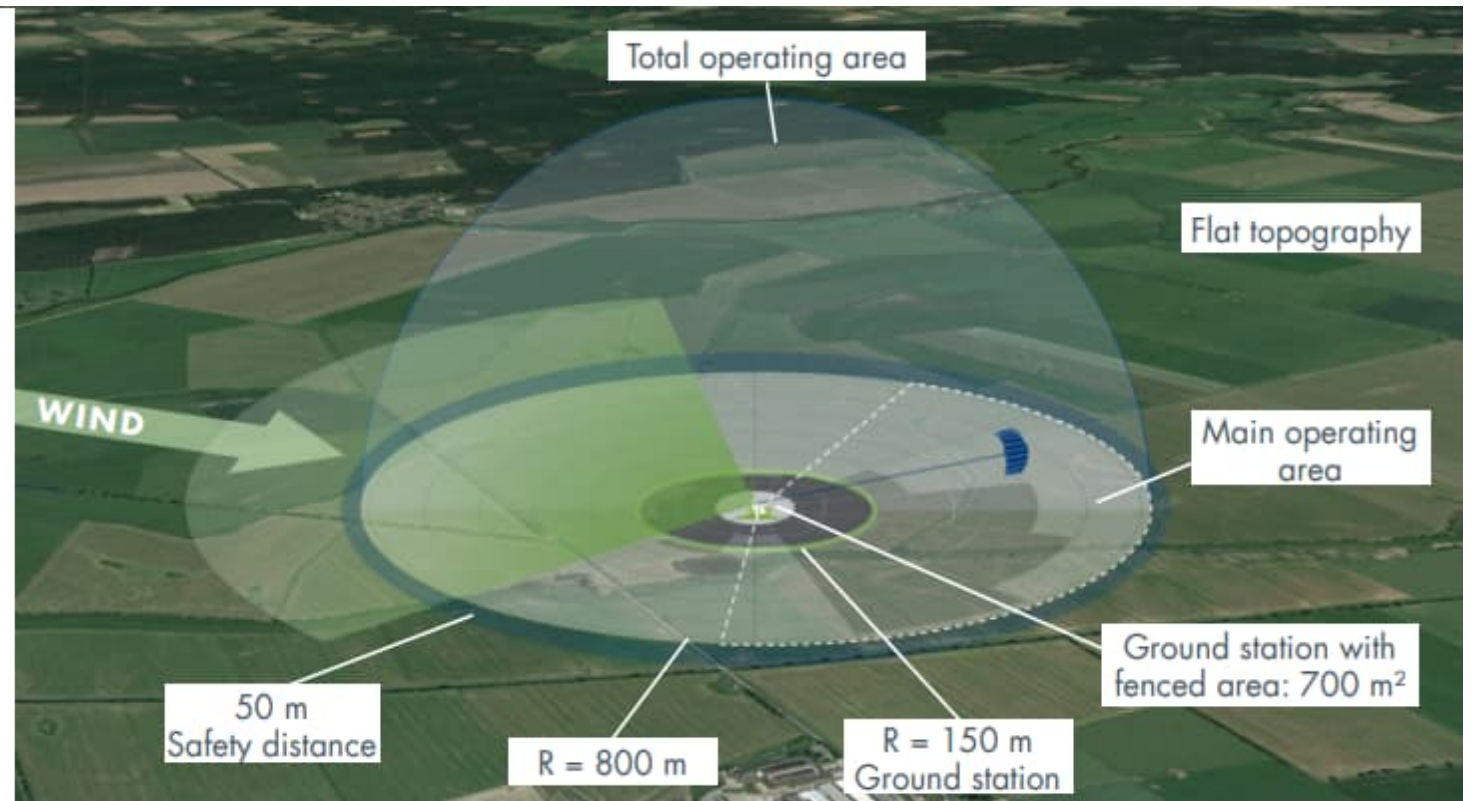
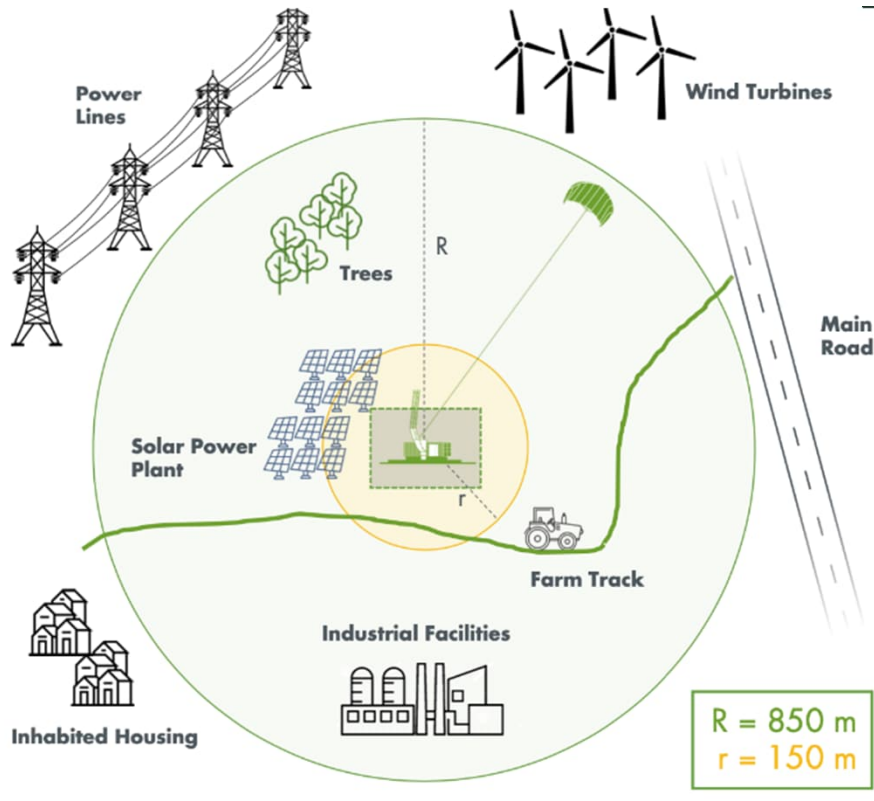


