IEA Wind TCP Task 32

Wind lidar technology development and transfer

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task 32
lidar

1. How technology gets to market

2. Vertical profiling wind lidar for ground-based resource assessment
3. Forward-looking lidar for wind turbine control
4. Closing

How does technology get in to use?

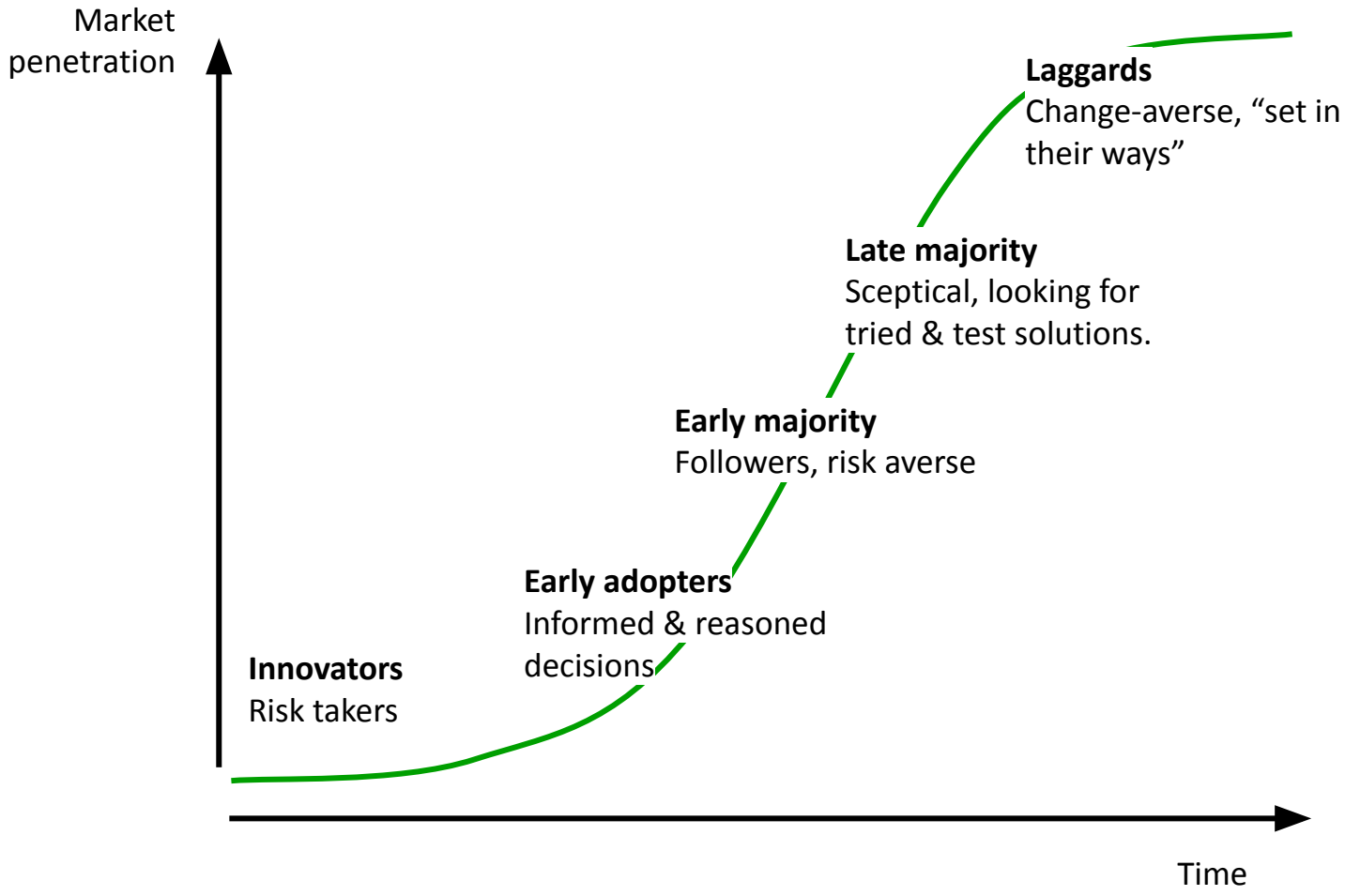
Photo by JC Gellidon on Unsplash

The “right” innovations...

1. fit the user’s needs
2. give competitive advantage
3. are not always the “best” innovations
4. change over time.

See e.g., Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy, 31(8–9), 1257–1274. DOI: 10.1016/s0048-7333(02)00062-8

Customers change over time



2. Vertical profiling wind lidar for ground-based resource assessment

3. Forward-looking lidar for wind turbine control
4. Closing

Lidar are not new

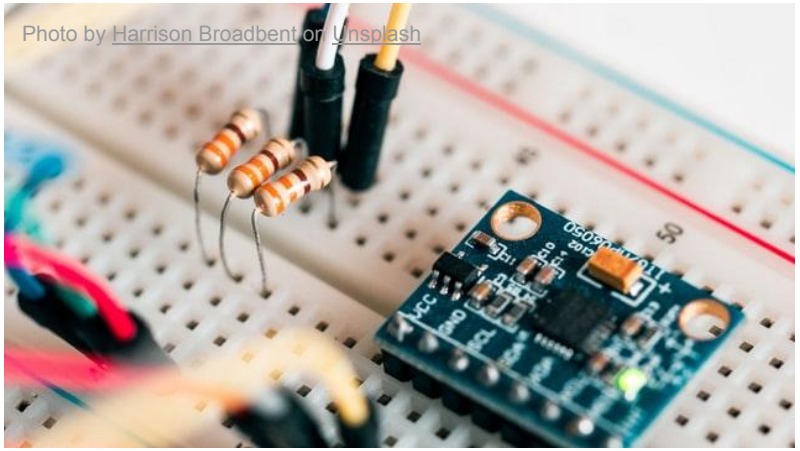
THIS communication reports observations made by us of optical echoes from atmospheric constituents (presumably dust) at heights of 60–140 km. They were detected with an optical radar.

