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

White Paper for Airborne Wind Europe

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A summary

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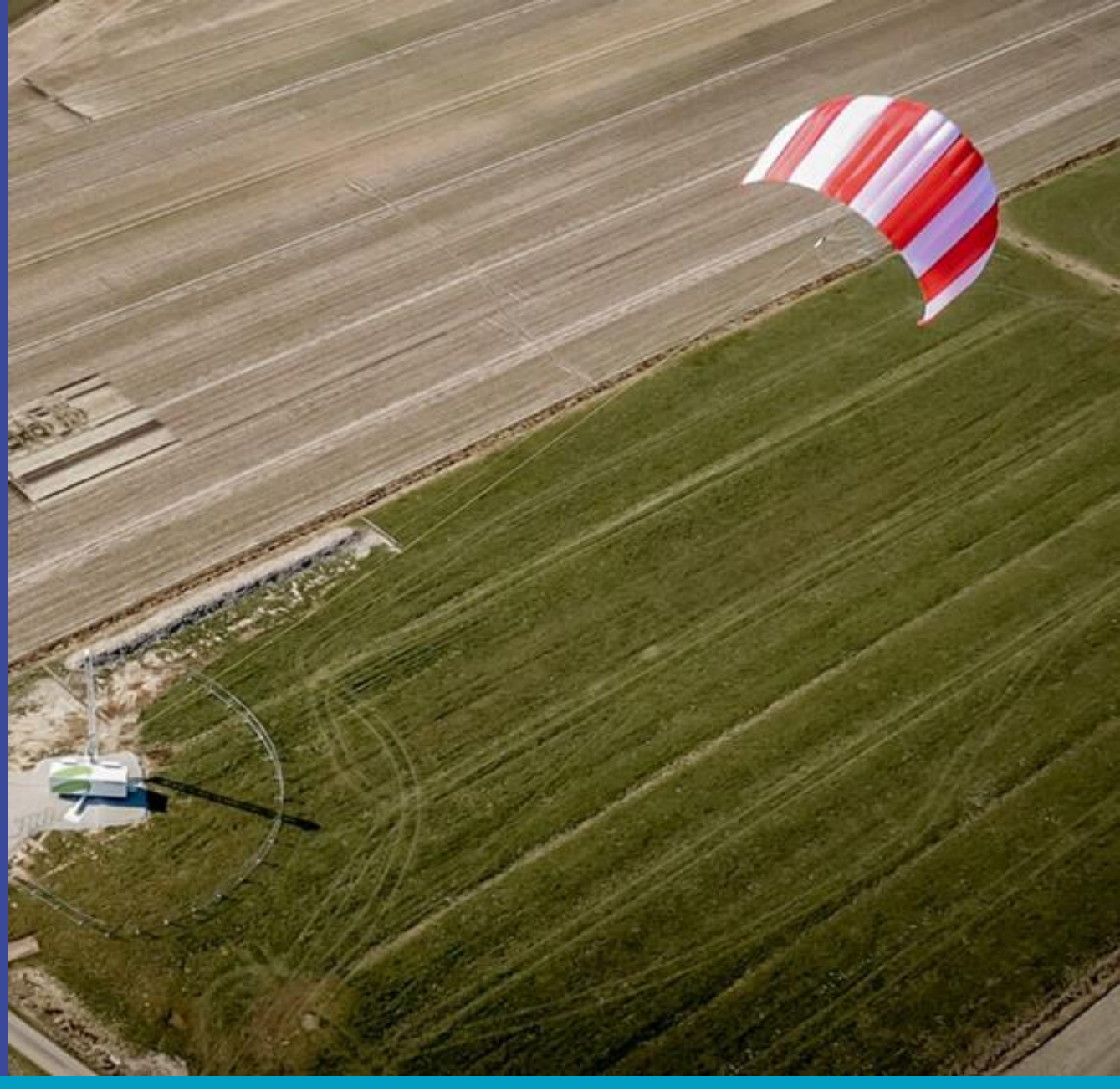

