

COWI offshore wind

marine engineering services



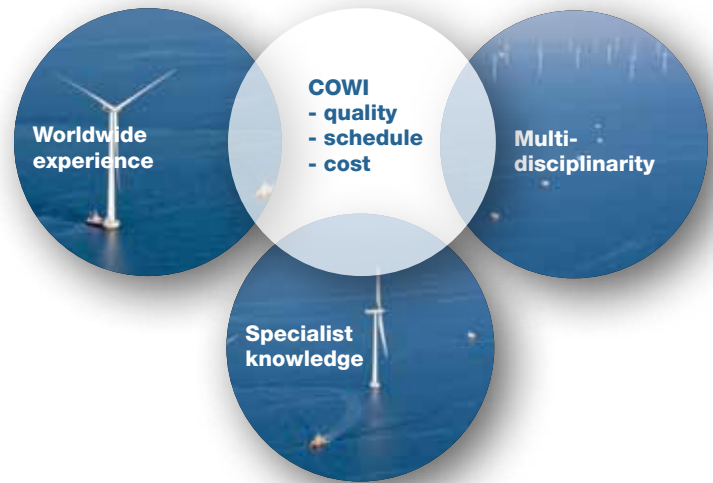
COWI

COWI expertise

COWI is a highly versatile and multidisciplinary company. We provide services within engineering, environment and economics and operate worldwide from more than 35 international offices.

COWI's expertise within offshore wind farm projects stands on the shoulders of our experience developed since 1930 within foundations for large bridges, offshore oil and gas projects, power systems, and marine structures.

COWI offers multidisciplinary and diversified consultancy and we draw our in-depth expertise within the wide range of disciplines required, which have successfully been applied to a wide range of offshore wind farm projects.



Services

- Feasibility studies
- Field investigations
- Planning
- Conceptual design
- Basic design
- Detailed design
- Installation studies
- Contracting
- Construction management
- Operation and maintenance

Disciplines

- Surveys and investigations
- Numerical and physical modelling
- Structural engineering
- Geotechnical engineering
- Marine, coastal and hydraulic engineering
- Scour protection design
- Wind resources
- Power systems
- SCADA
- Environmental impact assessments
- Risk analysis

Projects

- Wind resources and site selection
- Wind farm layout and design
- Foundations (monopile, tripod, jacket and gravity)
- Offshore transformer stations
- Offshore metering towers
- Installation studies
- Spudcan analysis for jack-up
- Power systems and SCADA
- Risk analyses

Surveys and investigations

and the investigations providing the design basis. COWI has extensive experience in programming, supervision and postprocessing of surveys and investigations in wind, wave, current and geotechnics.

Wind

COWI has carried out wind monitoring projects worldwide and accumulated a unique expertise in this field. Our services include identification of wind monitoring locations at the sites, specification of wind monitoring equipment or setting up measuring equipment and analysis of the collected data for wind calculation of wind energy resources.

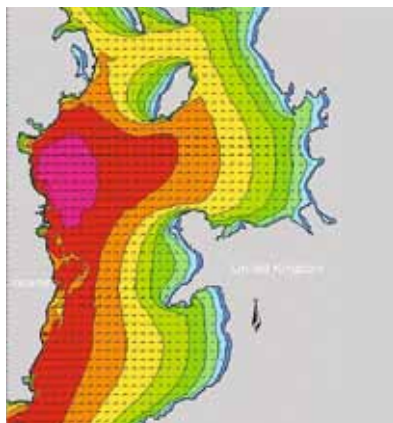
Furthermore, we optimise the design of the wind farms on the basis of the data from calculations of wind energy resources for the specific site, terrain, number and type of turbines. Based on our longterm experience in monitoring operations of wind farms we have know-how within siting of wind turbines at large and complex sites including shadow effect predictions by means of wind park optimisation software.

Geotechnics

Careful planning of geotechnical investigations is imperative for the provision of adequate soil information for the considered wind turbine foundation type(s). This may include strength and deformation properties for both static and dynamic loading.

A geotechnical investigation for offshore wind farms normally comprises geophysical surveys and geotechnical investigations.

Project quality relies on the quality of the surveys



Met-ocean studies

First a geophysical survey is carried out. This survey may comprise the following geophysical equipment: echo sounder, pinger, chirp, boomer, sparker, air gun and side scan sonar. Often as multi-channel surveys.

The geophysical survey is then followed by a geotechnical field investigation. This investigation comprises cone penetration test soundings and geotechnical boreholes with soil sampling and associated field tests.

Finally, geological descriptions and laboratory tests are carried out on the retrieved undisturbed and disturbed soil samples.