FIOCCO, G., & SMULLIN, L. D. (1963).
Detection of Scattering Layers in the Upper Atmosphere (60–140 km) by Optical Radar.
Nature, 199(4900), 1275–1276. DOI: 10.1038/1991275a0

The instrument for detection of instantaneous crosswind profiles of plume concentrations is a Mini-LIDAR system, originally designed by the German Aerospace Research Establishment, Department of Opto-electronics, and built under license for our purpose by IBS GmbH, Grafrath (Germany). It consists of a pulsed laser

Jørgensen, H. E., & Mikkelsen, T. (1993).
Lidar measurements of plume statistics.
Boundary-Layer Meteorology, 62(1–4), 361–378. DOI: 10.1007/bf00705565

Late 1990s: enabling R&D



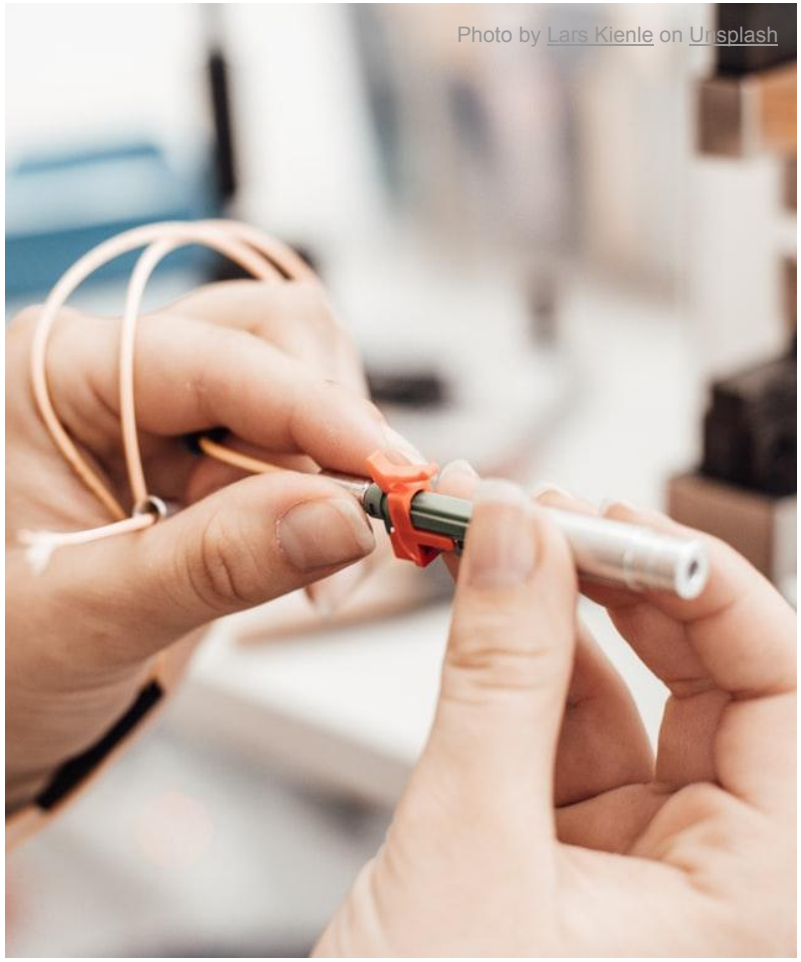
Wind lidar technology

+

Near-IR fibre optics

=

Opportunity for safe, reliable, portable lidar devices



See e.g., Karlsson, C. J., Olsson, F. Å. A., Letalick, D., & Harris, M. (2000). All-fiber multifunction continuous-wave coherent laser radar at 155 μm for range, speed, vibration, and wind measurements. Applied Optics, 39(21), 3716. DOI: 10.1364/ao.39.003716

Early 2000's: growth of wind energy

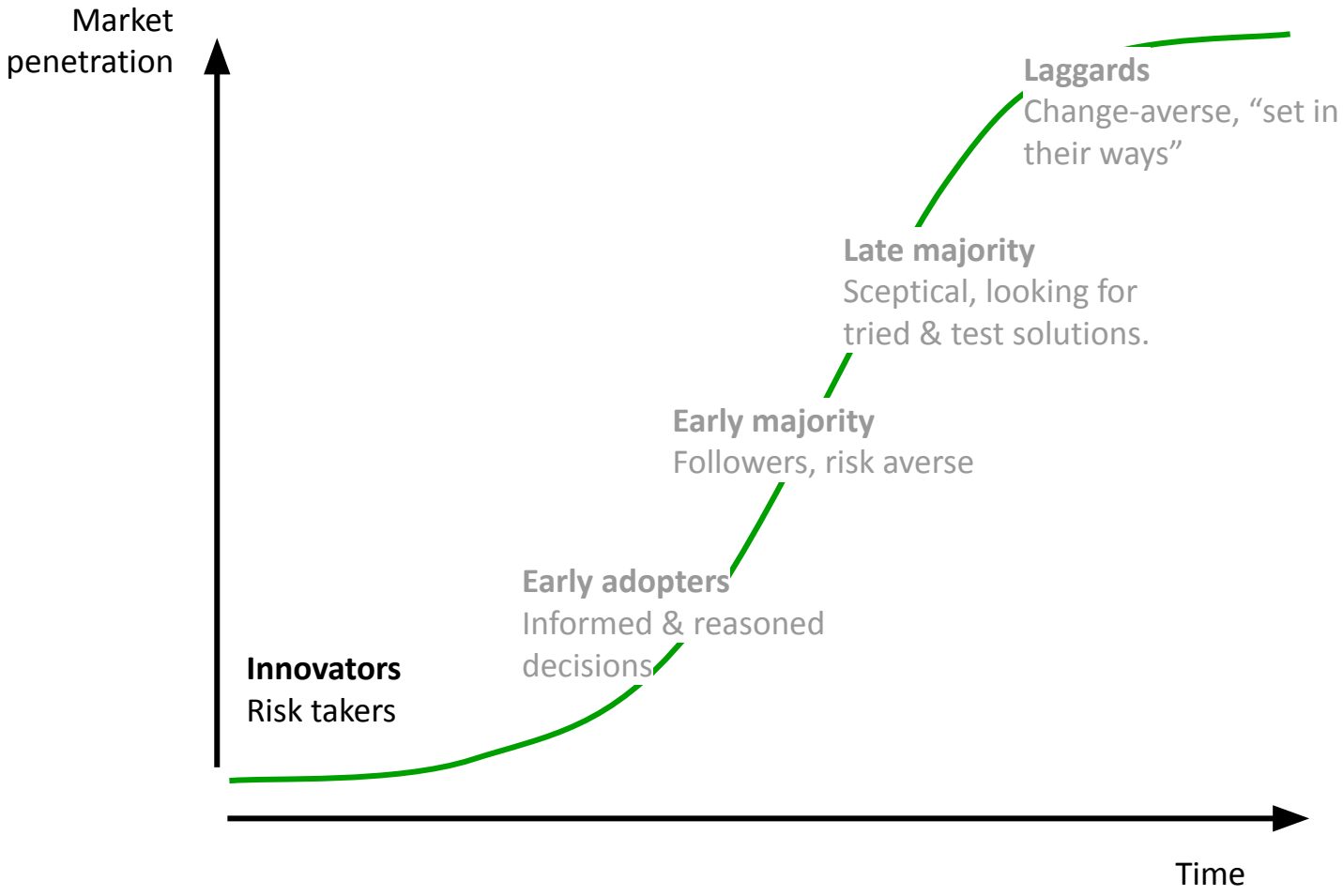
Photo by Cameron Venti on Unsplash

Early 2000s: product launches!

