



2026-06-16 / 8th International Workshop on Grid Simulator Testing

Update Fraunhofer IWES

Gesa Quistorf

Fraunhofer Institute for Wind Energy Systems IWES

- 400 staff
- 82 publicly-funded and EU projects
- € 45.5 m operating budget / year 2024

Bremerhaven
Main location

Leer
Oldenburg

Hamburg
Bremen

Hannover

Bochum

Leuna
Görlitz

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Motivation at Fraunhofer IWES

Grid integration testing at test benches

General purpose of grid integration testing

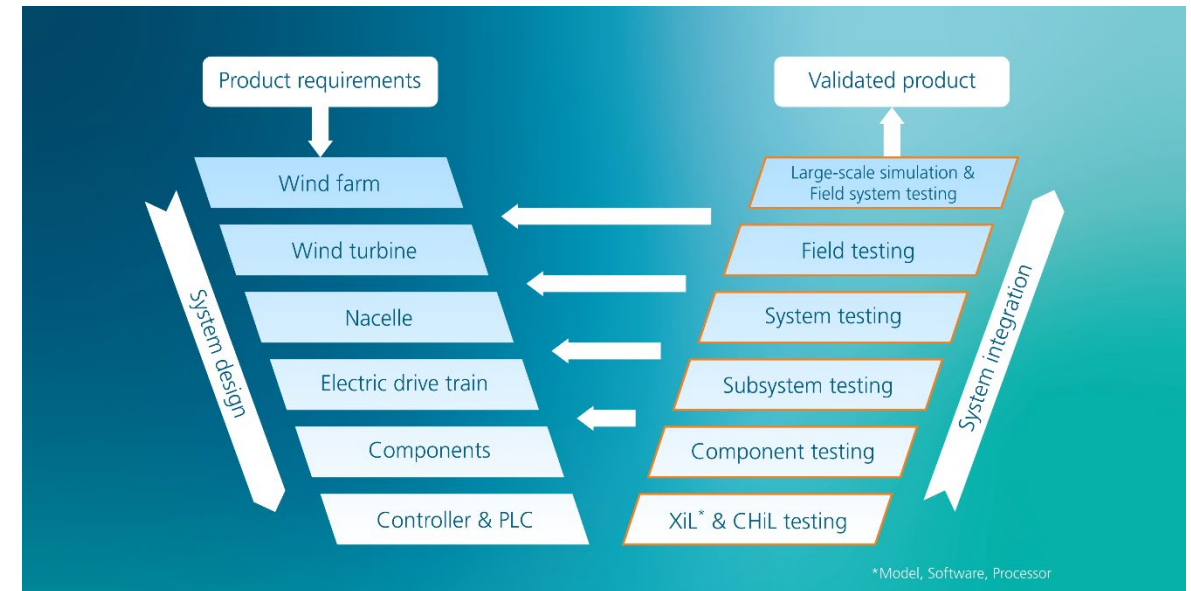
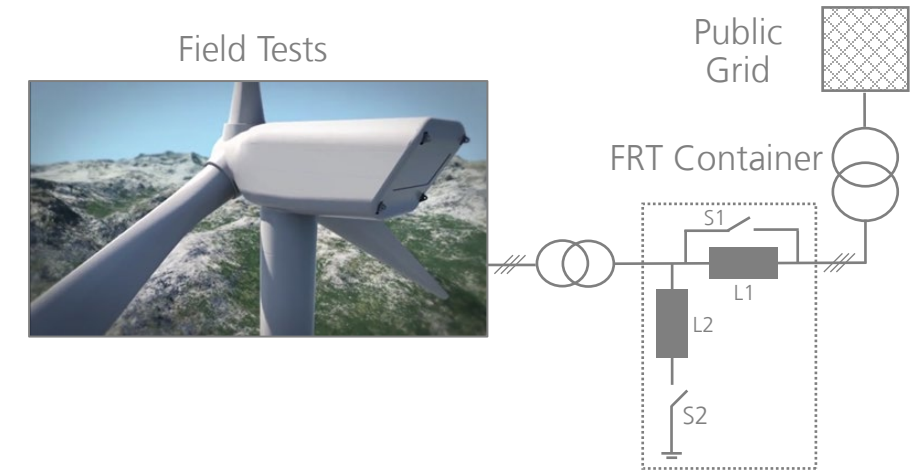
- Performance evaluation of turbine
- Generation of measurement data for model validation

