

THE COMPLETE SERVICE PACKAGE

COWI WIND



COWI

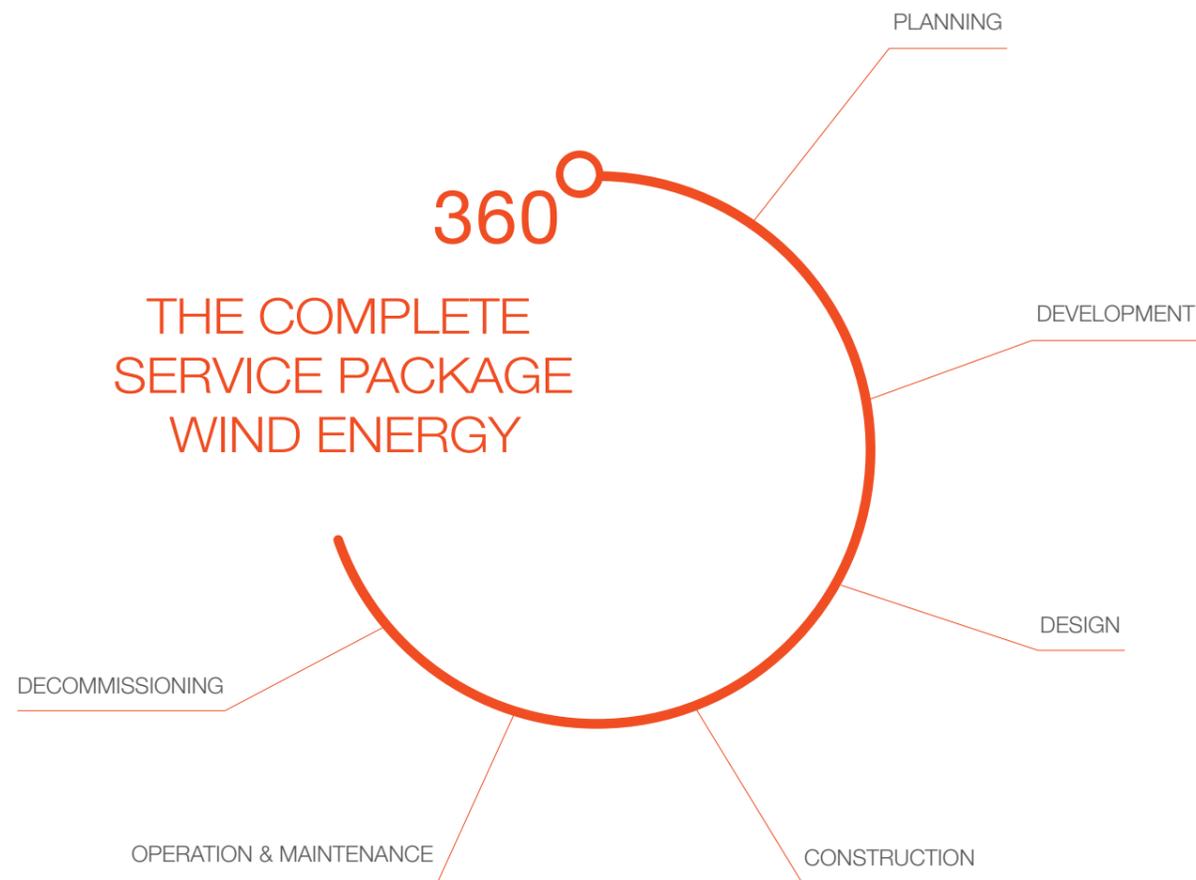
ABOUT COWI WIND

COWI is a leading multidisciplinary consultancy group that creates value for customers, people and society through our unique 360° approach. COWI has more than 80 years' experience in consultancy services and more than 6,200 employees worldwide.

COWI has significant experience within the wind energy sector, and we provide the complete service package from the identification of project sites to planning and design, contracting assistance, construction services, assistance during operation and maintenance, and decommissioning.

We have jointly worked on more than 800 wind power projects in 68 countries. Our experience in wind energy covers every aspect without exception. Our multidisciplinary company can assist with everything, as well as issues not specifically mentioned in this brochure, such as establishing policy frameworks or expansion of production facilities.

COWI provides services to a range of clients, including developers, turbine manufacturers, contractors, international financial institutions, development banks, investors and utility companies.



CONTENT

- 5 SITE PROSPECTING
- 5 WIND RESOURCE MEASUREMENTS
- 6 WIND STUDIES
- 7 SITE CONDITIONS & WTG SUITABILITY
- 8 OFFSHORE WIND RESOURCE ASSESSMENT
- 8 METOCEAN
- 10 FEASIBILITY STUDIES
- 12 DUE DILIGENCE
- 13 OWNERS / LENDERS ENGINEER
- 14 ENVIRONMENT AND PERMITTING
- 14 HEALTH AND SAFETY
- 16 CIVIL WORKS
- 17 OFFSHORE FOUNDATIONS
- 18 GRID STUDIES
- 19 ELECTRICAL SERVICES
- 21 OFFSHORE SUBSTATIONS
- 22 POWER CURVE VERIFICATION
- 23 MEASUREMENTS ON TURBINES



SITE PROSPECTING

COWI provides a wide range of site investigation services including identifying sites which have the lowest cost of energy. The site prospecting process consists of several phases, which are carried out for both onshore and offshore projects:

- › Mesoscale modelling for creating large-scale wind atlases and thereby identifying optimal locations within large areas
- › Ranking and selection of sites based on energy potential and overall development costs and constraints (landowner and land use, access conditions, grid connection, etc.)
- › Wind measurement strategy for further development of the most promising sites.

The first step in the overall site identification within larger areas is mesoscale modelling. The output of the mesoscale model is maps representing the wind energy potential for a given area. The maps are then integrated in GIS software together with other relevant information such as grid connection possibilities, restricted areas, access roads, etc. Based on this information, COWI provides a ranking of the potential sites.

The final ranking of the sites is based on preliminary feasibility assessments, presenting the technical and economic evaluation of each potential site. This step is carried out in close cooperation with the client.

When the client has selected the site(s) for further development, COWI can prepare a wind measurement strategy to provide on-site wind data applicable for a wind study of bankable quality.