Figure 3. Stages of evolution of the ZephIR lidar. Figure 3a shows the lidar head mounted on the nacelle of a Nordex N-90 wind turbine. Figure 3b shows prototype ground-based wind profiler at Risø wind energy test site, Høvsøre, Denmark. Figure 3c shows the ZephIR production model deployed in the field

Harris, M., Hand, M., & Wright, A. (2006). Lidar for Turbine Control: March 1, 2005 - November 30, 2005. Office of Scientific and Technical Information (OSTI). DOI: 10.2172/881478

First customers are innovators



Innovators are risk takers

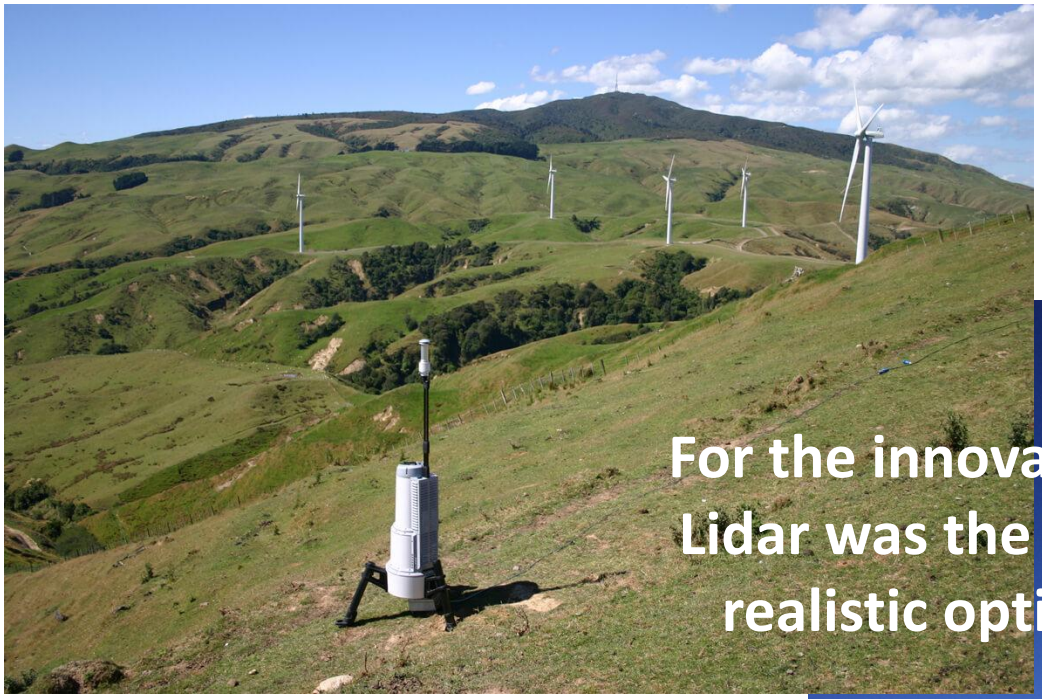


Photo © ZX Lidars 2021. Used with permission

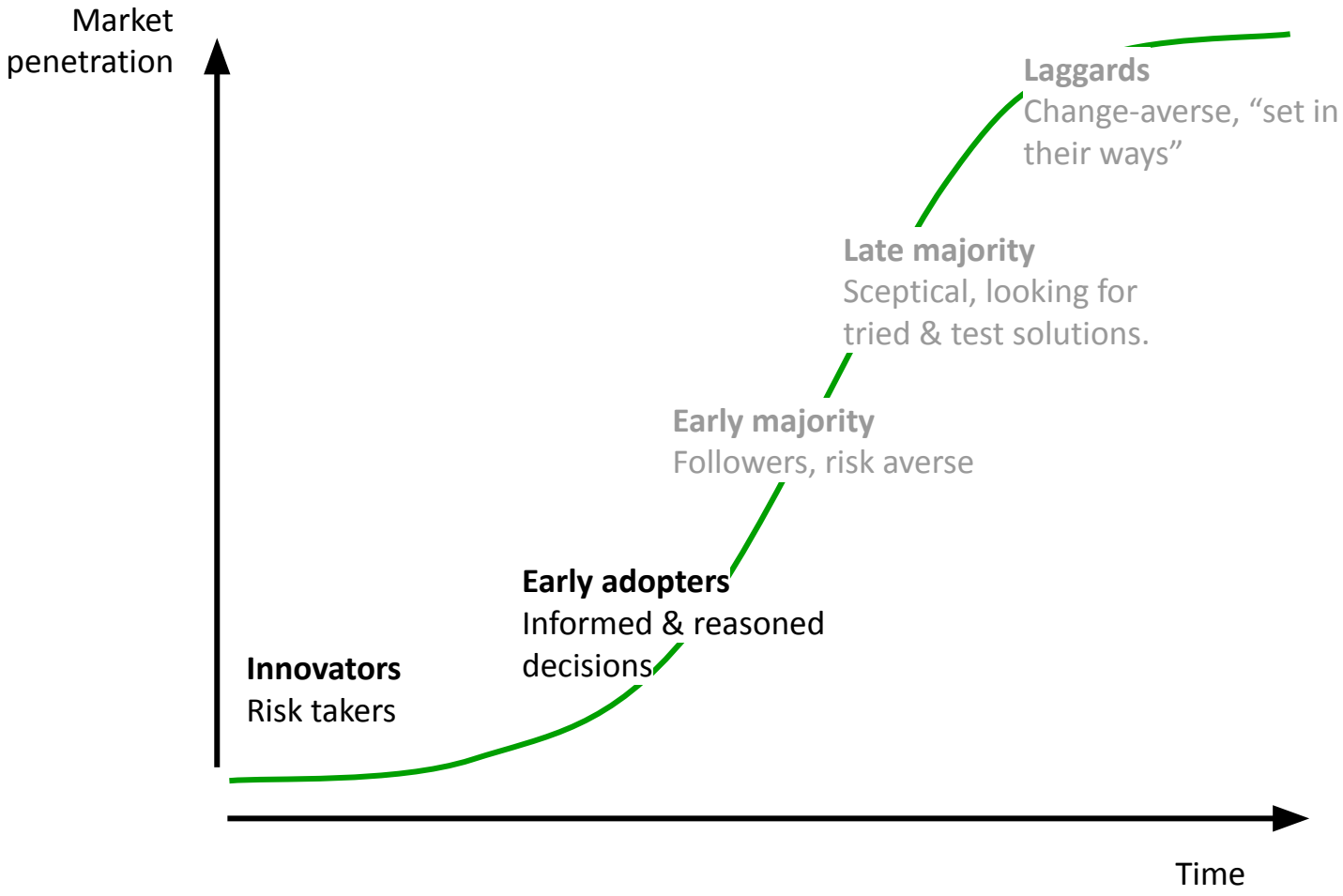
For the innovators: Lidar was the only realistic option