# Demonstration sites wanted!

## They will be springboards for opening a large range of AWE markets



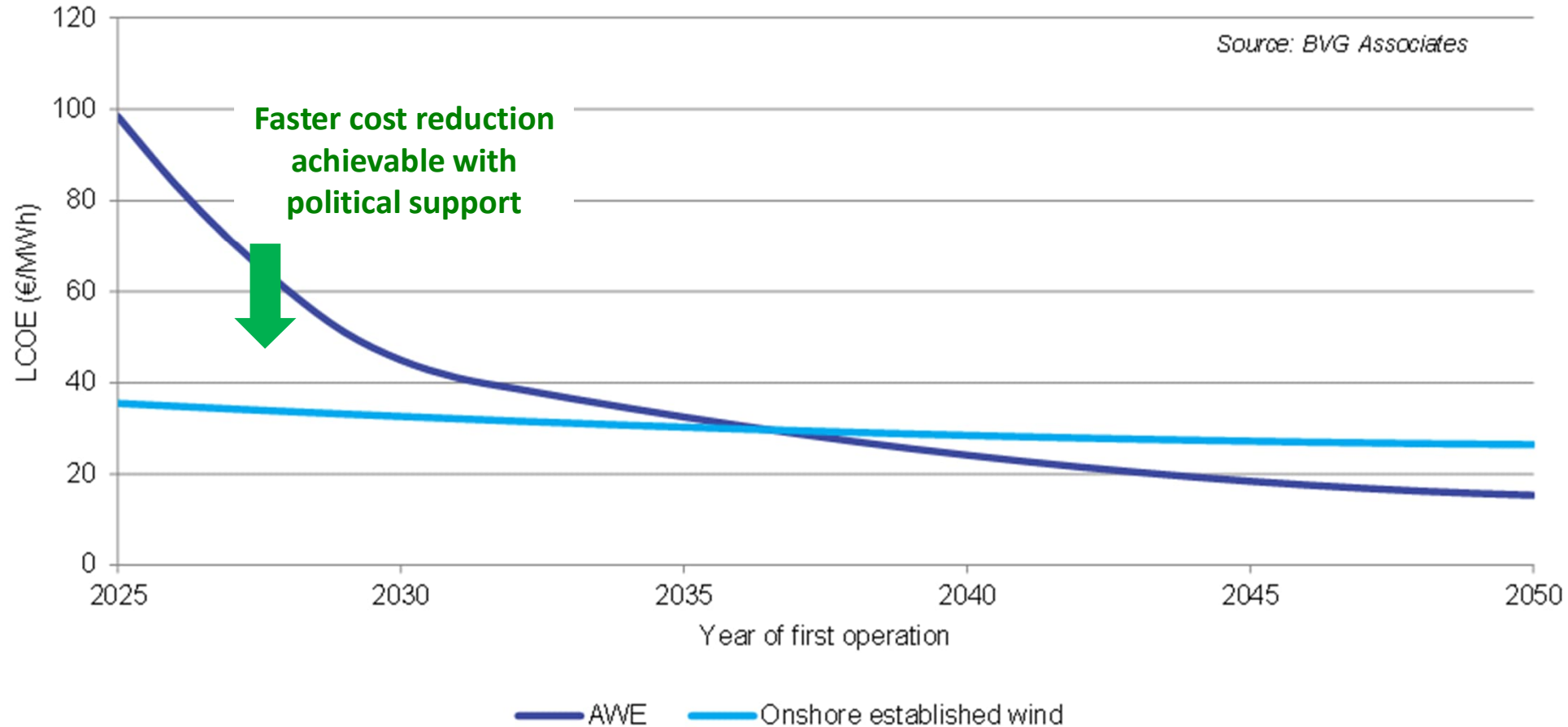
# AWE Site requirements: 800-1000m radius around ground station (Example Skysails). Agriculture activity within the operating area is still possible.