WIND RESOURCE MEASUREMENTS

High quality wind resource measurements are crucial when developing wind power projects. COWI is a co-founding member of MEASNET, and we have more than 35 years of experience in wind resource measurements. COWI can make recommendations on the optimum met mast instrumentation in various climates, as well as identifying the best location for the mast to optimize the site-specific wind resource measurement.

COWI can rent or procure any mast type with or without measuring equipment. From the cold climates of Norway, to the warm climates in the Kingdom of Saudi Arabia, the flat terrain in Latvia and the complex terrain in Bosnia, COWI has installed and monitored more than one hundred met masts worldwide. COWI manages met mast installation, operation, wind data analysis and mast dismantling. We deliver high quality measurements with comprehensive documentation/reporting according to MEASNET recommendations.

In addition to traditional wind resource measurements from met masts, COWI also offers remote sensing measurements with Lidar.



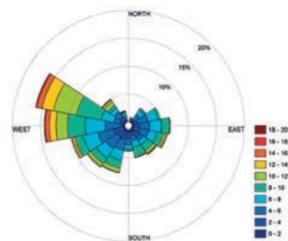
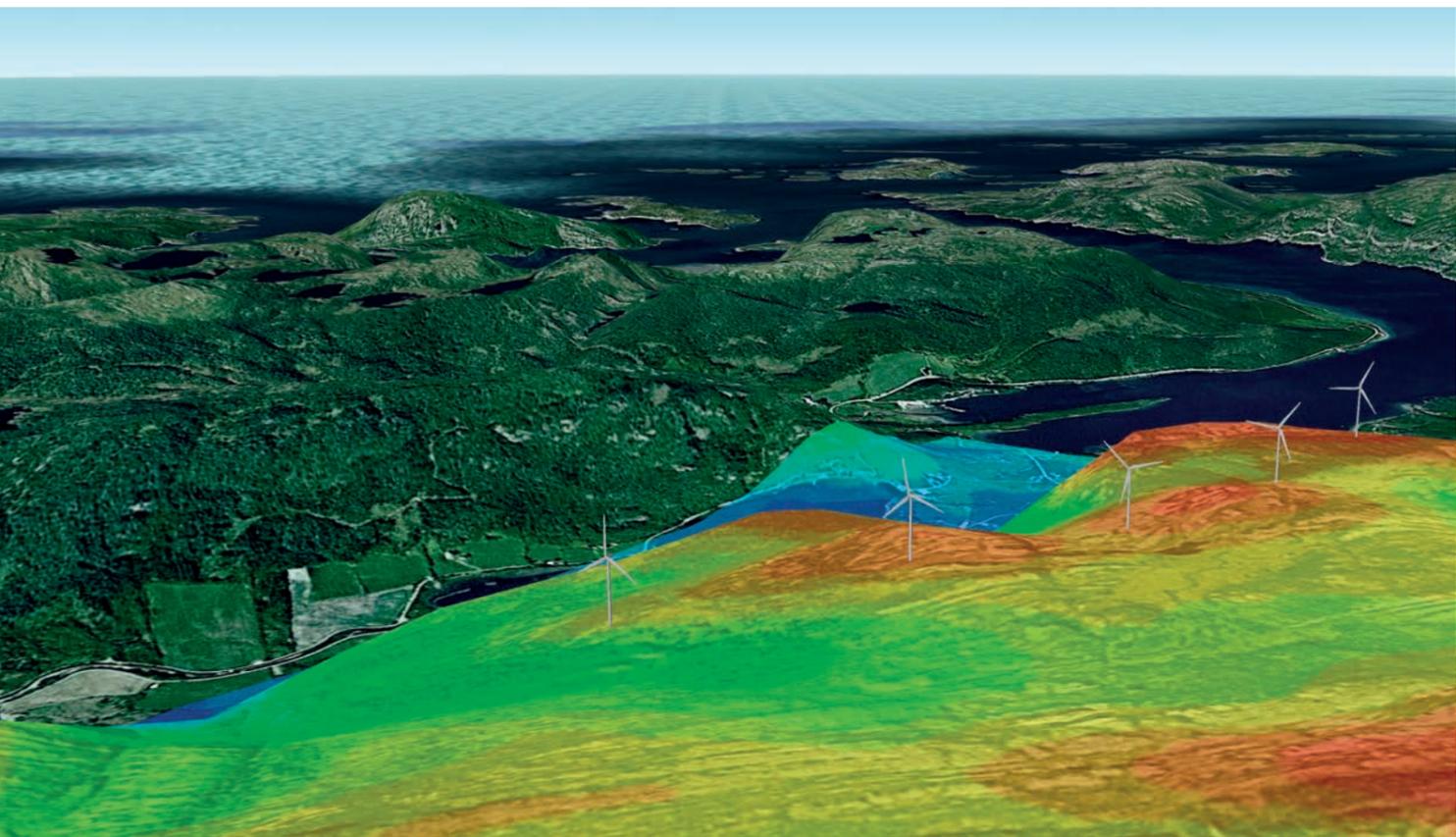
REFERENCE PROJECTS

- › **E.ON – Danish Nearshore Projects:** Complete site prospecting and selection of Danish nearshore projects for further development, Denmark.
- › **IDB – Wind Resource Studies for Nine Sites:** Validation of measurements, and independent evaluation of the energy performance of nine (9) pilot sites and correlation with the existing Bolivia Wind Atlas, Bolivia.
- › **BioTherm Energy – Ranking of 10 sites in South Africa:** Site prospecting, wind resource assessment, and ranking of ten sites, South Africa.



REFERENCE PROJECTS

- › **Statkraft – Roan project:** Installation and monitoring of met masts in complex terrain at Roan in Fosen, data screening and analysis, Norway.
- › **New and Renewable Energy Authority (NREA) – 200 MW project Gulf of Suez:** Installation and monitoring of met masts, data screening and analysis, Egypt.
- › **Laredo SAA / IFC – Laredo Wind Power Project:** Planning and implementation of a wind measurement campaign including data analysis for a potential wind project at the premises of the Laredo Sugar Company, Peru.