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Introduction

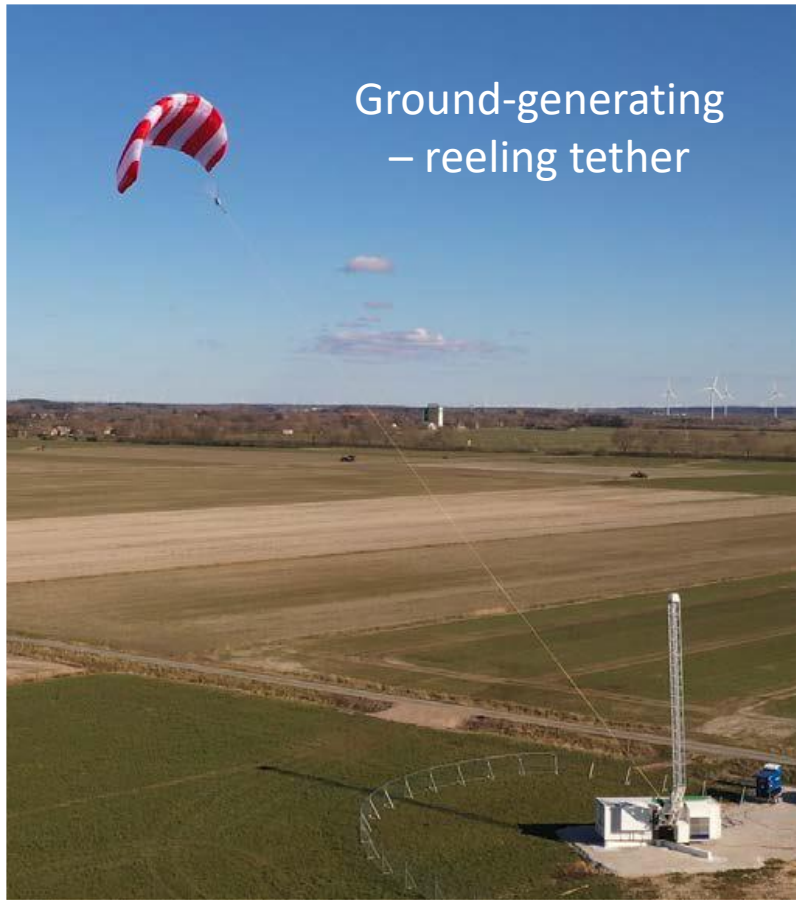
- BVG Associates has been accessing and advising clients about Airborne Wind Energy for 8 years
- The views expressed in this report are those of BVG Associates and the content of the report does not necessarily reflect the views of Airborne Wind Europe
- Thanks to all those who contributed
- Thanks to the funders:
  - Airborne Wind Europe
  - Interreg North-West Europe MegaAWE

