From Wind Resource to Bankability: Lessons from Low-Wind-Speed Projects and LiDAR-Based Wind Assessment in Asia

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Vincent has over 18 years of experience in the energy sector, mainly in international consulting, with the last 9 years focused on wind energy development across Asia. He currently leads AFRY's Wind Power business across APAC.

AFRY today

AFRY today

AFRY unlocks the energy and industry transition, strengthening resilience in society by providing **engineering**, **project management**, and **advisory services**

Net sales, USD
2.8b

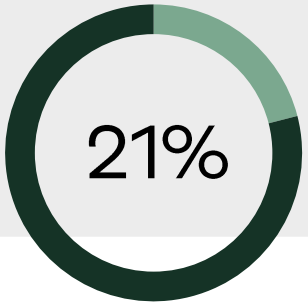
Number of employees
18,000

Established in
1895

Countries with offices/projects
50/100

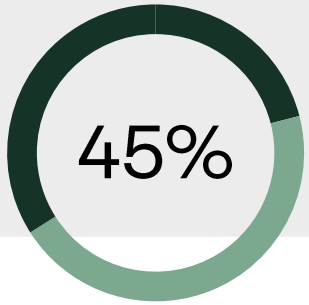
FY 2024

Global Division
Energy

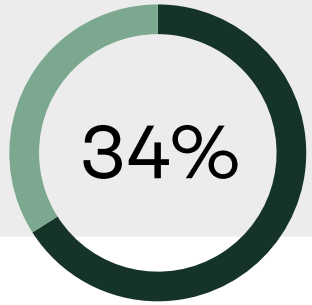


Revenue share of total

Global Division
Industry



Global Division
Transportation & Places



Energy Division - Segment Overview

Hydro

Nuclear

Thermal

(CCGT, LNG, Hydrogen & Ammonia, CCUS,...)

Renewables & Energy Storage
(Wind, Solar, BESS)

Transmission & Distribution

Management Consulting
(Energy Sector Management Consulting and Market Advisory)

AFRY Wind Power globally & across Asia-Pacific region

Global competence

- **90+ GW** wind projects globally
- **400+** wind projects delivered
- **30** years of experience
- **250+** wind specialists (80+ offshore)

Asia

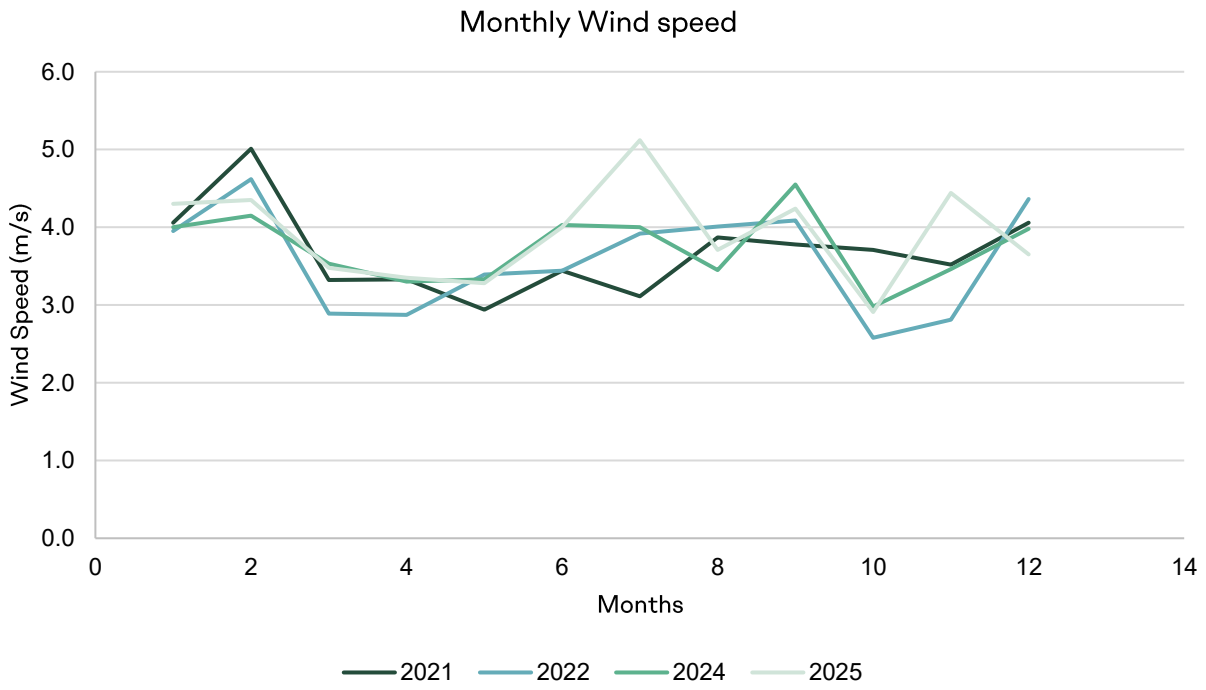
- Wind Power Services since **2008**
- **25,000 MW** of wind power projects in Asia
- **70+** people involved in wind projects
- **16** ongoing LTAs, **6** recent EPC tendering support projects, **6** ongoing wind OEs construction in APAC
- Multiple EYAs, Due Diligences (onshore and offshore wind)