WIND STUDIES

COWI has carried out several hundred wind studies of bankable quality worldwide for onshore as well as for offshore wind projects. COWI offers both first-hand assessment for financing and second opinions for due diligence.

COWI has a team of dedicated experts working full time with screening and analyses of wind data, wind resource assessments, micro-siting of turbines and Annual Energy Production (AEP) calculations. The team is using state-of-the-art software like the WAsP/WindPro linear flow models, and for more complex terrain the CFD flow modelling software WindSim and WAsP-CFD is used. For offshore projects, the FUGA wake loss model is used.

COWI also provides mesoscale wind data when on-site measurements or long-term reference data are not available. COWI has developed a method of using mesoscale data for the determination of the wind resource at offshore wind projects, which has been validated against measurements and has been certified by an independent third party. The mesoscale data is furthermore used for preparation of large-scale wind atlases and for general assessment of the wind resource potential and planning of on-site measurements.

REFERENCE PROJECTS

- › **Green Watts International – Al Rajef 82 MW Wind Farm:**
Wind study and site conditions for a site in extremely complex terrain prepared using CFD, Jordan.
- › **ICE / IDB – Tejona Wind Farm:**
Wind study and AEP estimate for possible re-powering of the Tejona Wind Farm, Costa Rica.
- › **Energija Projekt d.o.o – Senj 156 MW Wind Farm:**
Wind study and site conditions for a site in extremely complex terrain prepared using CFD, Croatia.
- › **IDB – Chiripa Wind Farm:**
Second opinion in the form of an independent wind resource assessment and energy yield estimate using WindPro and full CFD analysis, Costa Rica.

SITE CONDITIONS & WTG SUITABILITY

In addition to the wind studies, COWI carries out site condition studies in accordance with the IEC 61400-1 Ed. 3 standard. The important parameters such as extreme wind conditions and ambient and effective turbulence are analyzed in order to assess the wind class throughout the site. The design load driving parameters such as inflow angles and wind shear are also analyzed and assessed. Once the parameters have been identified the optimum wind turbine class can be selected; in particular the optimum rotor/generator ratio in order to extract as much yield as possible from a given site.

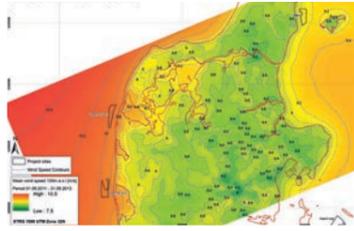
Other site condition parameters such as risk of lightning, probability of earthquake and estimation of seismic ground acceleration are also assessed.

In harsh climatic conditions, either in cold or hot climates, the suitability of wind turbines for the specific conditions is extremely important. In cold climates the effect of ice formation on wind turbines and the consequence on energy production is assessed as well as different heating systems to select the optimum wind turbine. In hot climates, for instance in deserts, both heat and sand are taken into account when selecting the optimum wind turbine.



REFERENCE PROJECTS

- › **New and Renewable Energy Authority (NREA) / Danida – Zafarana 60 MW Wind Farm:**
Assessment of the effect of sand combined with salinity on the performance of turbines in a 60 MW wind farm, Egypt.
- › **Elektroprivreda of Bosnia and Herzegovina – Vlačić Wind Farm:**
Assessment and evaluation of the possible effect of ice formation on wind turbines and consequence on energy production, Bosnia & Herzegovina.
- › **CEPM / Danida – Quilvio Cabrera Wind Farm:**
Assessment of the effect and consequence of high levels of salinity, especially in relation to the tower and blade constructions, Dominican Republic.



REFERENCE PROJECTS

- › **Energinet DK – Six Nearshore Wind Farms:**
Wind resource estimates based on a validated mesoscale model and provision of "virtual wind measurements". The data was made available to concession bidders to place their final financial bid to the Danish Energy Agency, Denmark.
- › **Havvind Århus Bugt A/S – Mejlfak Nearshore Wind Farm:**
Wind study of bankable quality based on validated "virtual wind measurements", Denmark.
- › **Energinet DK – Horns Rev 3 Offshore Wind Farm:**
Wind resource estimates based on a validated mesoscale model and provision of "virtual wind measurements". The data was made available to concession bidders to place their final financial bid to the Danish Energy Agency, Denmark.



REFERENCE PROJECTS

- › **Energinet DK – Six Nearshore Wind Farms:**
Met-ocean studies and certification of met-ocean design parameters by DNV-GL for several locations in Danish waters, Denmark.
- › **Energinet DK – Horns Rev 3 Offshore Wind Farm:**
Met-ocean study of wind and waves, and certification of met-ocean design parameters by DNV-GL, Denmark.
- › **wpd – Storgrundet Offshore Wind Farm:**
Met-ocean study including numerical modelling by MIKE21, Sweden.

OFFSHORE WIND RESOURCE ASSESSMENT

For the assessment of offshore wind resources, COWI uses an approach that differs from onshore assessments. The main reason for this is the difficulty and costs related to carrying out on-site wind measurements. Traditionally, the wind resource has been measured with offshore met masts, but as projects are moving into deeper waters and further offshore, alternatives to offshore met masts such as floating Lidars have been deployed and tested in recent years.

As a least cost alternative, COWI has developed a mesoscale-based approach to establish wind data at offshore wind farm sites. The mesoscale model is validated against existing met mast measurements, located both on- and offshore which can be found within the mesoscale domain area. The COWI approach makes it possible to assess the bias and the uncertainty of the mesoscale wind data. An independent third party, DEWI, has verified the approach and the obtained results.

For Danish nearshore and offshore project sites, the method has resulted in no bias between the met mast measurements and mesoscale wind data. Furthermore, the obtained uncertainties are acceptable and thus, the mesoscale wind data can be used for wind resource assessments of bankable quality.

COWI also assists with traditional offshore measurements using met masts or Lidar.

METOCEAN

COWI has substantial experience with carrying out met-ocean studies for offshore wind farms and obtaining upfront certification of met-ocean design parameters (e.g. wind, water levels, waves, currents, and sea ice) from accredited certifying agencies.