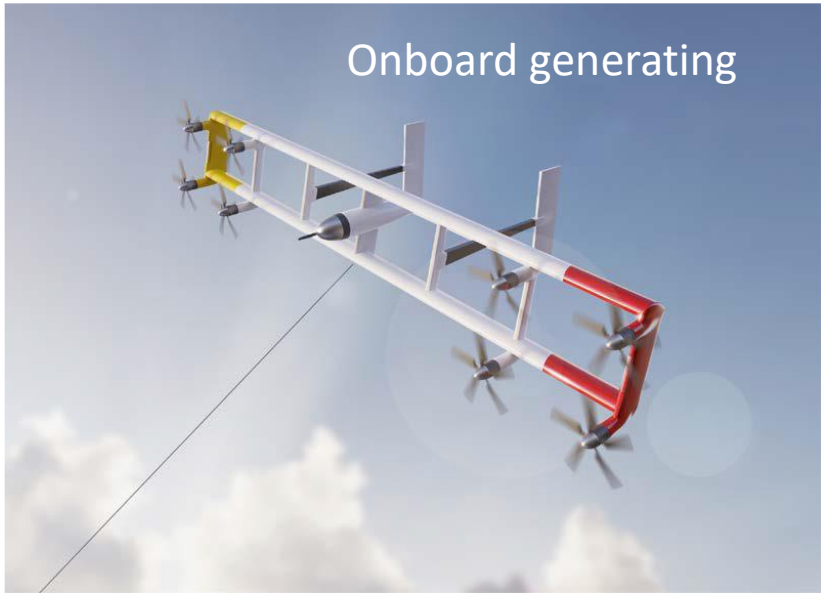
Airborne wind energy (AWE) is wind 2.0

- Game-changing solution accessing the large untapped wind resource potential at heights above established wind technology'
- Compared to established wind technology, AWE:
  - Opens new areas for energy from wind
    - Many countries are struggling to find enough viable sites for onshore wind, hence the move to offshore wind.
    - Has a much lower logistics requirement than established wind technology, hence it can be installed in places that established wind cannot. Many of these are high-wind areas offering low LCOE.
  - Increases energy generated per square km
    - Uses available space up to about three times more effectively since lower wake effect on downwind devices.
    - Has a higher capacity (load) factor than established wind technology on the same site with the same nominal capacity.
  - In time, can provide energy at lower cost
    - By the mid 2030s AWE will be able to compete with an average price lower than established wind technology, and