Wind turbine testing on prototype in field

- Time-intensive
- Cost-intensive
- No reproducible tests
- No orientation to the development process according to V-model

Use of test benches

- Grid compliance testing at test benches
- More than grid codes: testing to check future requirements
- Risk minimization within product development



Motivation at Fraunhofer IWES

Overview Infrastructure grid integration testing



DyNaLab

- Nacelle test bench
- Mechanical and electrical tests
- 44 MVA grid simulator
- 10 kV, 20 kV, 36 kV



Mobile Grid

- Wind turbine testing
- Mobile solution
- 80 MVA grid simulator
- 20 kV, 33 kV, 66 kV

ENGEL

- 30 MW test bench
- Subsystem test bench & converter test bench
- 44 MVA grid simulator & Mobile Grid

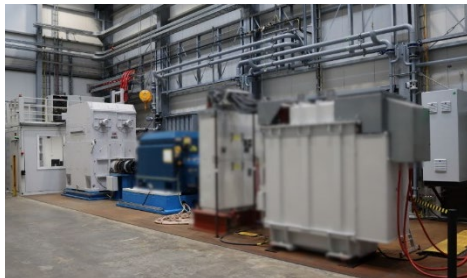
2015

2017

2021

2023

2026



HiL-GridCoP

- Subsystem test bench
- High-speed shaft connection
- 44 MVA grid simulator
- 10 kV, 20 kV, 36 kV



PQ4Wind

- Converter test bench
- 8 MVA per simulator
- 690 V ... 1.3 kV
- Harmonic injection to 10kHz

DyNaLab Location

ENGEL - Generator Emulator

**Wind Turbine Testing
Nacelle Test Bench**

10 MW Motor @11
rpm

ENGEL – Motor

30 MW Motor @ 400
rpm

Grid Emulator

44 MVA

10/20/33 kV



**Wind Turbine Testing
HiL-Grid-CoP**

9/13 MW Motor
Generator inverter
test bench

Mobile Grid

80 MVA Grid Emulator
20/33/66 kV

2 Strings each
40 MVA
10/20/33 kV

ENGEL – Emulated Nacelle Grid tEsting Laboratory

Project Motivation

Electrical challenges offshore energy system

- Converter dominated grid
- Parallel design and set-up of wind farms and offshore connection point (2 GW HVDC-Systems)
- Set-up of new technologies
- In Germany: Requirements Offshore Grid Code VDE-AR-N 4131 and offshore grid connection requirements from the TSOs

General purpose of detailed large-scale interaction simulation

- Design offshore connection system
- Derisking of electrical operation
- Optimizing operation of wind farms
- Electrical mechanical interaction mitigation on wind farm level
- Numerous new degrees of freedom in the operation of wind farms due to changing power systems

Integration of interaction studies
in grid compliance validation
process at test benches

ENGEL – Emulated Nacelle Grid tEsting Laboratory

Overview

Project terms

- Project duration: August 2023 – November 2026
- Founded by the German Federal Ministry for Economic Affairs and Energy (BMWE)