The Shift to Low Wind Speed Development

Wind Resource Characteristics Are Changing Across Southeast Asia's Project Pipeline

- Wind development in Southeast Asia is increasingly expanding beyond traditional high-resource areas into a broader range of site conditions.
- Our recent project experience shows a gradual reduction in average site wind speeds compared with historical developments.

Example of a low-wind-speed project currently in operation



Future growth will increasingly come from sites that would have been considered marginal 10 years ago

Shift Toward Low Wind Speed Development

High-wind regions are becoming saturated, and Asia's wind projects are moving from high-wind sites to areas with lower average wind speeds

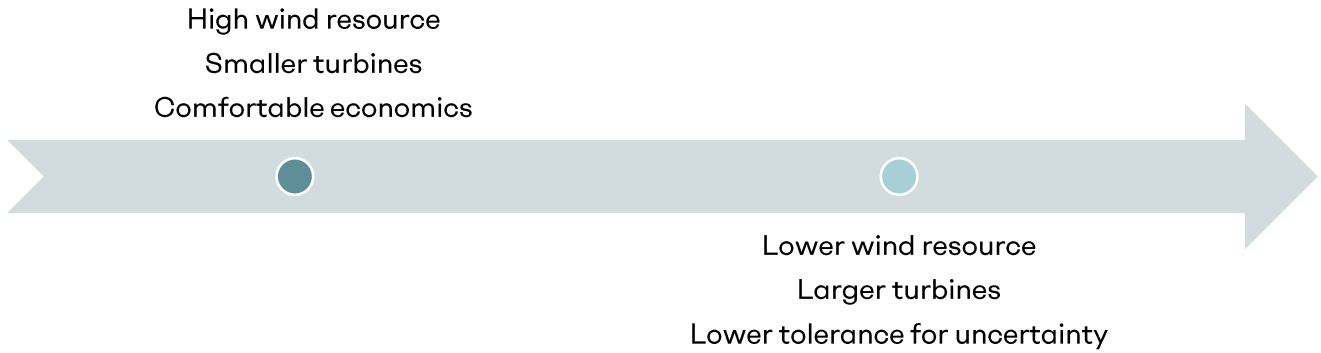
Market Shift to Low Wind Speeds

Lower wind speeds increase the importance of accurate wind assessment and financial risk management for developers and lenders