Using our in-house numerical modelling capabilities, we conduct state-of-the-art numerical modelling studies of waves and hydrodynamics (water levels and currents) to establish long-term time series of met-ocean conditions at various locations within the offshore wind farm site. Subsequently, advanced statistical analyses are conducted to establish the relevant extreme conditions for design.

The met-ocean studies are generally conducted and reported in accordance with the international standard IEC 61400-3.



FEASIBILITY STUDIES

Selection of an appropriate site and a suitable turbine are key issues for the economy of a wind power project. However, many other issues also influence the development of a project significantly. These issues include for instance environmental impacts, transportation challenges, and regulatory framework.

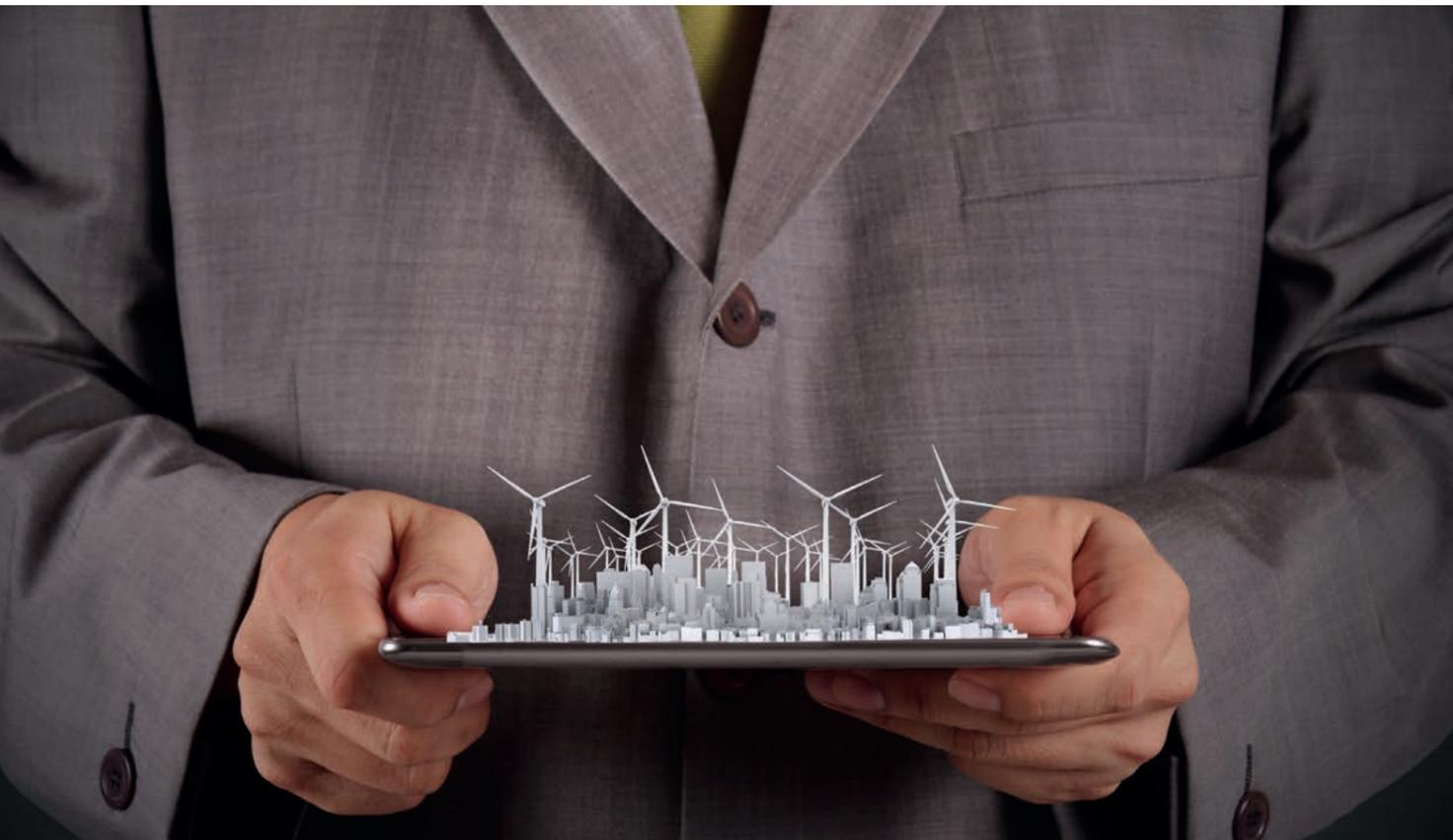
COWI has significant experience with project specific assessments, and undertakes feasibility studies for a wide range of clients including developers, utilities, and international financing institutions. The feasibility studies generally cover the following, but they can of course be tailor-made to meet the client's specific requirements and needs:

- › Wind resource assessment and calculation of the estimated annual energy production (AEP)
- › Site conditions and wind turbine suitability
- › Assessment of the geotechnical conditions
- › Grid impact assessment
- › Environmental impact assessment
- › Transportation assessment
- › Regulatory framework and permits/licenses
- › Estimation of CAPEX and OPEX
- › Financial analysis
- › Assessment of the project organization.

REFERENCE PROJECTS

- › **Elektroprivreda RS / KfW – Five Potential Wind Power Projects:**
Full feasibility studies for five sites with a total capacity of 235 MW, including cross-cutting issues such as regulatory framework, potential for local manufacturing and tender procedures, Bosnia & Herzegovina.
 - › **Wigton Wind Farm Ltd / IDB – Wigton Wind Farm Phase III:**
Feasibility study for the potential phase 3 extension of the Wigton Wind Farm, Jamaica.
 - › **Danida – Loi Hai Wind Farm:**
Review and assessment of a feasibility study for the project, Vietnam.
 - › **China Hydropower Engineering Consulting Group Co (CHECC) – Feasibility Study Template for Large Scale Wind Farms Including 3 Feasibility Studies:**
Assistance in preparation of a feasibility study template for large scale wind farms, including three actual feasibility studies for large scale projects in Heilongjiang, Jilin and Liaoning provinces, China.
-





DUE DILIGENCE

In relation to due diligence of wind power projects, COWI assists with transaction management to minimize the risks through identification and assessment of technical, environmental and financial issues. Our vast pool of experts within every relevant discipline ensures that we have the necessary experience and knowledge to assess and evaluate any kind of challenge.