Photo © ZX Lidars 2021. Used with permission

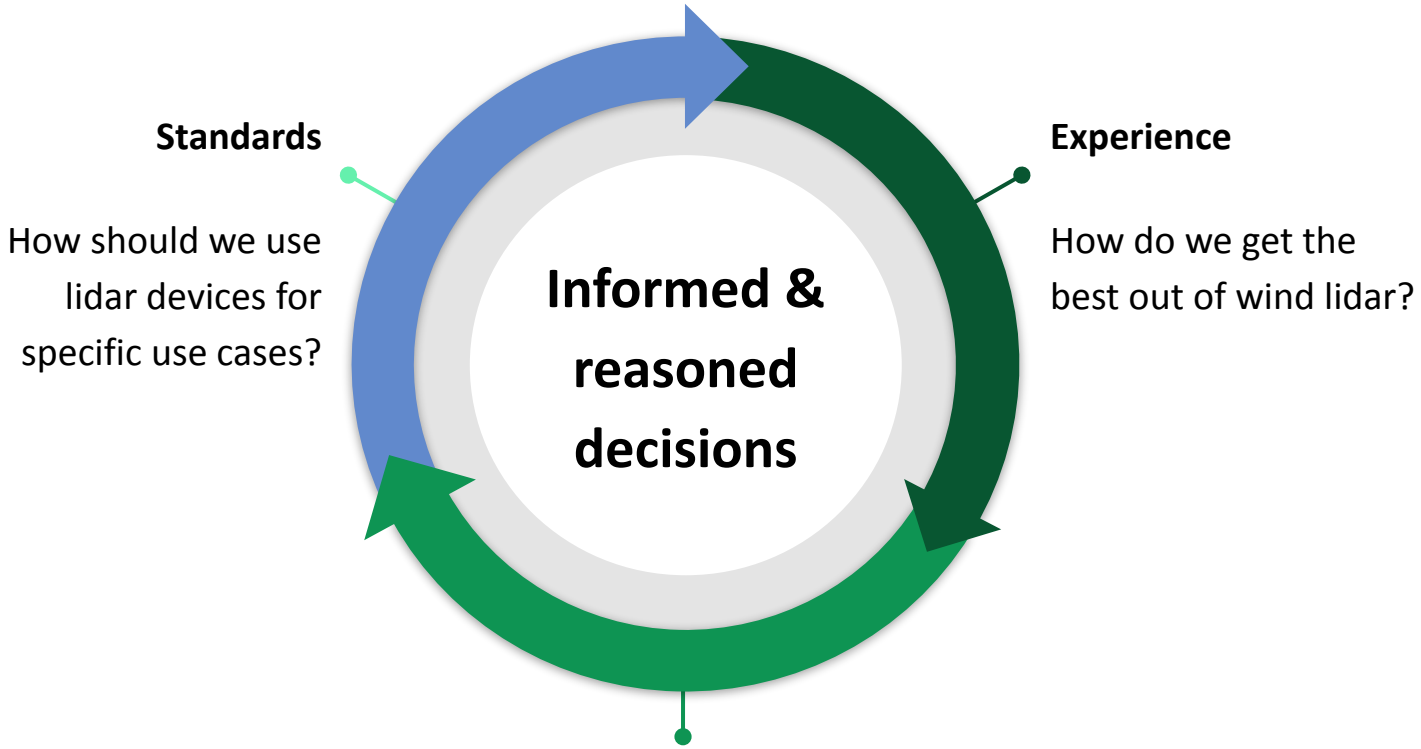
\+ Need for data
Balance-sheet financing
Unique capabilities of lidar

− No standards
Not much community experience

How do you reach “early adopters”?



What drives early adopters?



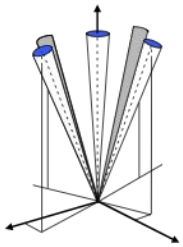
late 2000s: Increasing awareness

INTERNATIONAL ENERGY AGENCY

51st IEA Topical Expert M

State of the art of Remote Wind S
Techniques using Sodar, Lidar a

Risø, Roskilde, Denmark, January
Organised by: Risø



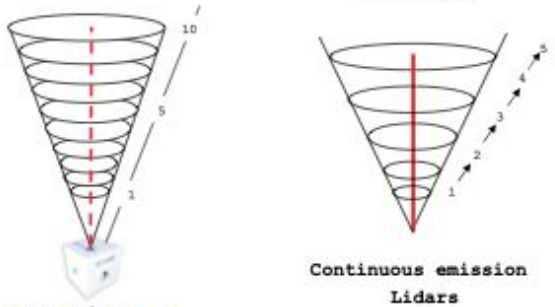
Scientific Co-ordination:
Sven-Erik Thor
Vattenfall AB, 162 87 Stockholm, Sweden

- The QinetiQ ZephIR system has been subject to a stringent test campaign to test the quality of data output;
- hore despite the complexity of and passed acceptance;
- similar conditions to the final esults offshore show better ore;
- 3%
  IO weather dependence seen)
  all
- shore and offshore;
- in both on- and offshore
  al for deployment in the wind nvironments.

Simultaneous measurement at any height

A 10 height profile
in 7 seconds
updated every 1 second

5 heights
in ~ 15 seconds



Continuous emission
Lidars

Wind Cube

Future Work

ment sites:
– To reduce uncertainty in flow and forest canopy models

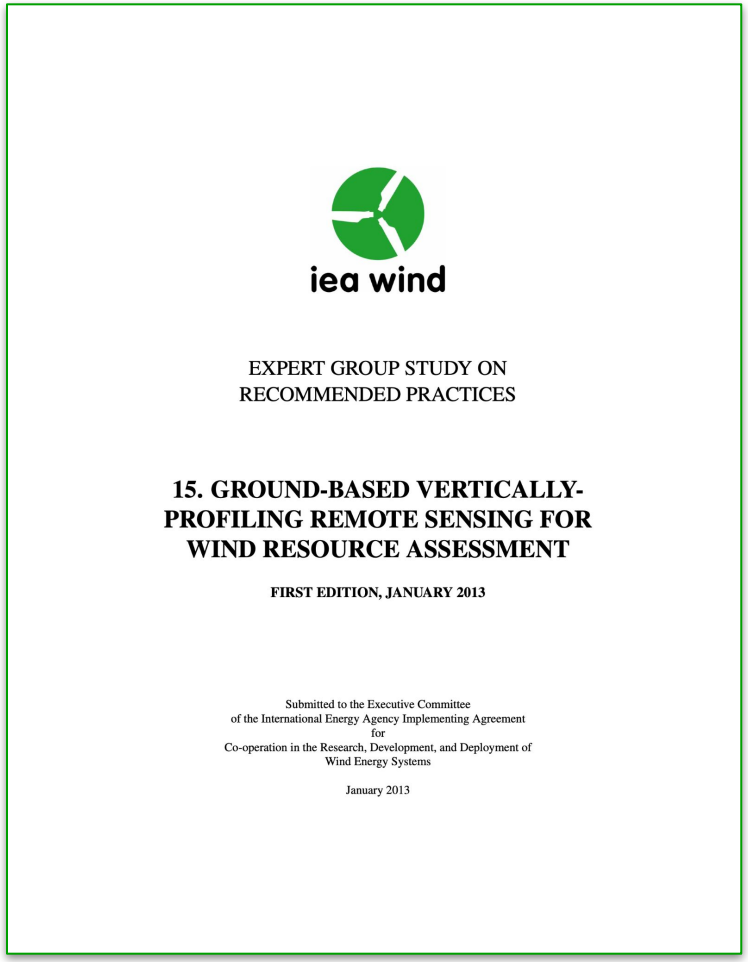
It was noted that there exists a general recommended practice for remote sensing. One in Germany (VDI 3786 Part 14, Verein Deutscher Ingenieure, Environmental meteorology, Ground-based remote sensing of the wind vector. Doppler Wind LIDAR, Dec. 2001) and elsewhere.