Need for Precision and Risk Management

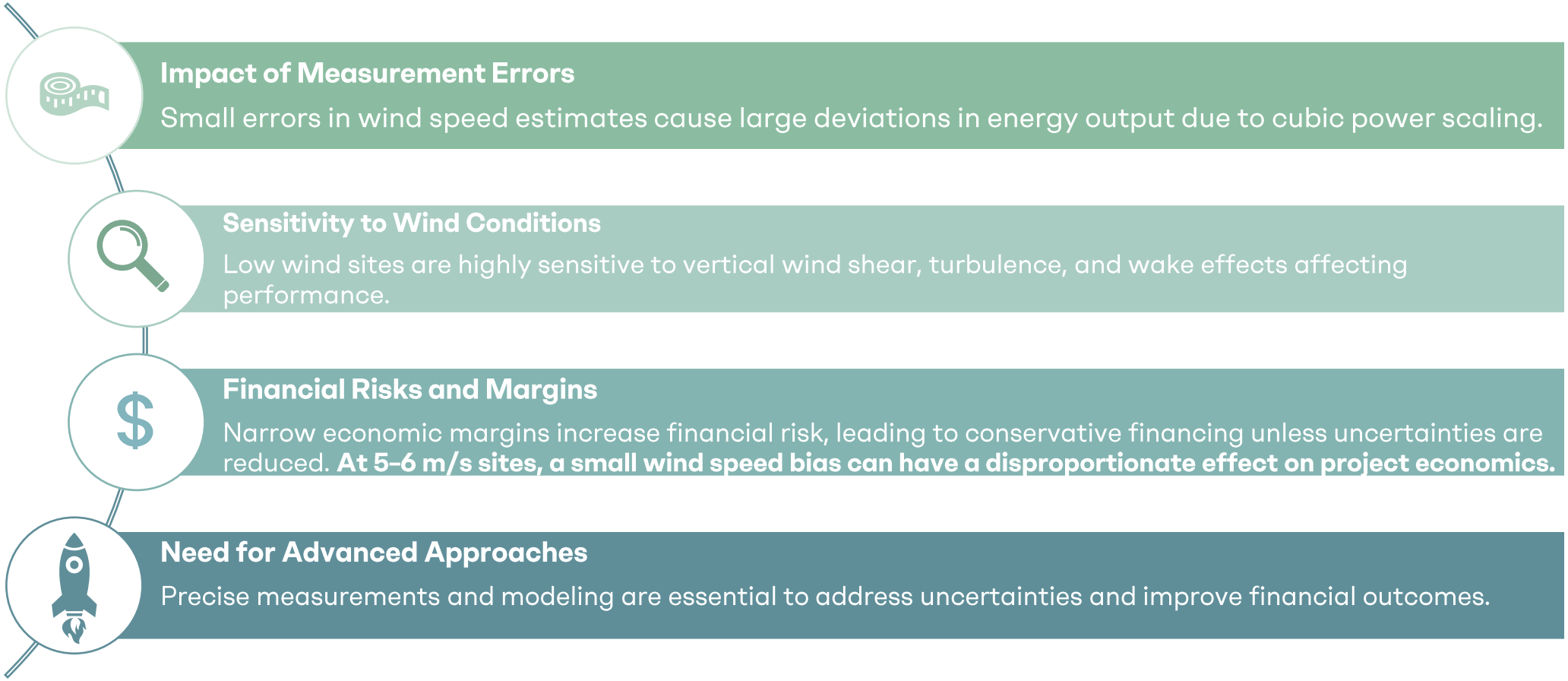
Emerging strategies such as better measurement, advanced turbine technologies, optimized project configuration

Changing Development Strategies



Measurement strategy becomes more important than ever

Key Challenges Specific to Low Wind Speed Sites



Impact of Measurement Errors

Small errors in wind speed estimates cause large deviations in energy output due to cubic power scaling.

Sensitivity to Wind Conditions

Low wind sites are highly sensitive to vertical wind shear, turbulence, and wake effects affecting performance.