The core of our services in a due diligence context is to assess different types of uncertainty related to the average annual energy production (AEP), and how these uncertainties affect the financial situation of a given project.

We also assess the suitability of the chosen turbine for the specific site, and we undertake technical assessments of the turbine supply agreement including the provided guarantees.

Finally, we assess the related service and maintenance agreement including the OPEX estimate.

Over the years we have performed due diligences for numerous banks, financial institutions, development agencies, multilateral development banks and investors counting among others Pension Danmark, BNP Paribas, Nordea, and Arctas Capital Group, Danida, IFC, ADB and EIB.

REFERENCE PROJECTS

- › Pension Danmark / PKA – Anholt Offshore Wind Farm:
Full technical due diligence of the 400 MW Anholt offshore wind farm, Denmark.
- › EIB – NER300 Wind Power Projects:
Technical due diligence of 8 innovative wind power projects, Europe.
- › Pension Danmark – Papalote Creek And Stony Creek Wind Farms:
Technical due diligence of three onshore projects; Papalote Creek I & II (380 MW) in Texas and Stony Creek (53 MW) in Pennsylvania, USA.
- › Client name confidential – Portfolio of Onshore Wind Turbines:
Technical due diligence of a portfolio of onshore wind turbines with a combined capacity of nearly 200 MW, Denmark.

OWNERS / LENDERS ENGINEER

COWI provides owner's engineering services to wind farm developers and owners, and lender's engineering services to investors and financing institutions.

As owner's engineer we prepare tender documents including micro-siting of wind turbines, road and foundation design and design of substation, electrical network and overhead lines. Furthermore, we have specialists within commercial conditions, and provide advice on contract format, structuring of guarantees etc. During the construction phase we commence with a review of the supplier's design where our experts' decades of experience as well as our multi-disciplinary line of work ensure that all types of design can be handled. We have extensive experience in dealing with contractors, and through our work we always ensure the optimal solution for the project and thereby the project owner(s). Special attention is given to the procedure at the time of Taking Over of the project but equally if not more important at the End of the Defects Liability Period.

COWI has a vast record of acting as a lender's engineer, with numerous clients counting development agencies, institutional investors and financial institutions. As lender's engineer we emphasise and pay special attention to our role as it is quite different from the role of an owner's engineer. We make use of all of our competencies to ensure the interests of the investor/lender and keep focus on the viability of the investment.



REFERENCE PROJECTS

- › North Wind Power Development Co. – Bangui Bay Wind Farm:
Technical assistance throughout project development, construction and operation of the 51 MW Bangui Bay wind power project, Philippines.
- › Danida – Various Wind Power Projects Worldwide:
Technical assistance to Danida in relation to the development, implementation and operation of wind power projects financed under the Danish Mixed Credits scheme, China, Costa Rica, Dominican Republic, Egypt, Philippines and Vietnam.
- › Lake Turkana Wind Power / AfDB – Lake Turkana 310 MW Wind Power Project:
For the turbine supply COWI provides design review, factory test attendance, on-site supervision, and inspection at Taking Over.



REFERENCE PROJECTS

- › **Danish Crown – "Factory" Wind Power Project:**
Full EIA of a potential wind power project located at the abattoir production facilities, Denmark.
- › **Municipalities of Copenhagen and Hvidovre – Wind Power Project Copenhagen:**
Screening of suitable locations for wind turbines in the two municipalities with special emphasis on visual impact and noise, Denmark.
- › **EnergiMidt Renewables – Døstrup Wind Farm:**
EIA study and preparation of an optimized sector management strategy mitigating potential problems for bats and at the same time minimizing energy yield losses, Denmark.



REFERENCE PROJECTS

- › **Statkraft – Various Swedish Wind Power Projects:**
HSE coordination of installation and instrumentation of 100-120 m met masts at various sites, Sweden.
- › **SWANCOR – Formosa-1 Offshore Wind Farm:**
Assessment of risk in relation to the installation of offshore foundations, Taiwan.
- › **Iberdrola – Wikinger Offshore Wind Farm:**
HSE coordination in the project design phase for an offshore foundation design, Germany.

ENVIRONMENT AND PERMITTING

COWI's environmental services cover the entire process from site finding through to construction supervision. COWI's expertise includes experience from numerous wind farm projects both onshore and offshore.

COWI's long term experience with project management in the EIA process covers every aspect including shadow flicker, noise, visual impact, ecology, ornithology, marine biology and habitats.

The visual impact of wind farms is assessed through the use of a landscape assessment, using GIS and high-resolution remote sensing.

In terms of mitigating measures, our broad in-house competencies allow us to find suitable and cost-effective solutions, which are in line with the requirements given by engineers, socio-economists and environmentalists and also accepted by neighbours and other stakeholders.