Objectives of ENGEL

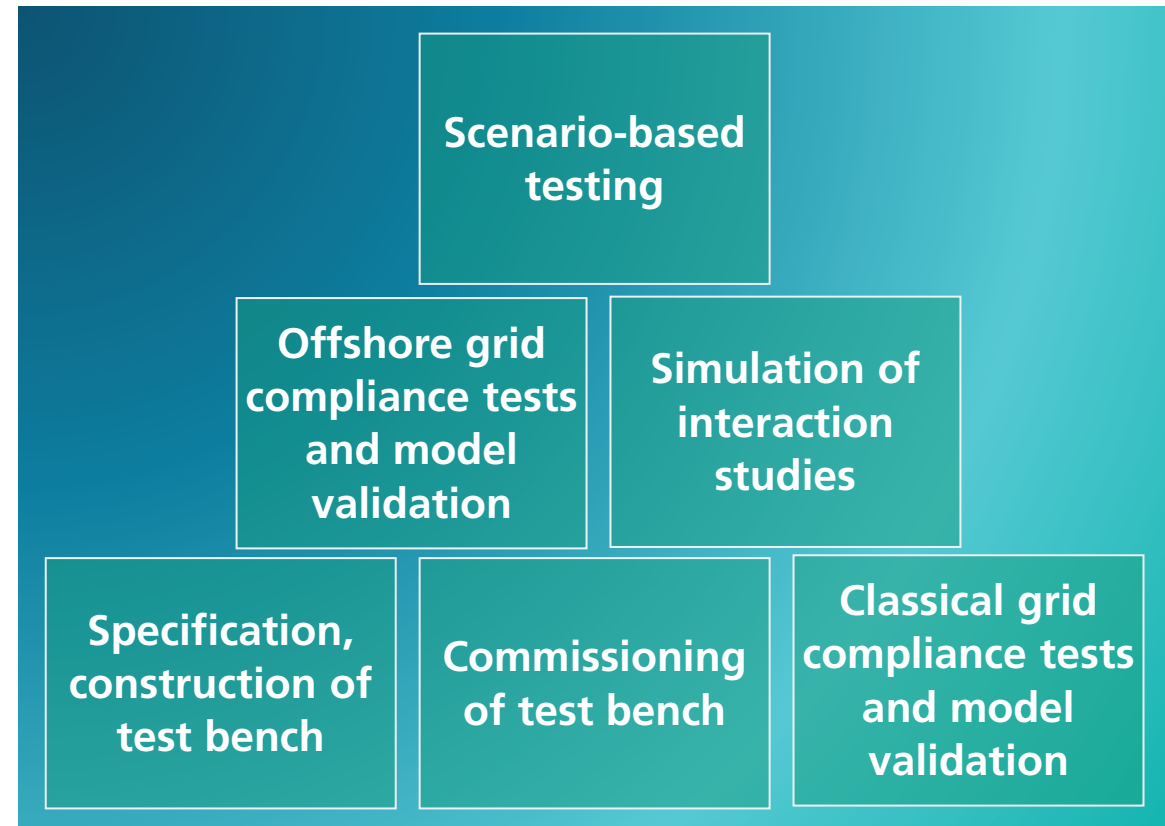
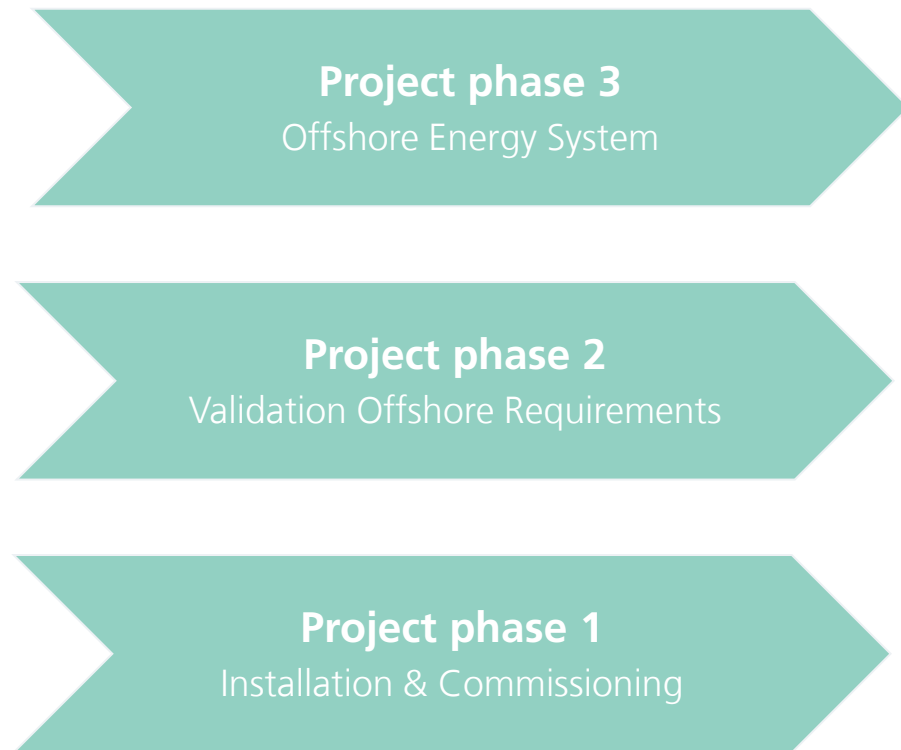
- Establishment of a globally unique test capacity for grid integration tests of future offshore wind turbines (OWT) up to 30 MW
- Expanding the validity range of impedance and EMT models on the basis of tests
- Ensuring the correct functioning of multi-megawatt wind turbines in offshore energy systems