Standards for deployment and data treatment
– Focus on "Bankability" of RS data

wind–wave–tidal

Standardization

2013: IEA Wind Recommended Practices



iea wind

EXPERT GROUP STUDY ON
RECOMMENDED PRACTICES

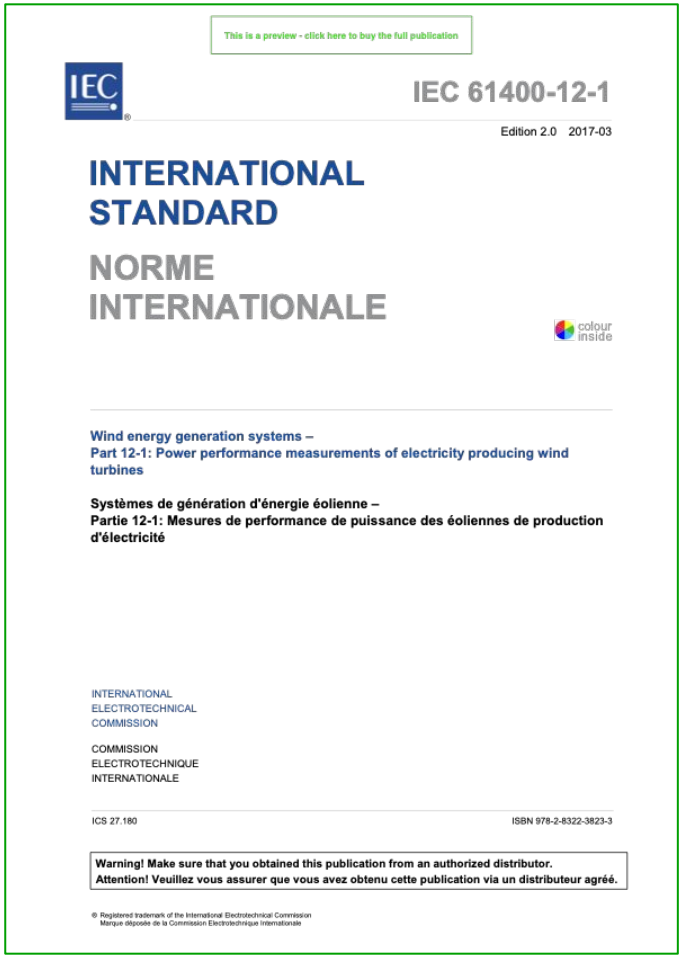
15. GROUND-BASED VERTICALLY-PROFILING REMOTE SENSING FOR WIND RESOURCE ASSESSMENT

FIRST EDITION, JANUARY 2013

Submitted to the Executive Committee
of the International Energy Agency Implementing Agreement
for
Co-operation in the Research, Development, and Deployment of
Wind Energy Systems

January 2013

2017: IEC 61400-12-1



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IEC

IEC 61400-12-1

Edition 2.0 2017-03

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Part 12-1: Power performance measurements of electricity producing wind turbines

Systèmes de génération d'énergie éolienne –
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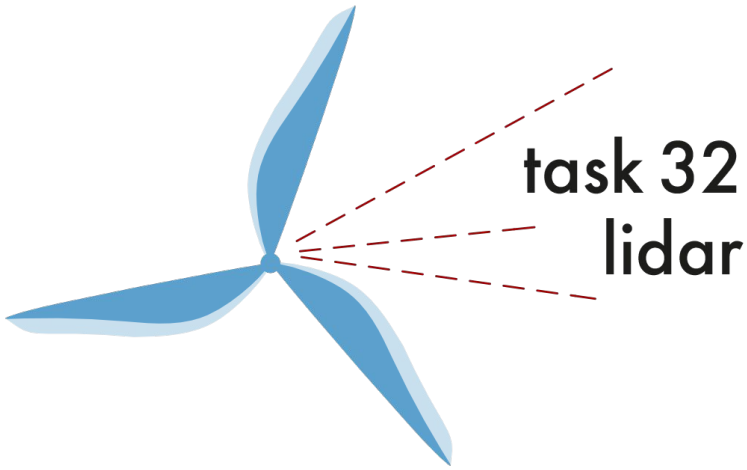
Sharing experience today



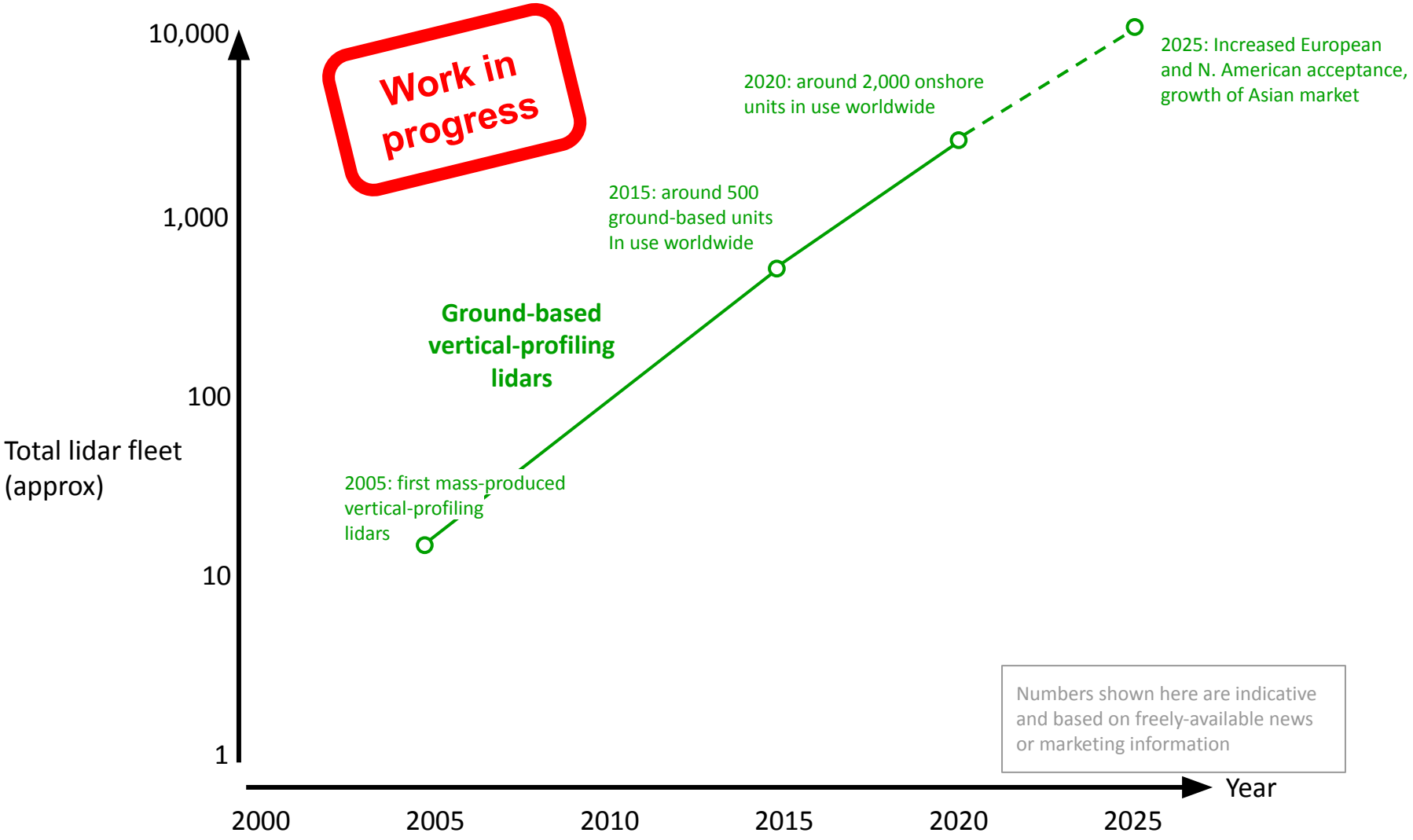
"Identifying and mitigating the barriers to the adoption of wind lidar for wind energy applications"