Financial Risks and Margins

Narrow economic margins increase financial risk, leading to conservative financing unless uncertainties are reduced. **At 5–6 m/s sites, a small wind speed bias can have a disproportionate effect on project economics.**

Need for Advanced Approaches

Precise measurements and modeling are essential to address uncertainties and improve financial outcomes.

Case Study: Overcoming the Low Wind Speed Challenge Through Innovation

Project Description

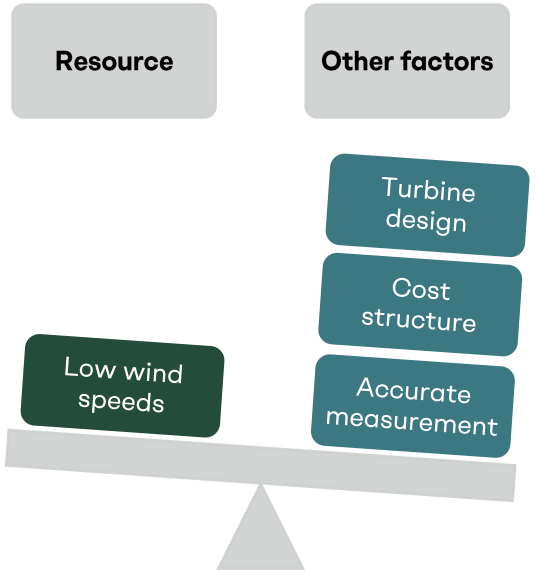
- Situated in northern Malaysia, with a total installed capacity of 100 MW.
- Historically considered "Nonviable" for the wind development
  - Limited investment
  - Lack of local experience
- Ultra low wind speed country which limits large scale wind power development

Wind Resource Alone Does Not Define Viability

Low wind is not necessarily non-bankable. It means a different strategy is needed

- Supportive tariff or government support
- **Low wind speed WTGs (Technology selection becomes critical to project viability)**
- **Optimized measurement campaign: remote sensing devices, such as vertical LiDAR, can support a smarter measurement campaign.**

Low wind speed WTGs with larger rotor can achieve an estimated **20-22% higher Gross production** in low-wind region compared to old typical WTGs



Is standalone LiDAR bankable for an onshore wind measurement campaign?

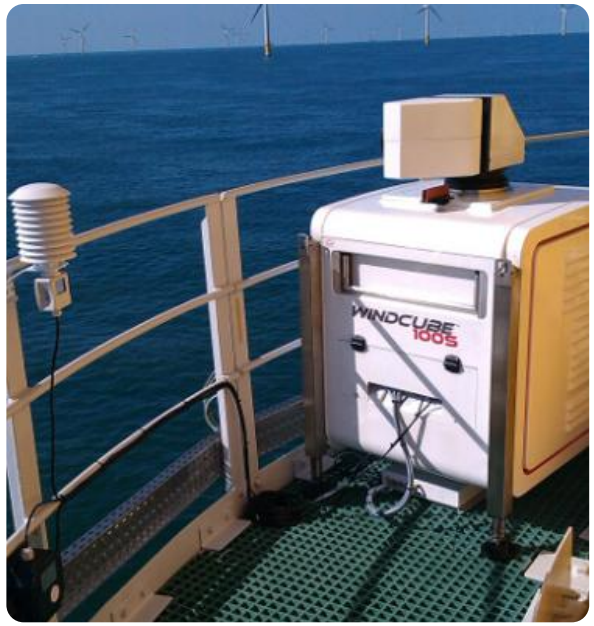
1) Yes, fully bankable
2) Yes, but only with validation
3) Not yet
4) Depends on the lender / project

LiDAR as a Development Tool

What's a LiDAR?

Wind **LiDAR** is a remote sensing laser device used to measure wind speed and direction at multiple heights.

