Project overview

The INNWIND.EU project is focused on innovative offshore wind turbines at 50m water depths and beyond, which significantly lowers the Levelized Cost of Energy (LCOE)

- **Investigate and demonstrate new designs** for 10-20 MW offshore wind turbines and their components.
- **Develop methodologies** for assessing innovative subsystem and turbine system designs.

Design and preliminary evaluation of the INNWIND.EU 20 MW Reference Wind Turbine

- **Derived from the upscaling of the 10 MW DTU RWT** and intended to be a Class IC.
- **Classical upscaling techniques** as starting point to configure 20 MW turbine subsystems.
- **Re-design of upscaled basis** to include learning curve expectations in terms of components masses and face particular challenges regarding the proper selection of the first systems' frequency in connection to the variable speed schedule of the turbine).

Read more in the full project reports:
www.innwind.eu/Publications/Deliverable-reports

INNWIND.EU

www.innwind.eu

PROJECT CONSORTIUM AND CONTACT

The **INNWIND.EU** consortium is made up of leading industrial partners, research institutes and universities.

COORDINATOR

DTU
DTU Wind Energy
Department of Wind Energy

PARTNERS

AALBORG UNIVERSITY DENMARK · CENER NATIONAL RENEWABLE ENERGY CENTRE · KAПE CRES CENTRE FOR RENEWABLE ENERGY SOURCES AND SAVING · DHI

Germanischer Lloyd Industrial Services GmbH · Garrad Hassan & Partners Limited · ECN · Fraunhofer IWES · ForWind Center for Wind Energy Research

Gamesa · Knowledge Centre WMC Wind turbine Materials and Constructions · Leibniz Universität Hannover · Magnomatics

POLITECNICO MILANO 1863 · RAMBØLL · SIEMENS

SINTEF · SUZLON POWERING A GREENER TOMORROW · UNIVERSITY OF PATRAS · TU Delft Delft University of Technology

University of BRISTOL · The University Of Sheffield. · University of Strathclyde Glasgow · Universität Stuttgart

Wind EUROPE · NREL NATIONAL RENEWABLE ENERGY LABORATORY

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INNWIND.EU

Innovative Wind Conversion Systems

10-20 MW

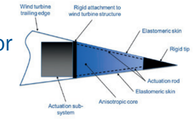
FOR OFFSHORE APPLICATIONS

NOVEMBER 2012 – OCTOBER 2017

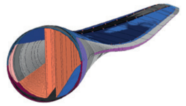
www.innwind.eu

The main project achievements

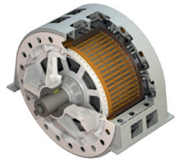
Rotor aerodynamics

CONCEPT	BRIEF DESCRIPTION
Rotor	Aerodynamics
Low induction rotor  Photo: CRES	Larger, less loaded rotor for increasing wind turbine capacity factor and reducing the wake losses without burdening rotor and turbine loads. New low-lift airfoils.
Two-bladed rotor R1.08 (192.6 m diameter) Two-bladed rotor R1.12 (199.7 m diameter)  Photo: DTU	Integrated aero/structural design of a two-bladed rotor of large diameter. Two designs considered: one with 8% stretching and a second one with 12% stretching.
Smart rotor (flaps)  Photo: Bristol	Active flaps are used for load control. Flexible elastomer trailing edge geometry, activated by pressure fluid. Here, combined to a simple individual flap controller close to industry standards.

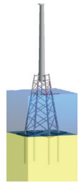
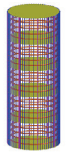
Blade structural design

CONCEPT	BRIEF DESCRIPTION
Rotor	Structural
Carbon truss blade structure  Photo: UPATRAS	The Reference Wind Turbine (RWT) blade is redesigned using an internal truss structure. Two designs are presented using glass-epoxy and carbon-epoxy materials. Main expected benefit is a significant reduction of blade mass.
Bend-twist coupled rotor  Photo: POLIMI	The 10 MW RWT Rotor is redesigned employing bend-twist coupling. Passive load mitigation by Bend-Twist Coupled (BTC) is here accomplished by exploiting the anisotropic properties of composite materials.
Integrated BTC with IPC  Photo: DTU	A 10 MW BTC blade is designed employing constrained optimisation. Individual pitch control (IPC) is used in parallel to further mitigate loads. Lowering the loads allows an increase of the rotor diameter and, thus, of the energy production.

Direct drive SC and PDD

CONCEPT	BRIEF DESCRIPTION
Drivetrain	Electro-mechanical conversion
Superconducting generator (SC)  Photo: GI-Gh	Two wire types for generators are considered: the MgB_2 and the RBa_2Cu_3O (RBCO) material. The high price of the RBCO wire is indicating that MgB_2 is most likely the fastest technology to implement. RBCO is considered to become the cheapest technology in the long-run.
Pseudo Direct Drive (PDD) Generator  Photo: Magnomatics	The magnetic pseudo direct-drive (PDD) generator is realising the possibility of applying magnetic gears in wind turbines. In a PDD generator, the magnetic gear and the electrical generator are mechanically and magnetically integrated.

Offshore support structures

CONCEPT	BRIEF DESCRIPTION
Offshore support structure	Structures
Advanced jacket  Photo: Ramboll	Mass and cost functions for a 10 MW reference have been established. The assessment of the material, welding and assembly costs result in a potential cost saving of up to 20%.
Semi-sub floater design  Photo: CENER	A steel asymmetric semi-submersible floater designed for sea depths of 200 m. This design is adopted as the INNWIND.EU 10 MW Reference Floater.
Semi-floater concept  Photo: DTU	A hybrid between a monopile type structure and a floating spar-buoy. It is composed of a buoyancy device, mooring system and an articulated joint mounted on a reinforced concrete base placed on the sea bed at 50 m water depth. It is especially beneficial for 2-bladed rotors due to avoidance of excitation from rotor harmonics.

Technological and scientific breakthroughs


Photo: Fraunhofer IWES


Photo: DTU


Photo: WMC

Wind profile data set up to 310m height

above mean sea level from high-resolution meso-scale simulations performed with the Weather Research and Forecasting (WRF) Model (available for the full year 2011) and one month's wind and wave data.

A Pseudo-Direct Drive generator (PDD®)

by Magnomatics. This is an extremely efficient non-contact magnetic gear integrated within a Permanent magnet (PM) generator. This unique configuration results in an extremely high torque density single package which eliminates any mechanical gearing and meshing teeth.

Results of two wave tank tests for floating support structures

(semi-submersible and tension leg platform) for a scaled model of the INNWIND.EU 10 MW turbine.

Measured data available at: *www.ifb.uni-stuttgart.de/windenergie/download_mess-daten.en.html*

MgB_2 Superconducting Direct Drive generator

A scaled MgB_2 coil has been demonstrated and a corresponding 10MW front mounted generator has been investigated in terms of size, mass, efficiency and cost. It has been found to have a lower efficiency than the PDD and a higher LCOE

Material and component experiments for support structures

such as:

- new sandwich materials
- joining techniques of steel and hybrid material
- vibrated installed piles
- bucket-soil interaction tests.

High Temperature Super-conducting Direct Drive

Scaled generator coils of the RBCO material has been demonstrated and used in the design of direct drive generators of 10-20 MW. Siemens Wind Power has concluded that this technology will not be superior to the expected permanent magnet direct drive technology in 2020.