  - Has lower environmental impact
    - Has a 40%+ lower carbon intensity than established wind technology, is easier to decommission, and may reuse offshore infrastructure.
- Like established wind, AWE has the potential to contribute energy generation at scale'

Many types

3 main types, with variation within them including horizontal/vertical take-off and flexible/rigid wing:





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Starting commercialisation

- The first commercial 150 kW AWE single-kite system was supplied by SkySails in 2021.
- At least four other companies are following with 50-150 kW devices and are expected to achieve installations in the period 2022 to 2025.
- First mover sales profile:

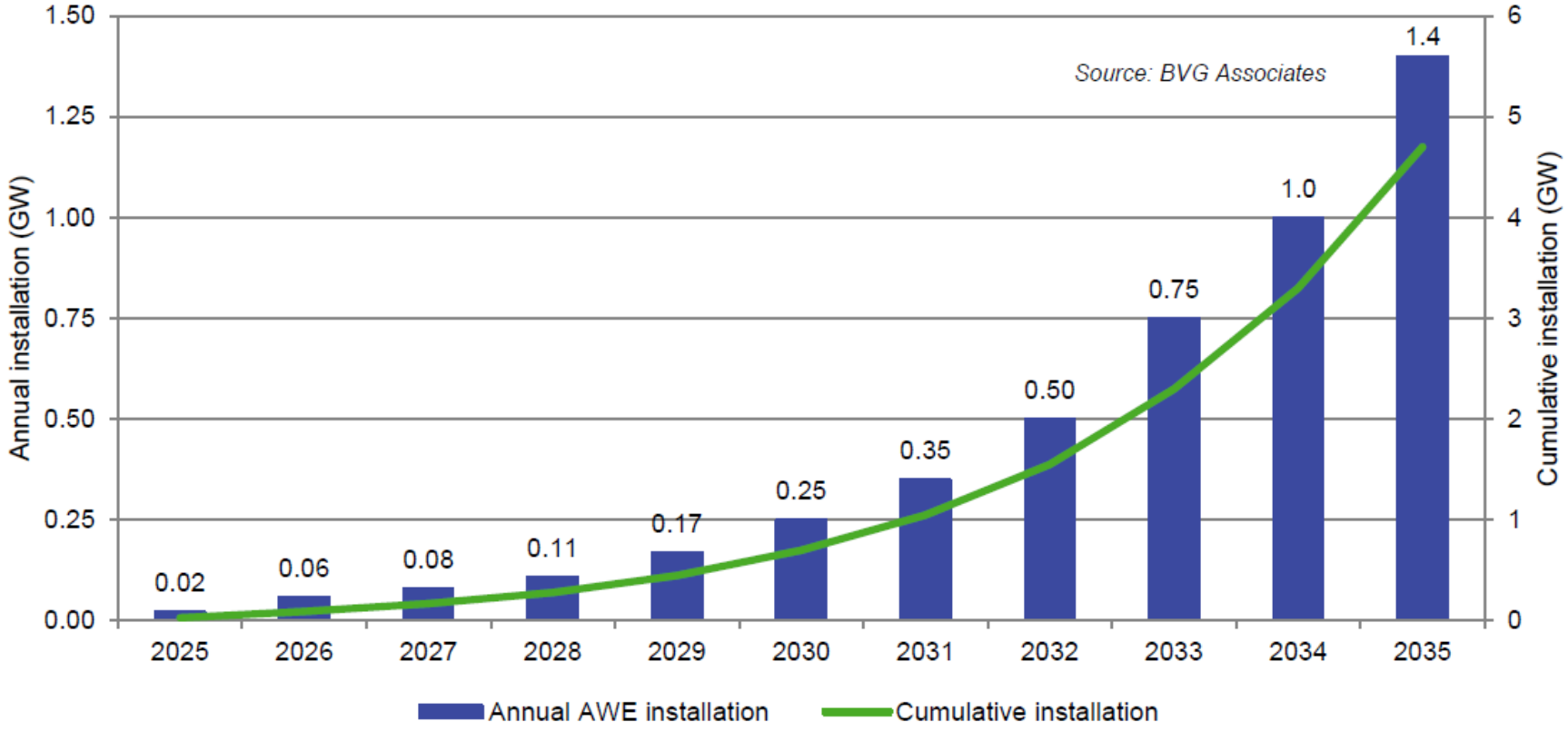
Year	Sales (kW)	Description of sales
2021	150	First 150 kW AWE single kite system
2022	450	450 kW system
2023	750	First array of 5 x 150 kW devices
2024	4,000	4 arrays of 5 x 200 kW devices
2025	16,000	8 arrays of 10 x 200 kW devices
2026	32,000	16 arrays of 10 x 200 kW devices

