

Data and facts

Fraunhofer IWES Wind Lidar Buoy – Offshore Wind and Ocean Measurements

Measuring offshore wind conditions

Traditional met masts for wind measurements are simply too costly and inflexible for offshore sites. Nowadays, »Floating Lidar Systems« (FLS) are commonly used. FLS are platforms equipped with a lidar device, which uses laser beams to measure the wind speed and direction at heights of up to 300 m. Due to the remote location and harsh environment, the survivability and reliability of the buoy hull, the autonomous power supply, and the adequate compensation of the wind measurement for buoy motions are of high importance.

Fraunhofer IWES' Floating Lidar solution

As one of the leading wind energy research institutes, Fraunhofer IWES has been working on floating lidar systems since 2009 and deployed its first prototype in 2013. Fraunhofer IWES operates its Wind Lidar Buoys in scientific projects and, since 2017, in commercial projects, delivering wind and metocean resource measurements and analysis.

The hull of the Wind Lidar Buoy is based on a German navigation buoy with a track record of 40 years, which was modified to accommodate a higher-grade power supply and specialized sensor payload. The lidar device is integrated in a fully encapsulating housing to protect it from the wave impact and briny environment. The compact, steel design of the FLS enables it to withstand severe sea states during storms and typhoons.

The power supply is redundant and intermeshed to ensure reliability from the micro wind turbines, the photovoltaic modules, and the backup generator. The energy storage is duplicated over three battery banks. All the power system elements are connected to a data communication system (BUS), which enables automated management based on real-time information. The FLS runs renewable energy sources; in case of exceptionally low input, the backup generator starts automatically. The generator has the capacity to run the buoy for 12 weeks on its own with eco-friendly GTL diesel fuel.

The Fraunhofer IWES Wind Lidar Buoy is typically equipped with either a ZX Lidars ZX300 or a Vaisala WindCube v2.1 lidar. Redundant meteorological sensors are fitted to the superstructure and oceanographic data is recorded with underwater-mounted sensors. The IWES engineering team can accommodate custom sensors flexibly to suit specific requirements.

The FLS is monitored 365 days a year via web-based surveillance tools to ensure uninterrupted operation. All key statuses are frequently received and the data from the sensors – including compensated wind data – are transferred daily.

Our competences at a glance

- Development, production, and operation of FLS
- Data monitoring, analysis, and quality control
- Proven, in-house motion compensation algorithm for even more accurate measurement data
- Continuously high quality of research, technical improvement, and flexibility



Validation and acceptance

Fraunhofer IWES verifies lidar devices against 200 m met masts (IEC 61400-50-2). The assembled FLS is then typically deployed offshore for calibration against a met mast and fixed lidar. The North Sea FINO3 research platform is often used for this.

Both Fraunhofer IWES FLS-Types achieved Stage-2 maturity of the Carbon Trust OWA Roadmap in 2016 / 2017. The ZX300 FLS-Type successfully attained the Roadmap's Stage-3 commercial type maturity in March 2024.

Some of our long verification trials results in the North Sea:

@ ~100 m MSL with WS > 2 m/s	WindCube FLS type	ZX300 FLS type	ZX300 FLS type	ZX300 FLS type
Reference mast	FINO3	NSO	FINO3	FINO3
Trial duration (days)	182	272	192	160
System availability	99.6%	100%	99.8%	100%
Data availability	98.1%	99.4%	96.0%	99.5%
Wind speed slope	0.997	0.985	1.002	0.998
Wind speed R ²	0.992	0.996	0.994	0.994
Wind direction slope	0.993	0.988	0.997	0.998
Wind direction offset	-2.93°	0.37°	2.16°	-0.81°
Wind direction R ²	0.991	0.997	0.985	0.995

Technical specifications (default configuration)

Buoy specifications

- Height: 9.2 m; diameter: 2.5 m; weight 5.6 t
- Material: DIN 1.0036 steel hull, aluminum lidar housing
- Moorings for 100 m, 250 m, and 1,000 m water depths

Lidar options

- ZX Lidars ZX300 up to 300 m
- Vaisala WindCube V2.1 up to 300 m

Data communication

- Data transfer: WiFi, mobile network, satellite
- Data storage: redundant system with over 2 years of raw data capacity

Power system

- Primary input: 3 micro wind turbines and 6 PV panels
- Storage: AGM batteries (up to one week of autonomy)
- Backup power: 5 kW GTL diesel generator

Additional sensors

- 3 motion sensors: recording position and 3D motion
- 2 weather stations: atmospheric pressure, temperature, wind speed and direction, relative humidity, precipitation
- Surface water temperature and CTD sensor
- Seabed water pressure and temperature
- Optional: ADCP, oxygen, others on request

FLS operation and data analysis

Fraunhofer IWES offers not only customizable measurement campaign delivery but also cutting-edge data analysis, measurement concepts incl. multiple lidar devices of different types, and the possibility to include data modeling.

Further information

The Fraunhofer Institute for Wind Energy Systems IWES conducts application-oriented research for a sustainable future. The focus topics of the Fraunhofer IWES are offshore, hydrogen, test infrastructure and digitalization. The research work in these future-oriented key technologies plays a central role in the innovation process and strengthens the business location for the benefit of our society by transferring the research results to industry. More than 400 employees at nine locations are developing innovative methods to accelerate the expansion of the wind energy and hydrogen economy, minimize risks, and increase cost efficiency.

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