COWI has extensive experience in the planning and subsequent evaluation of geotechnical investigations for offshore wind farms.

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Wave measurements and analysis

COWI's marine expertise comprises design and monitoring of wave measurement campaigns for the purpose of establishing complete sets of hydrographic data applicable to design and study activities including the verification of numerical models. Campaigns cover meteorological data and marine data including water levels, waves, current, water temperature and salinity.

COWI performs analyses of hydraulic data and definitions of joint extreme wind, wave and water level design parameters.

Wind and wave modelling

State-of-the-art numerical modelling of operational and extreme wave field is carried out by means of the MIKE 21 suite of programs.

The calculations include tidal motions, flow and storm surge set-ups due to wind and barometric pressure.



Geotechnical investigations

Foundations

Over the years COWI has developed innovative off-shore foundation concepts that are today regarded as proven and accepted.

Our foundation design expertise also includes monopiles, four-legged jackets as well as jack-up installed STAR tripods.

The Nysted gravity base foundation, today considered the conventional gravity foundation, was an innovative design developed together with the contractor to meet the site specific challenges set by foundation conditions as well as fabrication and installation requirements.

COWI's project approach, combining hydraulics, geotechnics, structural engineering and fabrication/installation

procedures into integral solutions, provides the client with optimal solutions for his specific project needs.

COWI uses state-of-the-art design numerical models and design tools in all phases of the project.

COWI's unique in-house FEM program IBDAS is an integrated design and analysis tool. It allows for integrated parametric geometrical modelling, structural analysis and verification of structures against internationally recognised codes and standards as well as generation of construction drawings.

The features include static and dynamic analyse in the full range of limit states: ULS, SLS, FLS and ALS.

The verification of structural strength and the stability in the construction phase are coherent in the design activities.

This includes impacts during transport and installation such as loads induced from lifts, dynamic impact during transportation, and impact during installation.

We conduct installation studies taking the permissible weather windows into account and we provide the client with a basis for optimising his installation requirements.



*Thornton Bank,
foundation for
5 MW WTG*



Photo: Petri and Beiz

Red Sand 2 gravity base foundation - lifting operation



Transition pieces for London Array, 175 monopile foundations



London Array 630 MW,
175 foundations

Design

Structural design

Over the years COWI has developed innovative offshore foundation concepts that are today regarded as proven and accepted standards. Our offshore foundation design expertise includes:

- gravity base
- monopiles
- jackets
- tripod foundations
- superstructures, such as substations (transformer platforms)

Appurtenances

Offshore foundations are to be provided with J-tubes for the electrical cables.

In addition, offshore foundations are to be provided with boat landing(s), access ladder and safety cage, service platform with railing in order to facilitate the inspection and maintenance during the operational period.

Cathodic protection of the foundation structure may also be required.



STAR jacket, owner: Maersk Oil

Scour protection

COWI has extensive experience within the field of scour protection, offshore foundations, sub-sea cables and cable landfalls.

Our specialist knowledge of flow phenomena, scour materials and construction processes is combined with advanced numerical models and physical model tests to provide optimised design solutions.





Photo: Ian Cormack

*Punch-through analyses
for jack up operations*

Installation assessment

Jack-up risk assessment

COWI has carried out risk evaluation regarding the seabed conditions for jacking up on a number of offshore wind turbine sites.

The risk assignment is focusing on: The sea bed conditions, bearing capacities and penetrations of footings, risk of

punch through of softer layer below footings, other ground related risks in conjunction with jacking up operations.

Grid connection design

COWI services include design of grid connections for wind farms. The design includes the power system within the wind farm and the connection to the high voltage transmission system.

Our know-how includes:

- Power system analyses for large-scale integration of wind power
- Power quality analyses in relation to grid codes
- Grid connection optimisation
- Optimisation of distribution grids with wind power generation
- Design of grid connection and reactive power compensation
- Optimisation of internal power distribution system for wind farms
- Design of wind farm power substations
- Short circuit and relay protection analyses
- Disturbance monitoring in systems with variable wind production.



*Transformer platform and
foundation design, Nysted*



- COWI offices
- Selected offshore wind projects



DS/EN ISO
9001 certificate

COWI is a leading international consulting firm. We provide state-of-the-art services within the fields of engineering, environmental science and economics.

With offices and 6,000 employees all over the world, we offer consultancy services and plan projects using our extensive knowledge of local markets while drawing on the international experience of our entire organisation.



Nysted, 165 MW, Denmark

Photo: Jan Djerning/BAW/Scanpix

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