- Together the expected total cumulative market reaches over 90 MW by the end of 2026.

Route to volume market impact

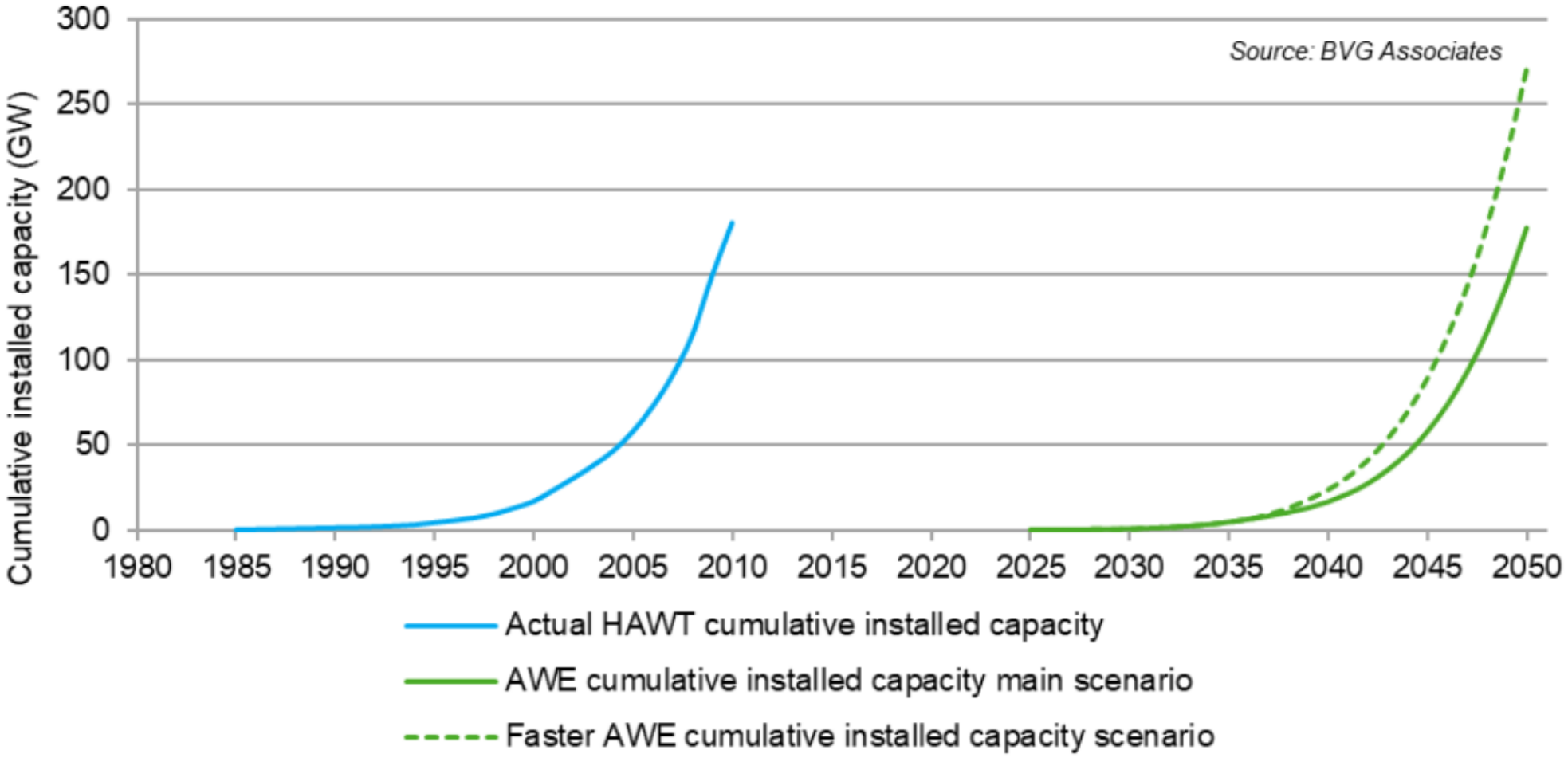
We modelled a scenario of market growth of AWE systems to 2050 based on:

- Sales forecasts of leading AWE technology developers (AWE-TDs), and
- The historic growth of established wind.



4.7 GW at end of 2035

Route to volume market impact (continued)



271 GW at end of 2050

177 GW at end of 2050

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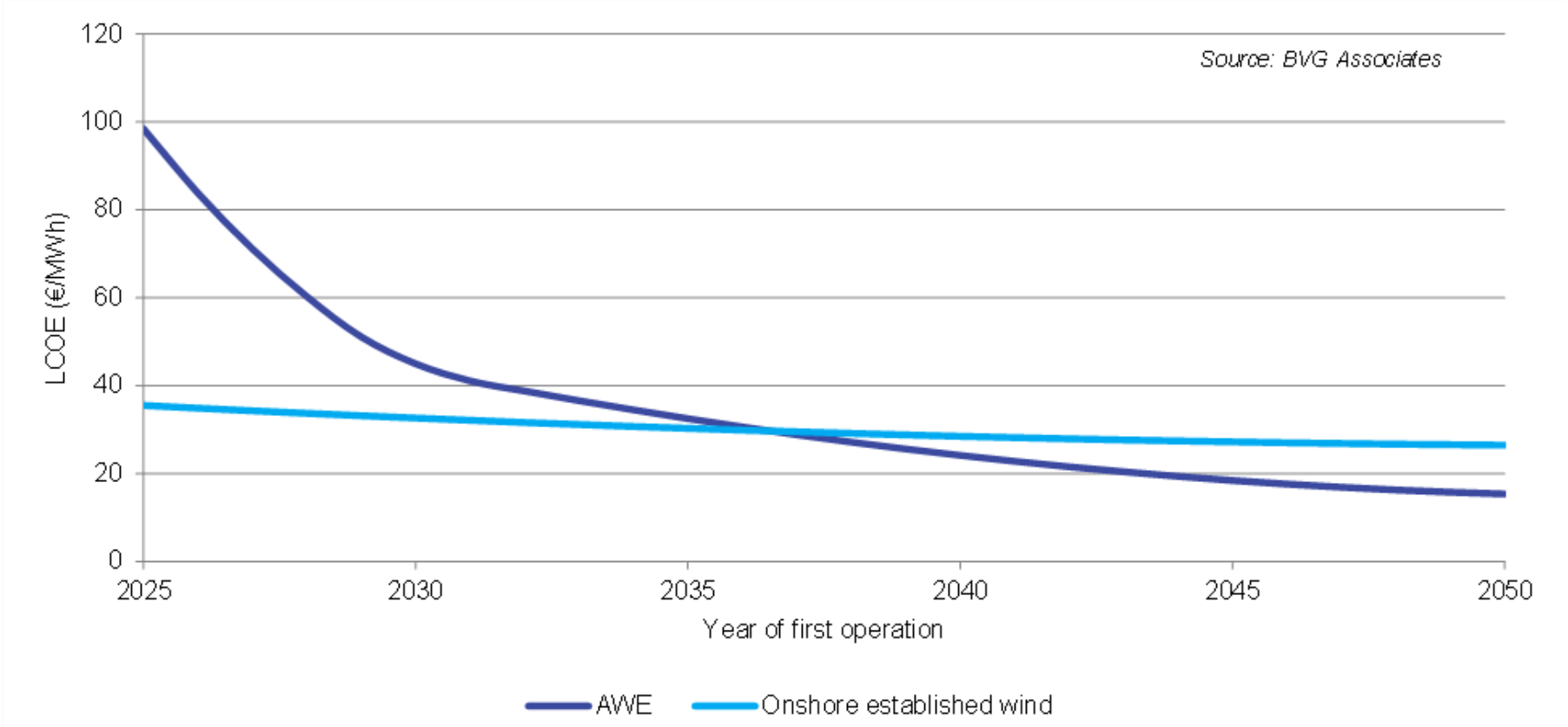
Levelised cost of energy (LCOE) trajectories