Project Partners

Vestas



ENGEL – Project Plan



30 MW Test bench for offshore wind turbines

Build up of infrastructure

Build up of two actuators

30 MW Generator – Emulator

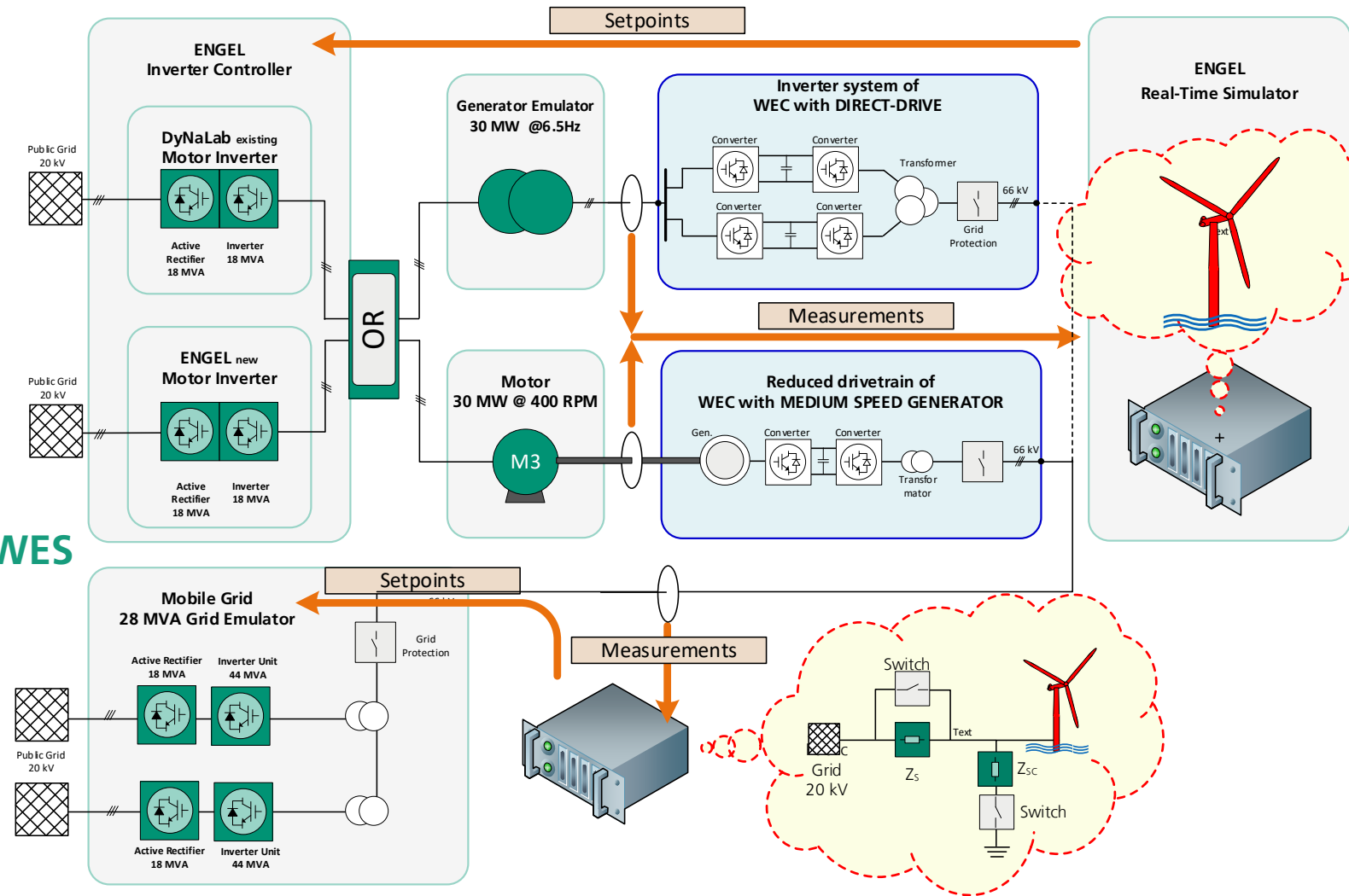
- for testing direct-drive wind turbines

30 MW Motor

- for testing hybrid drive wind turbines

Integrating test bench into existing IWES infrastructure

- Co-use of the hardware and test hall of the nacelle test bench (DyNaLab)
- Connection to Mobile Grid (80 MVA grid emulator; up to 66 kV)
- Use of the existing HiL framework



ENGEL Installation



ENGEL Installation



Validation of grid forming capabilities

Motivation

- Market-based procurement of grid-forming capabilities started in Germany in January 2026