"The purpose of the consortium is to reduce cost of wind energy by better de-risking wind energy projects of new generation"

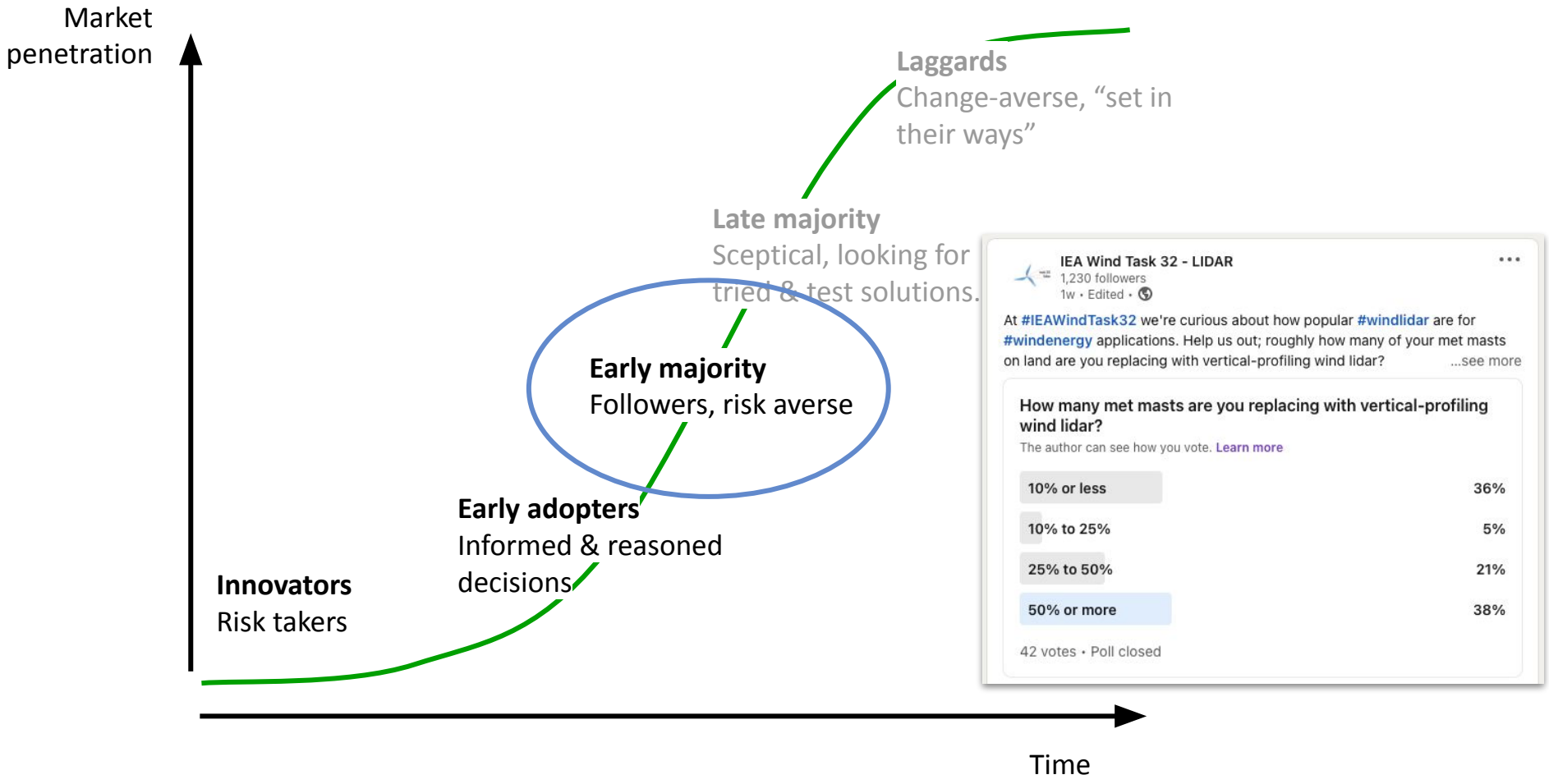
2021: part of the landscape

Ryan Duffy on Unsplash

The lidar fleet



Next: the early majority



Bringing vertical profilers to the next level

Photo by JC Gellidon on Unsplash

Early majority are **“followers, risk-averse”**

We’ve got the evidence & framework for low-risk use.