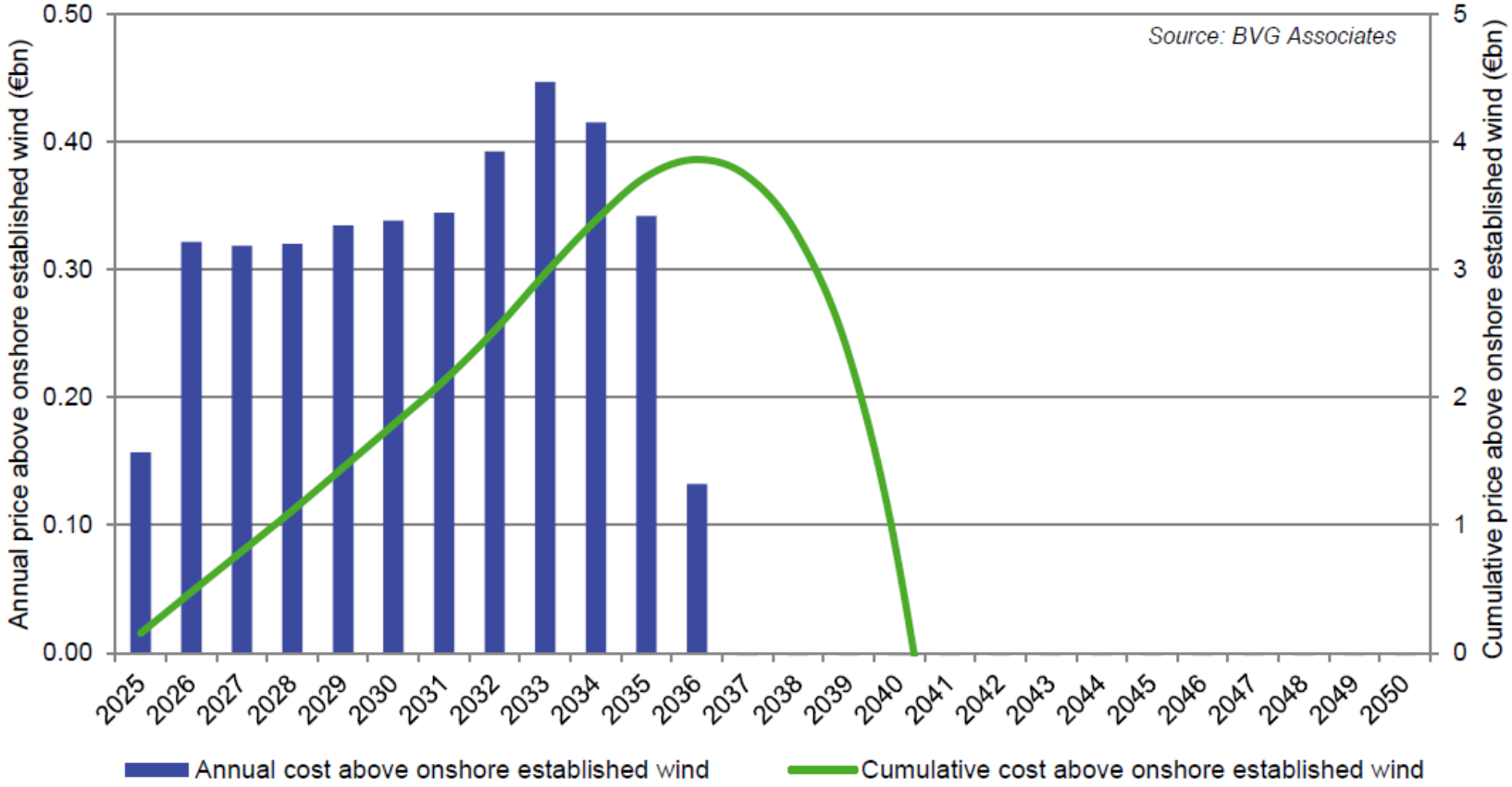
We modelled future LCOE trajectories to 2050 for AWE and established wind technology from cost and energy production forecasts and using learning rates for established wind of 10% and for AWE of 15% to 2030 and 10% thereafter.