Onshore vertical LiDAR



Offshore LiDAR (fixed)

Offshore LiDAR (floating)

Nacelle-mounted Scanning LiDAR

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Why LiDAR Matters for Early-Stage Screening

Instead of carrying high cost upfront from installing met mast, deploying LiDAR is the solution to understand wind regime with lower cost

Benefits through use of LiDAR in site-screening phase

- Fast deployment
- Lower upfront cost
- Measurement at multiple heights
- Relocation flexibility
- Earlier go/no-go decisions

	Met mast	LiDAR
Cost	High	Lower
Installation time	Slower	Faster
Permitting	More complex	Usually easier
Flexibility	Fixed	Relocatable
Best use	Bankable reference	Screening / complementary WRA

LiDAR helps developers avoid committing major capex before understanding whether the site has real potential.

Case Study: Cost-Effective Screening with LiDAR in early-stage projects

Onshore Wind Farm Project in Cambodia

- Located in Cambodia in elevated plateau
- Wind speed : 5-6 m/s

Key Challenges

- **WTG layout relocated to a more promising area**
- Limited historical wind data infrastructure
- Low-moderate wind resource
- Tariff and bankability challenges (Emerging regulatory framework)

LiDAR Solution

- Deploy a portable LiDAR to gain confidence about the resource
- Install met mast and conduct collocation
- Use the collocation to estimate LiDAR uncertainties and relocate the LiDAR to various positions

LiDAR can be used as a screening tool to assess wind resource potential before committing to full met mast investment.

Photo Source: Windpower Monthly

Reducing Uncertainty with LiDAR Integration in WRA

When it comes to large area of Project, more measurement locations are required to capture the wind regime of each WTG clusters

Benefits through use of LiDAR in Wind Resource Assessment

- Cost-effectively reduce the flow modeling uncertainty
- Reduce the vertical extrapolation uncertainty
- Understand Wind Regime beyond Hub Height up to 200 – 300 m
- Higher accessibility in remote area

LiDAR Reduces Uncertainty When:

✅ **Properly validated**

✅ **Combined with met mast measurements**

✅ **Used at representative locations**

✅ **Fully integrated into the WRA methodology**

The objective is not more measurements, it is lower uncertainty.

Reference: https://www.zxlidars.com/

Case Study: Reducing Uncertainty with LiDAR Integration in WRA

Onshore Wind Farm Project in Laos

- Located in Laos, Complex Terrain
- Project area: 30 x 30 km^2
- 600 MW installed capacity

Key Challenges

The large project area and complex terrain create non-uniform wind flow requiring multiple measurement locations due to terrain-induced measurement distortions