Validation and certification process is already in place

- FNN-Guideline:
 - Technical requirements for grid forming capabilities including provision of inertia - Requirements and verifications for grid-forming units and plants (Version 2.1, English version published April 2026)
- FGW Technical Guidelines:
 - Supplements for TG 3, TG 4 and TG 8 are published in December 2025 and March 2026

Challenges

- Test bench testing of wind turbines is currently not permitted!
- Reproduction of field tests ➔ Research project PRAKTISCH (Project partner: Nordex)



Validation of grid forming capabilities of a BESS -
final test this week 😊

Testing of hybrid power plants

Scalable Testing – Setup

DyNaLab Location

- Subsystem test bench
 - Wind turbine

Old Airport Location

- Converter test bench
 - PV Converter
 - Grid emulator
- Hydrogen Lab
 - Elektrolyzer
 - BESS

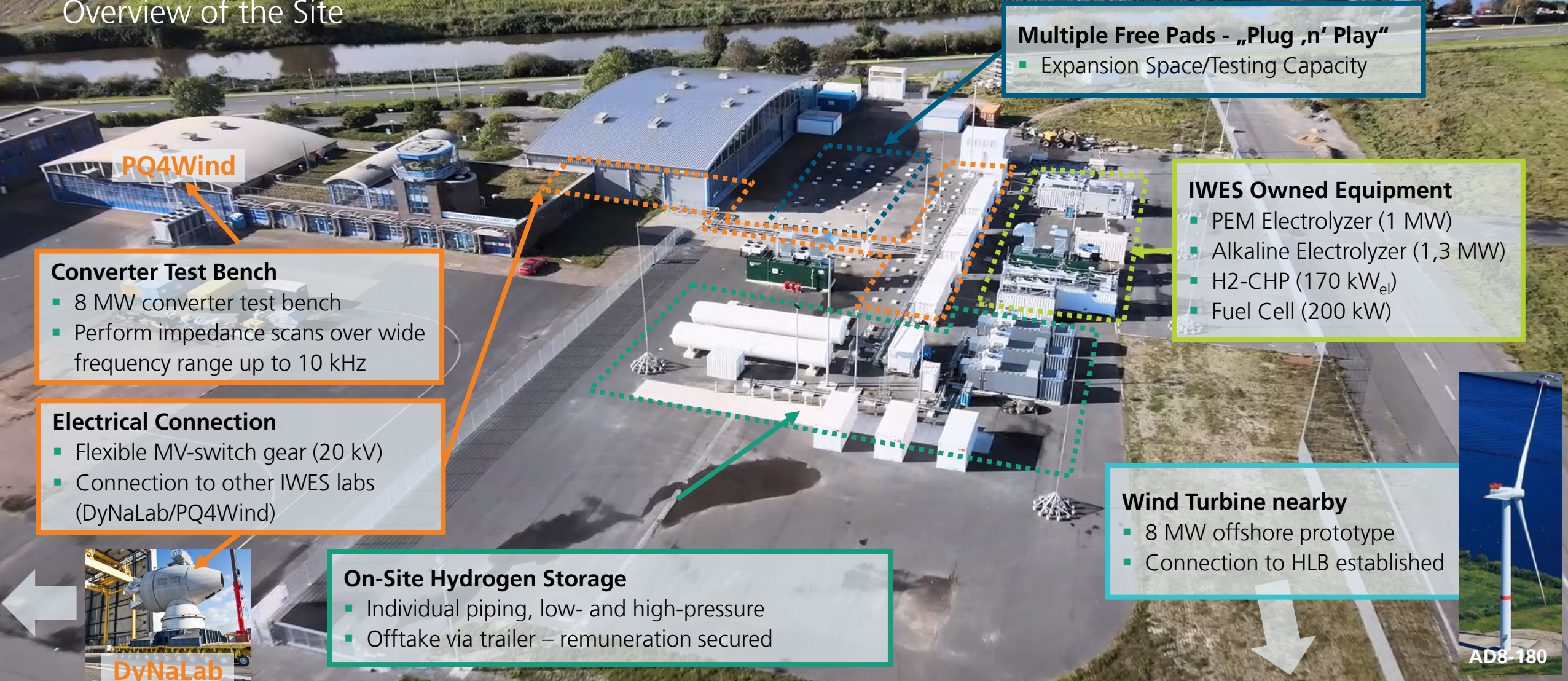
Connection

- Via MV-cable



Converter Test Bench and Hydrogen Lab Bremerhaven

Overview of the Site





Thank you
for your time!

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