Lidar needs to become <u>really simple to use</u>

- Hide all of the complexity
- User friendly & robust
- Carefree solutions

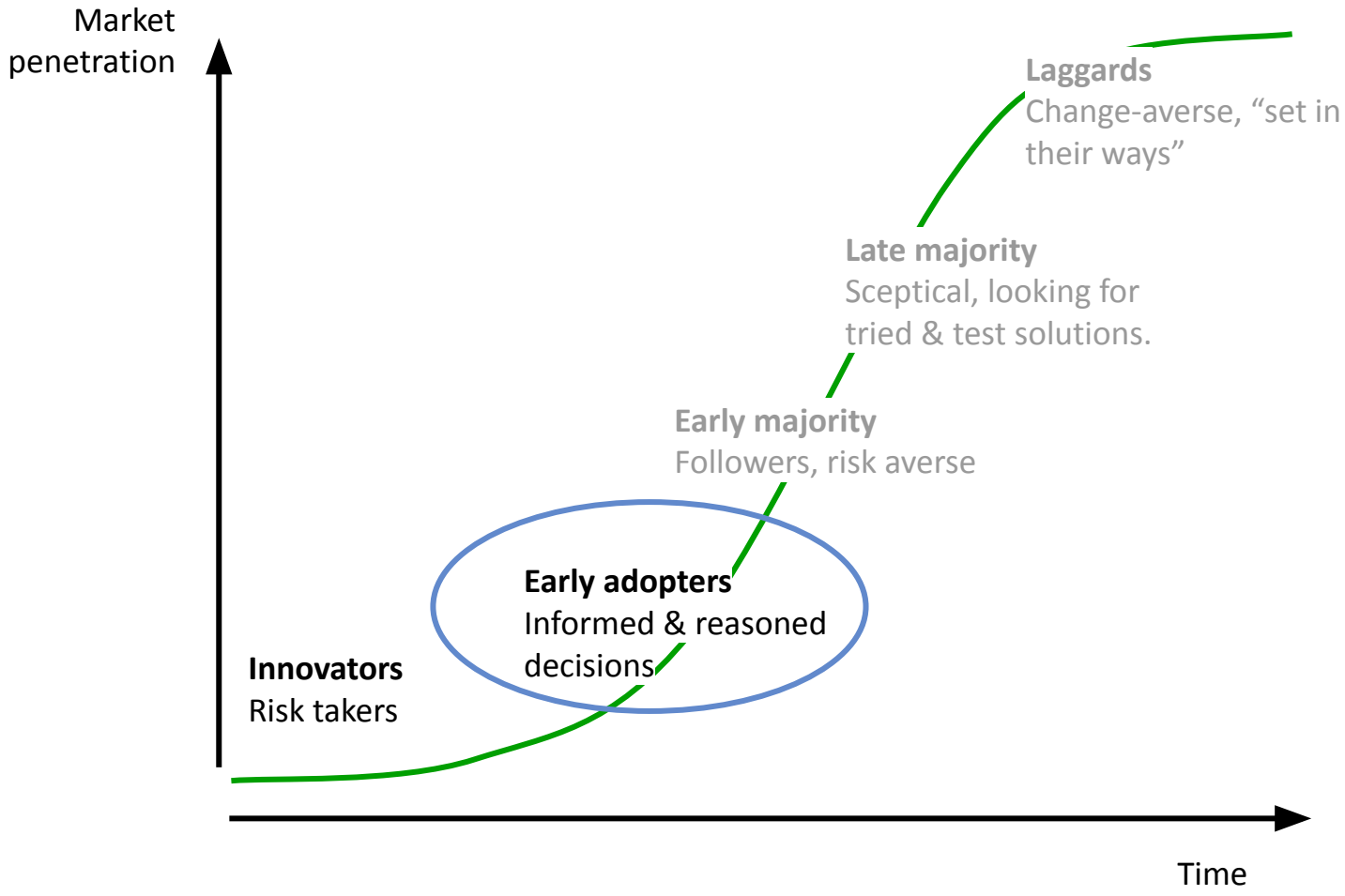
3. Forward-looking lidar for wind turbine control

4. Closing

Where we are today

Photo by Dennis Schroeder / NREL

Current status of LAC

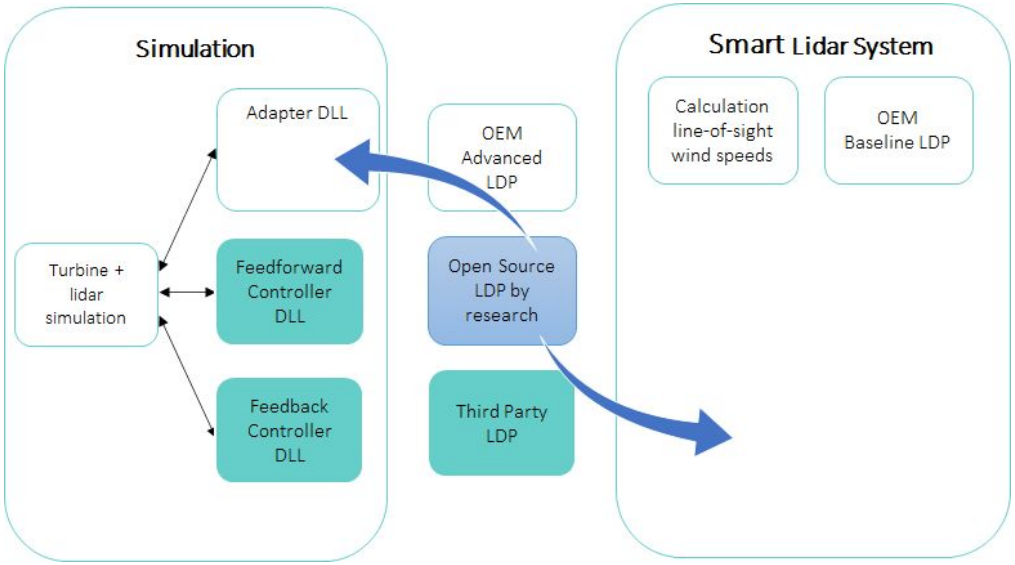


Early adopters

https://www.youtube.com/watch?v=Evw3oJesqSo

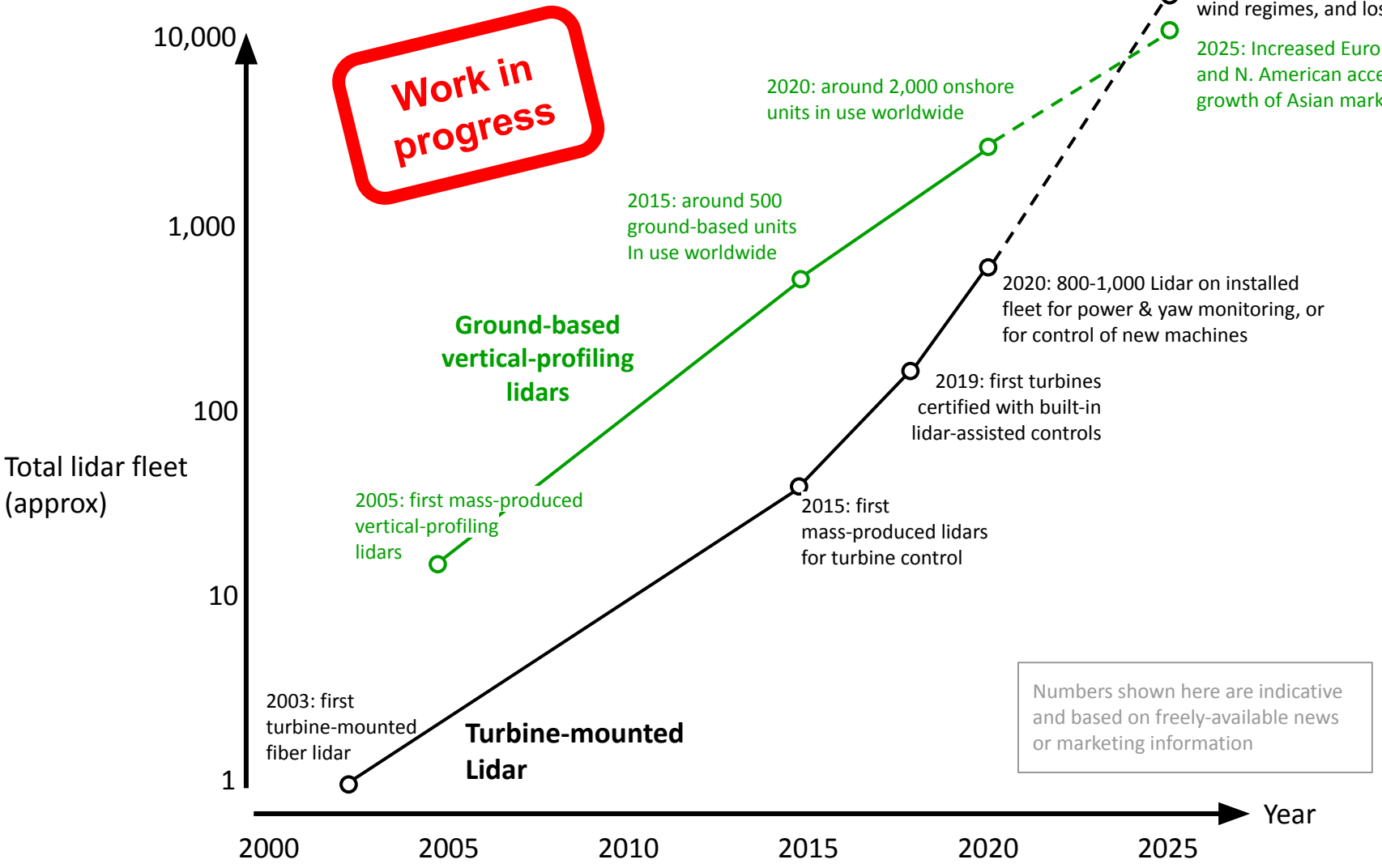
- First wind turbine with lidar certified by Goldwind and DNV in 2019 (link)
- Feedforward controller and lidar data processing developed by sowento and Goldwind (link)
- Important milestone reached! Goldwind already installed 1000 turbines with a total capacity around 3 GW by end of 2020 (link)
- MOVELASER already delivered more than 1500 lidar systems, most of them are used for LAC (link)