AWE cost in excess of that for established wind turbines

- The extra cumulative cost to get AWE to the break-even point compared established wind technology is about €4 billion in the 11 years from 2025, when just over 10 GW of AWE will have been installed.
- Most of this cost difference will need to come from public support.

Annual peak of €0.45 billion per year in 2033.



Industry development support

Other public support is also required for industry development, growing to about €125 million per year between 2023 and 2030 with additional funding from the industry and investors. This is to cover:

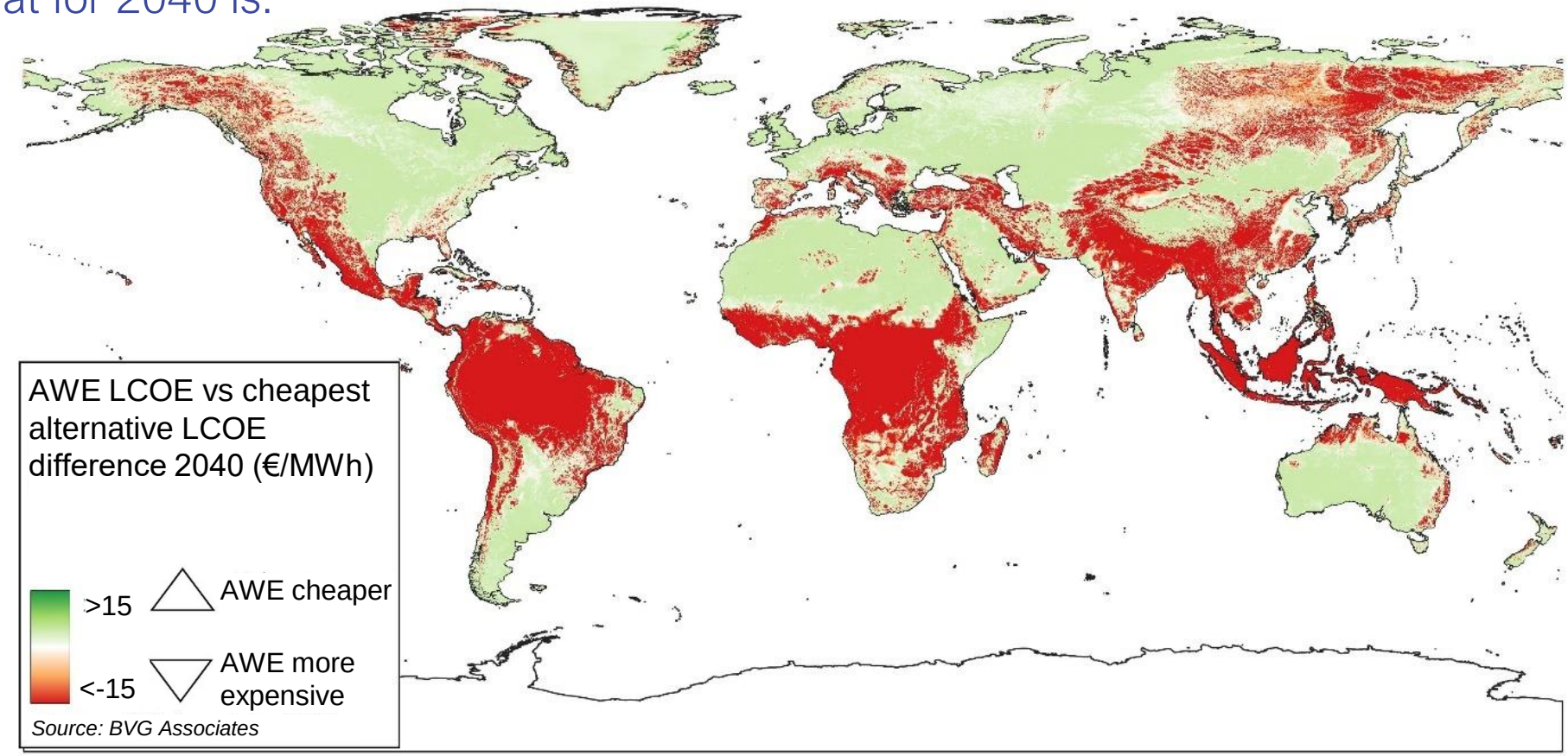
Area of support	Note	Fraction of other public support
Direct innovation grants	Includes funding prototype testing	60%
Supply chain development grants	For equipment and expertise to assist manufacturing	10%
AWE test site grants or sponsorship of electricity produced	For provision of open access test sites and their operation and developing associated performance verification	5%
Site development grants	Grants for those seeking to develop the first AWE farms	5%
Acceleration support	Tailored business growth support for each grant recipient	5%
Grant programme support	For programme development, competitions and their launch, grant monitoring: administering grants above	5%
Support for standardisation	Develop guidance and standards needed	5%
Addressing regulatory barriers such as permitting especially related to air traffic	Resource for regulators and planning bodies to develop and administer the frameworks needed for AWE to be deployed at scale	5%

The AWE ask

- Public support of about €5 billion is needed, split as €4 billion for project electricity price support and €1 billion for industry development support.
- As with all new energy technology, this helps ensure that:
  - Sufficient R&D happens
  - Companies have the necessary stability to efficiently undertake technology and product development
  - Regulatory regimes are established
  - The early commercial projects promptly go ahead
  - The environment needed for AWE technology to be deployed at volume in existing markets is established, and
  - AWE is able to properly develop to compete with established wind technology.
- The funding needed is expected to come from different countries, ideally with collaboration.
- The need to spend much of the public money will only arise after progress has been demonstrated against the early milestones.

Other sections in the report include:

- Discussion of the offshore potential, and
- Presentation of a separate LCOE analysis for representative AWE system versus cheapest alternatives for a 500kW project. That for 2040 is:



Conclusion

- Compared to established wind technology, AWE:
  - Opens new areas for energy from wind
  - Increases energy generated per square km
  - In time, can provide energy at lower cost, and
  - Has lower environmental impact.
- £5 billion of public support is needed to enable AWE deliver these benefits, with net benefit already in 15 years.
- The public support of about €5 billion, split across various countries is small compared to that spent supporting established wind technology.
- Given AWE is such a promising technology, with such potential to help in the fight against climate change, provision of support to accelerate its development is urgently needed.

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