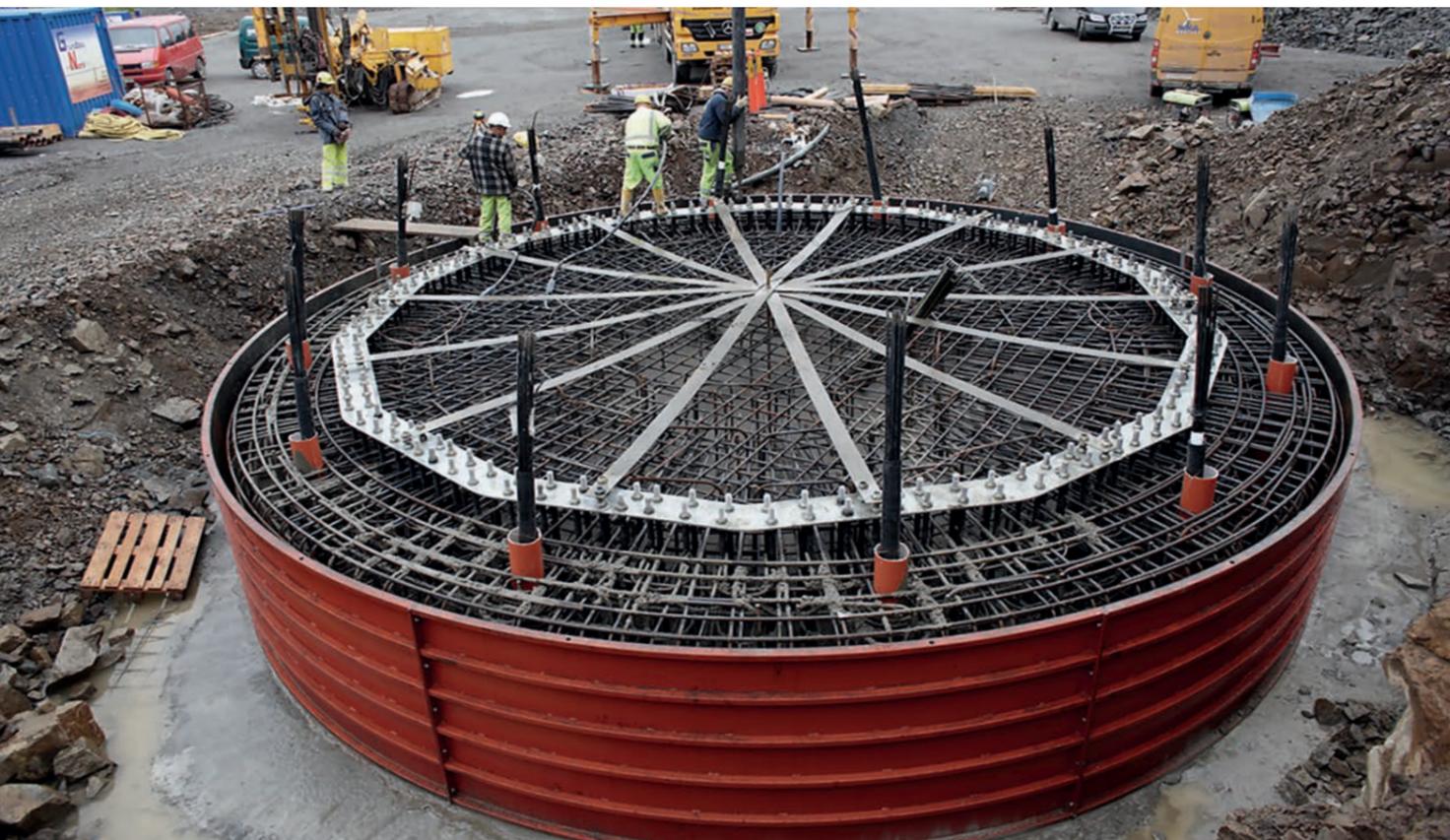
For the construction phase COWI offers management of permits, licenses and consents. All mitigating measures, necessary permissions and site supervisions are handled in full accordance with regulation and policies.

HEALTH AND SAFETY

For COWI, health and safety plays a key role in all of our projects. COWI's health and safety specialists are internationally recognized for their comprehensive and thorough work and for the practical results they achieve. Continuous client involvement and efficient communication ensure that the results are ready for implementation.

Our general health and safety policy is based on the idea of integration of health and safety management within the client's overall management system. Early implementation of health and safety procedures are crucial especially in relation to general staff awareness.





CIVIL WORKS

COWI provides the full balance of plant package for civil works including foundations, crane pads, lay-down areas and roads (electrical services are described in a later section in the brochure).

We have designed foundations for more than 12,000 onshore wind turbines over the past 35 years, and we provide fully certified designs including all required and verified documentation. Optimizing the design of foundations is all about being fully acquainted with the wind climate, soil conditions, turbine loads and structural design potential. The challenge is to provide the client with the optimum design with regard to both feasibility, cost and robustness.

Geotechnical investigations are one of the key parameters when optimizing foundations, roads etc. COWI provides full geotechnical investigations including planning, implementation and interpretation of results. We also offer second opinions on geotechnical investigations already carried out.

Gravity based, piled and rock-anchored foundations – we have designed all variants, and we take a pride in balancing size and strength to ensure a cost-effective design with the required design life.

COWI is also involved in the development of concrete, steel and hybrid towers for wind turbines with hub heights up to 130 meters in Europe, USA and Asia. We have designed in-situ cast concrete towers with sliding form, post-tensioned elements, and concrete-steel hybrid towers.

REFERENCE PROJECTS

- › Siemens Wind Power – Østerild & Tim: Detailed foundation design for the first onshore 6 MW turbines, Denmark.
- › Vestas – Various Danish Wind Power Projects: Detailed foundation designs fully certified by independent third party for numerous Vestas projects, Denmark.
- › Worley Parsons RSA – Jeffery's Bay Wind Farm: Second opinion on foundation design, South Africa.
- › HOFOR A/S – Prøvestenen: Full civil works package consisting of tender and design documents, Denmark.
- › Suzlon – Amayo Wind Farm: Second opinion on foundation design and supervision of casting of the foundations on-site, Nicaragua.

OFFSHORE FOUNDATIONS

COWI undertakes structural design for offshore wind foundation projects through all phases of a project. We develop the foundation designs from the initial conceptual stages, where the optimal foundation type is determined, through to the detailed design phase to the supervision and monitoring of the installed and completed structures.

Detailed designs of monopile, jacket, and gravity based foundations have been undertaken for a series of contractors and utility companies.

For London Array Offshore Wind Farm, COWI designed 175 monopile foundations in 0-25 meter water depths and different soil conditions. Piles in diameter of 4.7 or 5.7 meter and foundations in lengths of up to 85 meter were designed for the 3.6MW Siemens turbines.