How can we bring LAC to the next level?



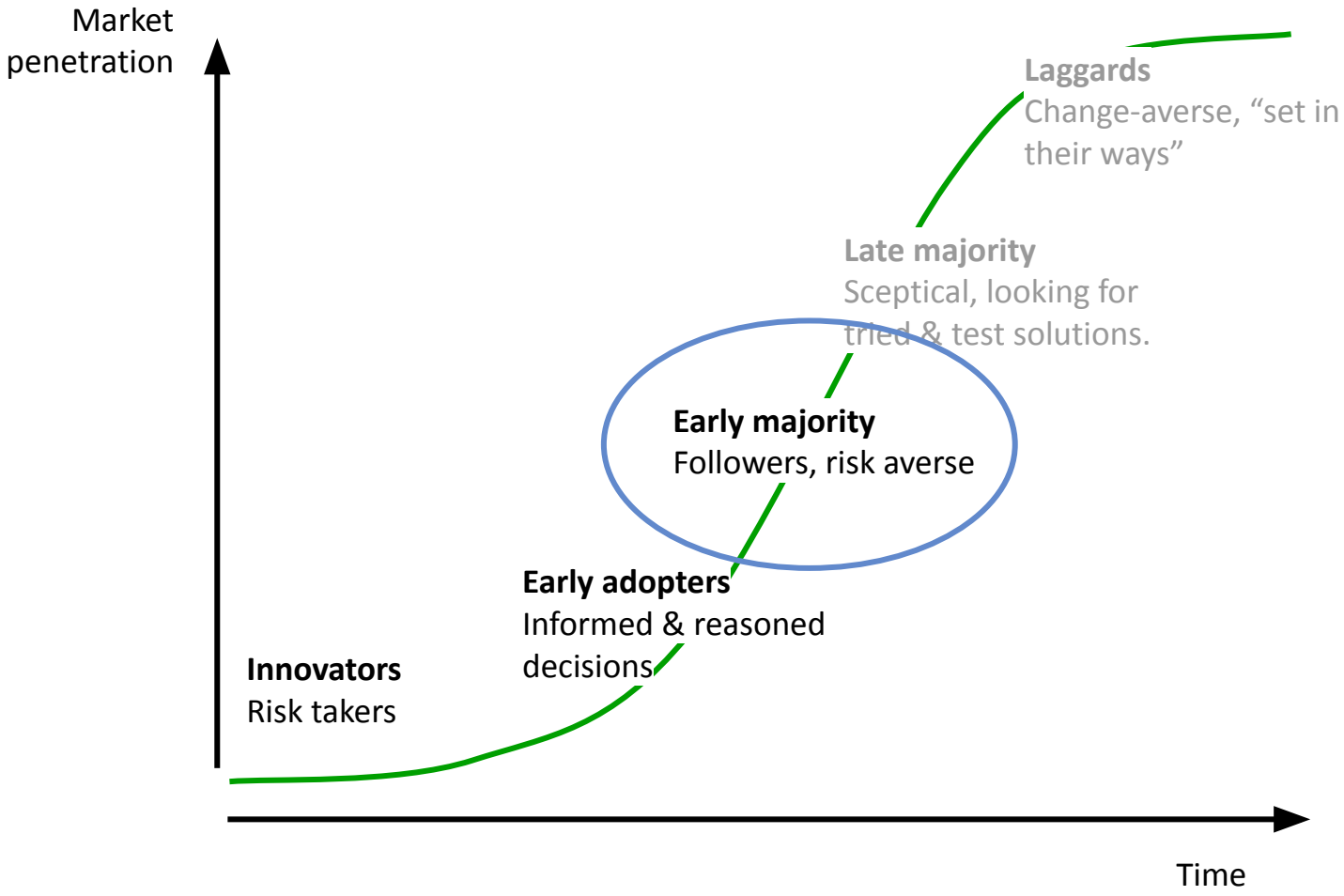
- Improving the technology
  - Develop “smart lidars”!
  - Use model-predictive-control (MPC)
  - Systems engineering: Technically best solution vs commercially best?
- Reduce risks
  - Share experiences
  - Develop recommended practices
  - Work on certification standard
- Increase benefit by coupling with other ideas
  - Load verification
  - Condition monitoring
  - Wind farm optimization
  - Life-time extension

The lidar fleet

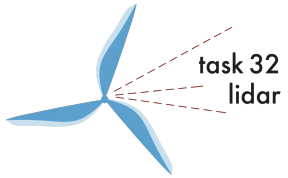


4. Closing

We're reaching the early majority



Future needs from wind lidar R&D



Making lidar the wind measurement tool of choice will need:

- Low cost
- Ease of use
- Ease of integration
- Flexibility
- **YOU**

Mission
Task 32 members work together on research to make wind lidar the best and preferred wind measurement tool for wind energy applications

Vision
Using wind lidar will be easy. It will bring advantages and opportunities that enable the deployment of wind energy.

Values
Innovation, inclusion, diversity, cooperation, and openness.

Get in touch with Task 32

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University of Flensburg

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