# AWE Site requirements: 400m between ground stations (Example Skysails)

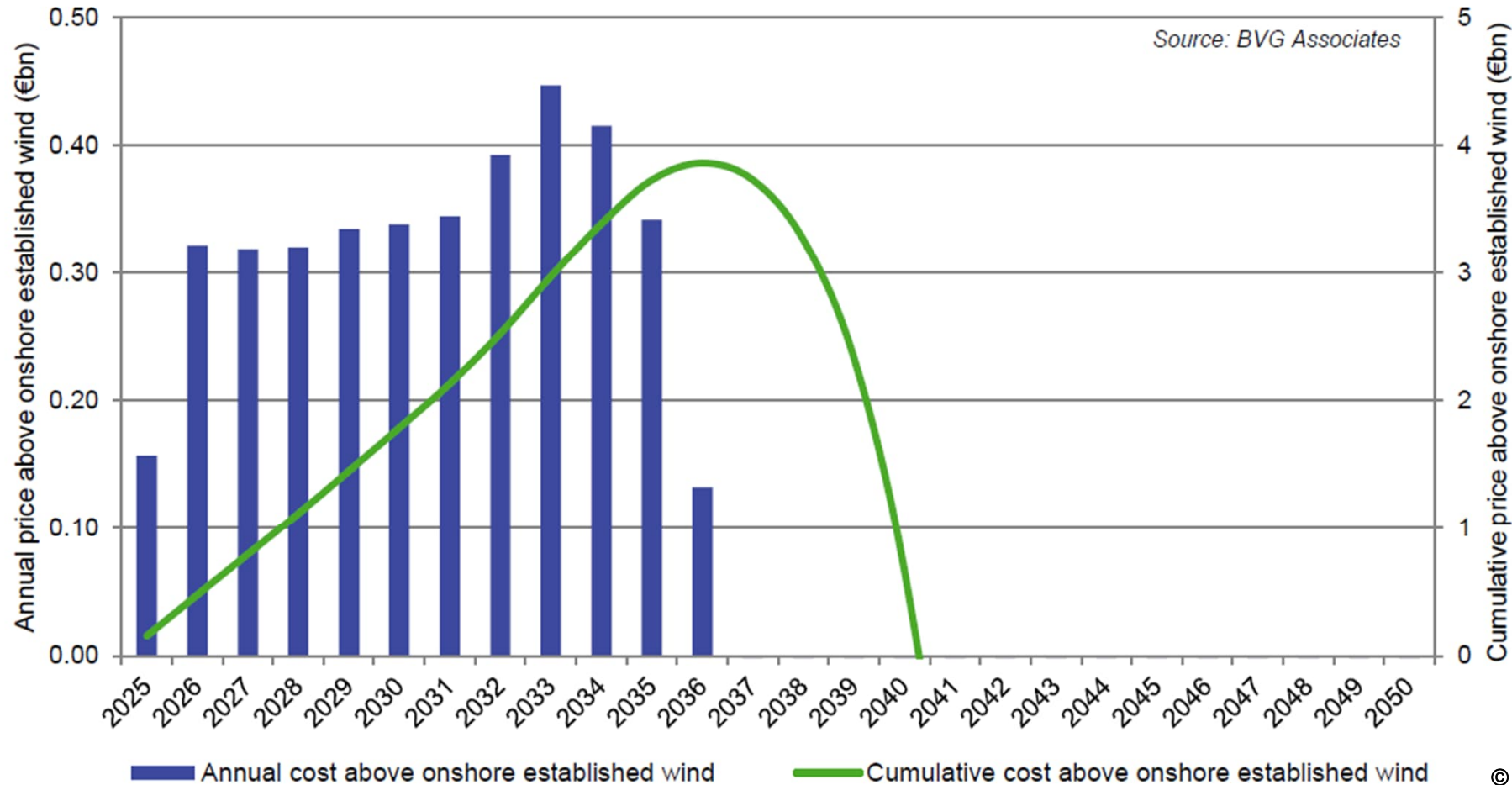


**AWE is at less than 20 ct€/kWh already today. LCOE will reach break-even with established wind in the 2030s – and even earlier with political support.**



© BVG Associates 2022

## Some €4 billion of price support over 13 years required to cover cost difference, ideally through AWE-specific FiT, CfDs or tenders, implemented by Member States.