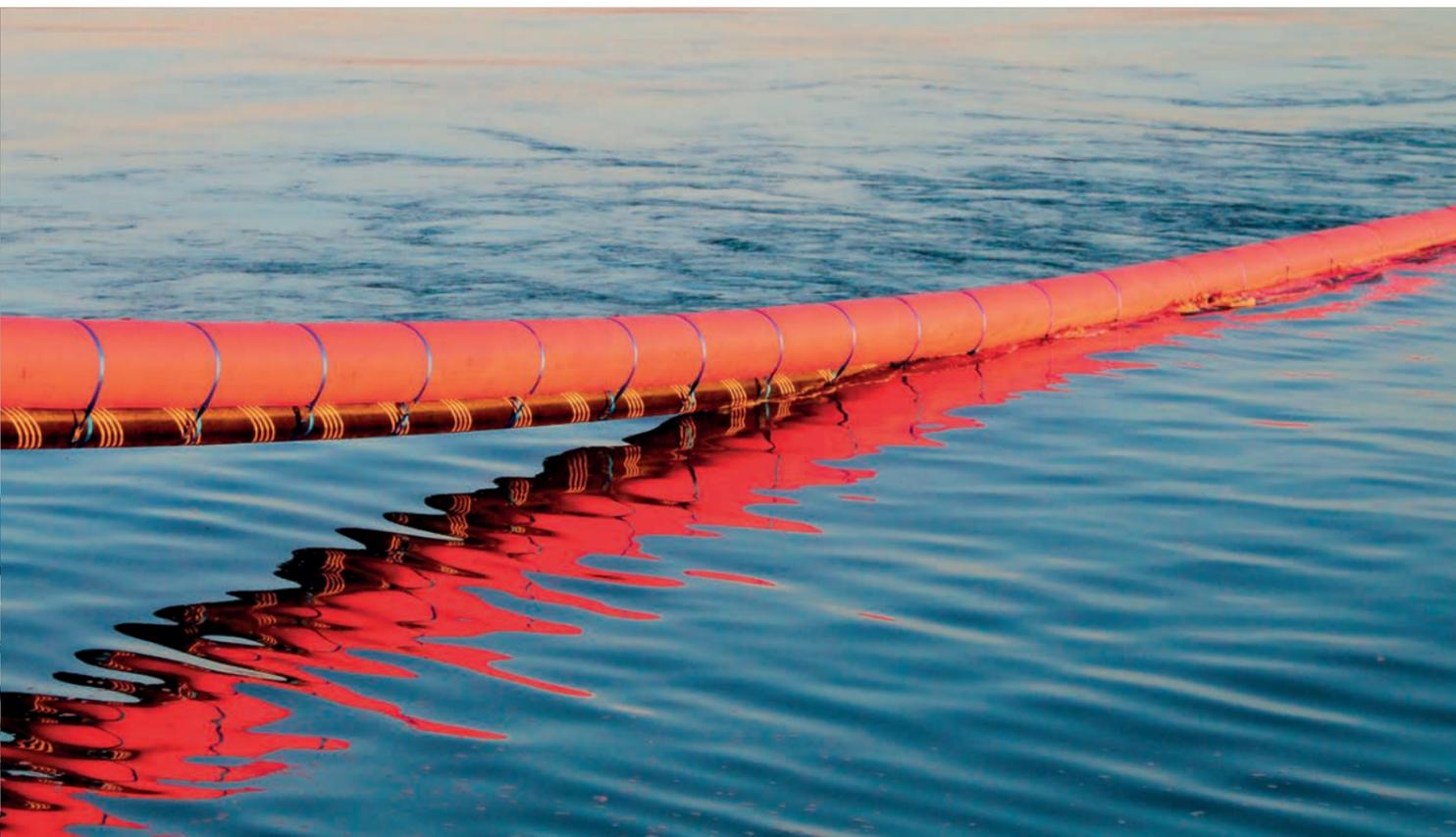
COWI has designed jacket foundation structures carrying Areva 5MW turbines in 40 meter water depths to withstand the ice forces of the Baltic Sea. As part of the project, the development of a new optimized transition piece with strong emphasis on ease of construction was carried out for Wiking Offshore Wind Farm.

COWI is a world leader in design of concrete gravity offshore wind turbine foundations with experience in offshore wind farms including Kaarehamn in Sweden, Nysted and Rødsand 2 in Denmark as well as Thornton Bank in Belgium.



REFERENCE PROJECTS

- › Aarsleff-Bilfinger Berger JV – London Array Offshore Wind Farm: Design of monopile foundations for 175 wind turbines - 630 MW, United Kingdom.
- › Iberdrola – Wiking Offshore Wind Farm: Design of jacket foundation structure and development of a new optimized transition piece for 70 wind turbines - 400 MW, Germany.
- › EON – Rødsand 2 Offshore Wind Farm: Design of 72 concrete gravity foundations, Denmark.



REFERENCE PROJECTS

- › **Statoil – Horns Rev 3 Offshore Wind Farm:**
Basic design and grid study impact of entire wind farm, Denmark.
- › **UPME / IDB – Impact Analysis for Integration of Wind Power Generation:**
Determination of the needed transmission infrastructure or reinforcement needs to feed 400MW wind power into the grid and analysis of correlation and complementarity between wind power and hydro power on a monthly basis for the 10 years, Colombia.
- › **IDB – Integration of Large Amounts of Wind Energy:**
With a possible expansion of 1000 MW of wind power by 2016, a comparative study of grid regulation was conducted and a proposal for future grid regulation presented, Uruguay.

GRID STUDIES

Grid studies are offered by COWI to identify technical issues at early stages of the wind farm development. Such issues can be extremely costly later in the project if not recognized and dealt with in due time.

Studies are prepared in transmission system and other major parts of electrical infrastructure, including other power plants. The studies reveal if the wind farm output can be exported through the network without restrictions. Typical studies cover load flow and fault level analysis, contingencies, transient and dynamic analysis.

Major electrical and grid connection components for wind farms are identified and sized in studies forming a basis for budget estimates, technical specifications and procurement.

Grid code compliance for a wind farm is verified for owners and investors. PQ and UQ capability diagrams, dynamic and transient stability, fault ride through capability, voltage and frequency regulation and harmonic analysis are studied.

Additional studies and services are offered such as insulation coordination studies, development and validation of simulation models for wind farms, and grid code compliance by on-site test and measurements.

Simulation software such as DigSILENT PowerFactory, NEPLAN and EMTP can be applied.

ELECTRICAL SERVICES

COWI provides a wide range of electrical services for both onshore and offshore wind farm projects, and has cooperated closely with many manufacturers, developers and operators worldwide. Our electrical experts have extensive knowledge and experience in the electrical disciplines related to on- and offshore wind farms.