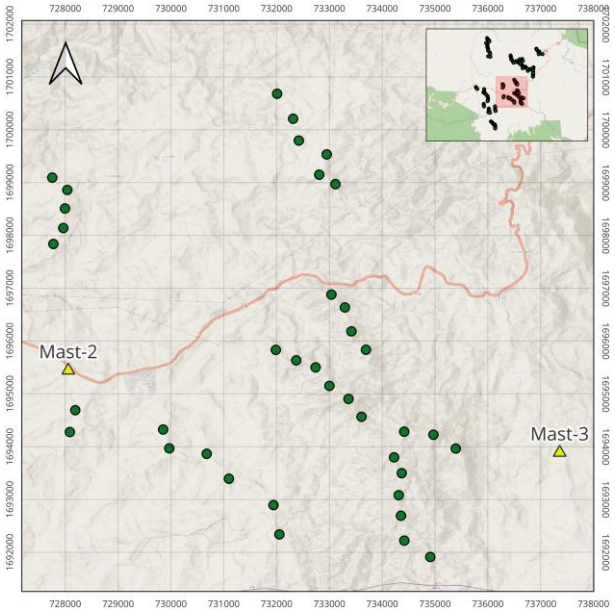
Role of LiDARs

Multiple LiDARs

- Improved spatial representativeness
- Reduced wind flow modelling uncertainty

The selected approach

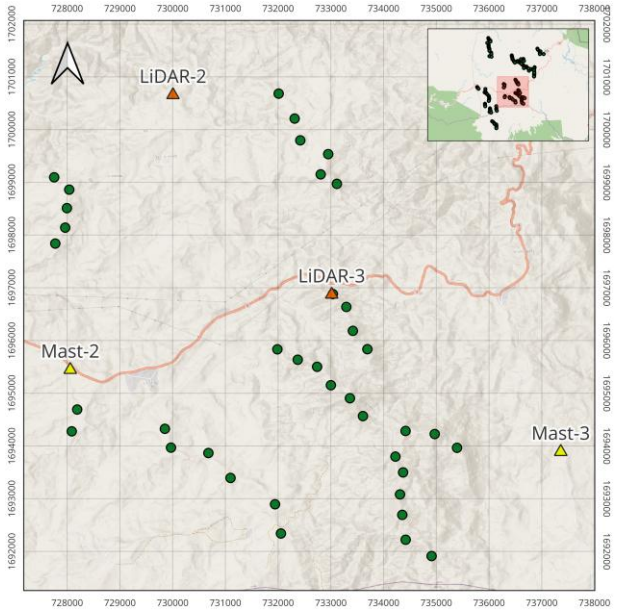
Baseline



COST

UNCERTAINTY

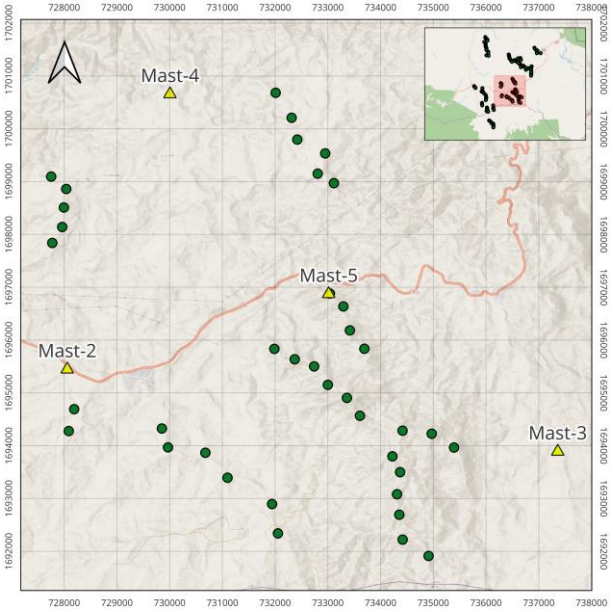
LiDAR-Integrated approach



COST

UNCERTAINTY

Met Mast only

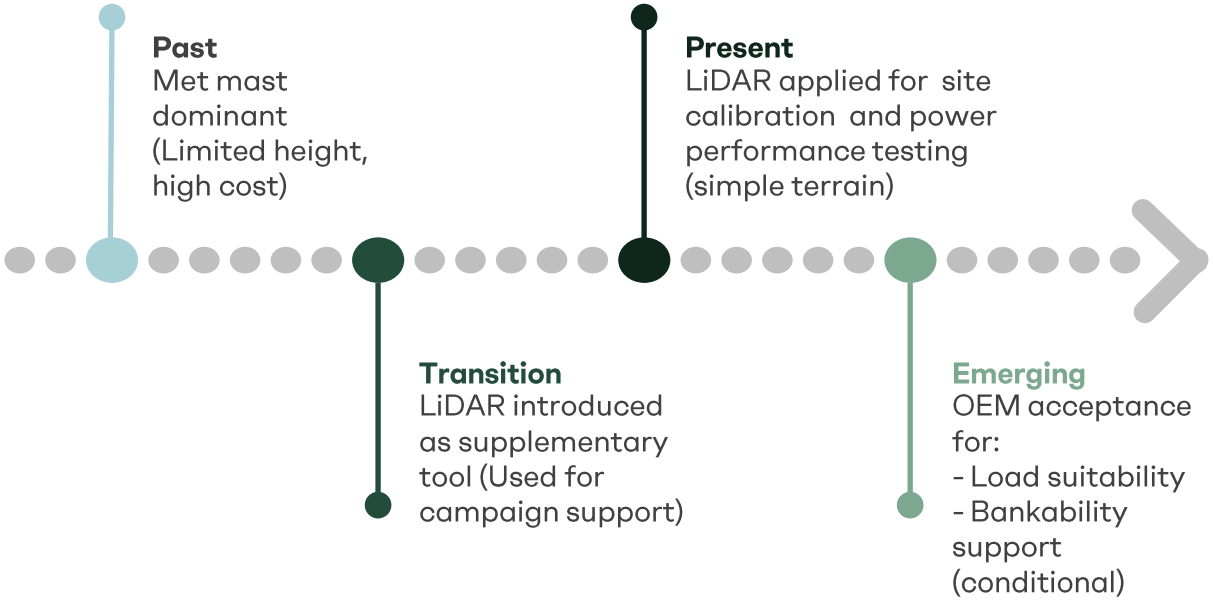


COST

UNCERTAINTY

Standalone LiDAR as a Bankable Solution?

Evolution of LiDAR Acceptance



Power Performance Testing:

LiDAR is permitted under IEC 61400-12-1 with defined requirements (e.g., site calibration)

Load Suitability:

- Used in practice by Chinese OEMs.
- Accepted by some European OEMs such as Nordex under strict validation requirement.
    - Currently limited to specific systems (WindCube (Vaisala) and ZX LiDAR)

Note !

- Acceptance varies by OEM ;
- Met masts still required for fully bankable datasets

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Why LiDAR Does Not Fully Replace Met Masts

LiDAR Limitations

- **Lender acceptance remains conditional**
  Many lenders still require independent validation before accepting LiDAR-only campaigns.
- **Requires validation**
  LiDAR measurements require calibration and validation to demonstrate measurement accuracy and reduce uncertainty.
- **Campaign duration is limited**
  Short-term LiDAR campaigns require MCP with long-term reference datasets to represent long-term wind conditions.
- **Site-dependent performance**
  Measurement quality may be affected by complex terrain, atmospheric conditions, or environmental factors.

Why Met mast still matter?