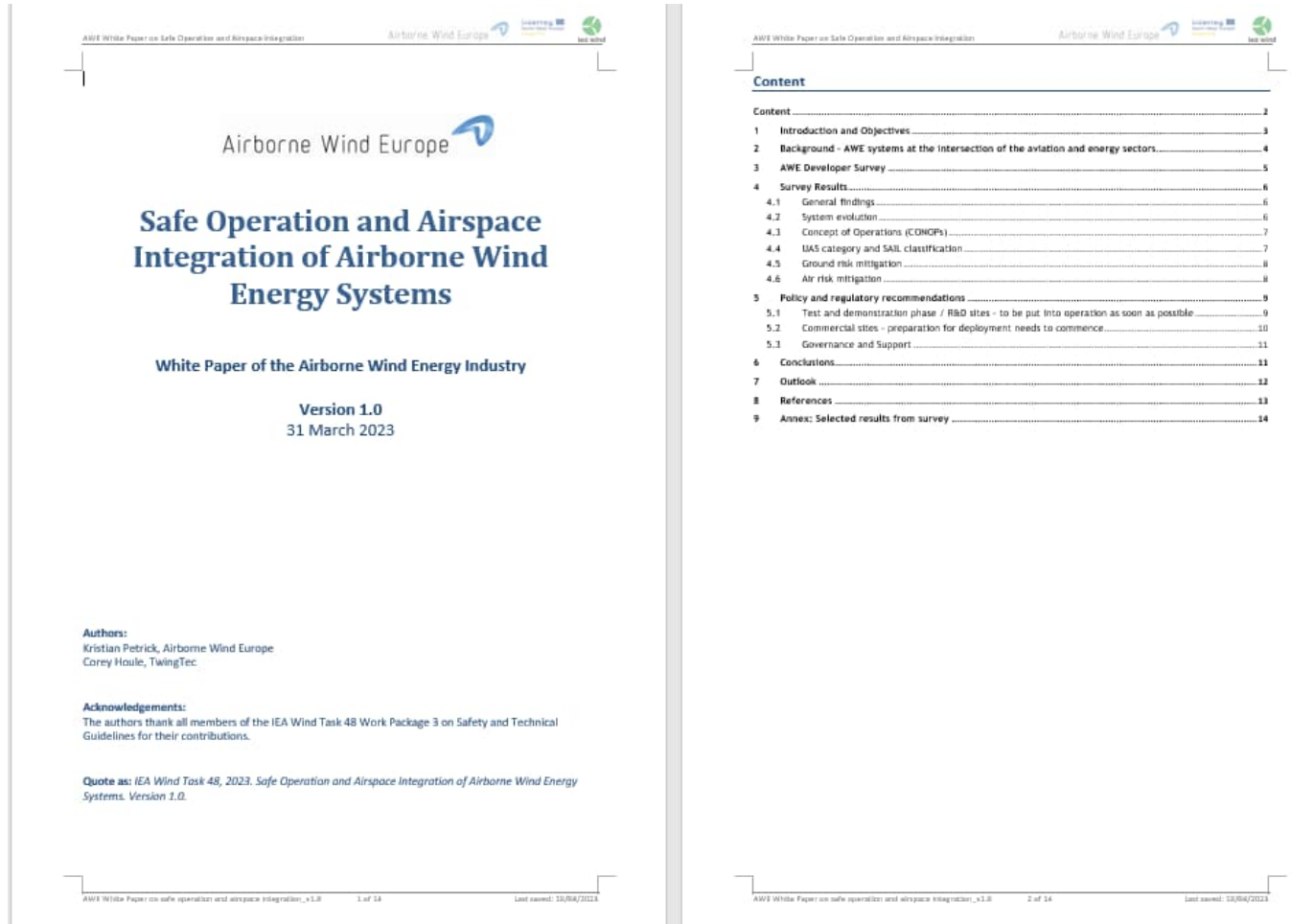
© BVG Associates 2022

**Example:**  
 Calls for tender for AWE on- and offshore projects could already be launched today to create a pipeline which attracts investors.

# Airborne Wind Energy combines two sectors: power generation and aviation



# The AWE sector has made a pragmatic proposal which will now be discussed with stakeholders (EASA, CAAs, competent authorities, etc.)



[AWEurope, 2023: Safe Operation and Airspace Integration of AWE Systems - Airbornewindeurope](#)