- Met masts remain the industry benchmark for financing and are widely accepted by lenders.
- Direct measurement reliability and lower data availability risk. (Lower sensor uncertainty, higher extrapolation uncertainty compared to LiDAR)
- Met masts provide the reference data required for LiDAR calibration, validation, and uncertainty reduction.

While LiDAR enhances wind resource characterization and reduces extrapolation uncertainty, met masts remain a critical reference for validation and bankable energy assessments.

Bankability and Lender Acceptance

LiDAR has evolved from an emerging measurement technology to a widely accepted solution for wind resource assessment. Improvements in validation, standardization, and operational experience have increased confidence among independent engineers and lenders.

Met Mast

Fully Bankable

Met Mast + LiDARs

Fully Bankable

Stand-alone verified onshore LiDAR

Bankability subject to lender acceptance

Unverified LiDAR

Usually not Bankable

Floating LiDAR = Fully Bankable

- Industry accepted validation framework
  - Carbon Trust OWA guideline
  - Stage 3 maturity
- IEC61400-50-4

Reference: https://www.vaisala.com/en/dnv-and-aes-clean-energy-q-and-a?utm=, https://www.dnv.com/services/remote-sensing-verification-218408/

Conclusion

Conclusion

- Low-wind-speed projects can be bankable.
- As wind speeds decrease, measurement uncertainty becomes increasingly important.
- LiDAR is not replacing met masts, but it is becoming an essential part of a bankable measurement strategy.

The question is no longer whether LiDAR should be used, but how it should be integrated into a bankable measurement campaign.


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