COWI's electrical experts are up to date with the latest developments in technology and technical requirements to the electrical components and market demands, and have focus on bringing down the cost of energy by optimizing design, installation and operation, and by implementing new solutions. COWI's electrical engineers are experienced in working in small project groups, as well as in large and complex project organizations either as project managers or as specialists.

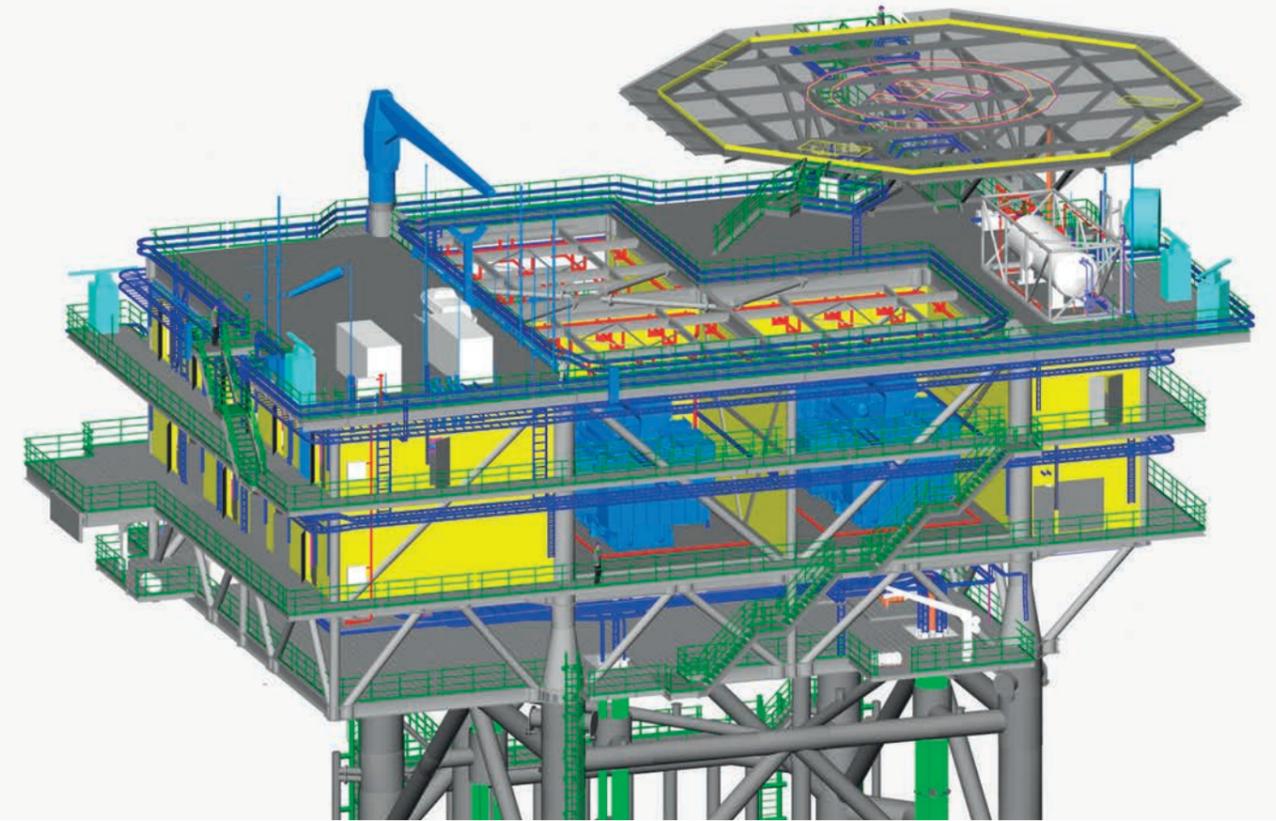
COWI provides all electrical services:

- › Basic, conceptual and detailed design
- › Array cable systems
- › Export cable systems
- › Electrical substation design
- › Onshore cable connection
- › Onshore substation
- › Power system integration
- › Preparation of tender documents and tender review
- › Procurement assistance.



REFERENCE PROJECTS

- › **DONG Energy – Walney 1 and Westermost Rough Offshore Wind Farms:**
Export and array cable management for two 200 MW offshore wind farms, United Kingdom.
- › **Siemens Wind Power – WesterMeerWind Offshore Wind Farm:**
Assistance on electro technical design for cable system and substation, evaluation of tender documents, technical coordination of interfaces between sub-suppliers, and participation in negotiations with sub-suppliers, Netherlands.
- › **JSC Georgian Energy Development Fund – Gori Wind Farm:**
Conceptual design of electrical network, on-site substation, transmission line, and grid connection, Georgia.



OFFSHORE SUBSTATIONS

COWI carries out both conceptual and detailed design of entire offshore substations. We have in-house expertise in designing all components, both electrical and structural. COWI has designed both jacket and gravity foundations. In relation to platforms, COWI has extensive experience in designing the topside and secondary steel structures including boat landings and helicopter landing deck. The electrical design includes transformers, switchgears, auxiliary transformers, earthing resistors, and SCADA system. In addition to this, firefighting systems, HVAC systems and sewage systems are included in the design. COWI has the necessary capabilities and experience in-house to prepare either a full detailed design of the entire substation or specific components if that is requested by the client.

COWI also assists clients with technical tender documents, supervision and inspections.

3D-MODEL OF TRANSFORMER PLATFORM

The above illustration is a stand still image from the Autodesk Software (AutoCAD Plant and Navisworks), which enables designers and the Client to "walk around" at the offshore platform and inspect all details and locations.

The model is designed and developed in close cooperation with a corresponding structural model. Combining the two models enables simultaneous creation of the detailed design for the structure, as well as the mechanical and electrical design.

REFERENCE PROJECTS

- **Energinet DK – Horns Rev 3 Offshore Wind Farm:**
Conceptual and detailed electrical, mechanical and structural design of topside and jacket foundation for the offshore substation, Denmark.
- **Energinet DK – Kriegers Flak A & B:**
Conceptual and detailed electrical, mechanical and structural design of topside and jacket foundation for the offshore substations, Denmark.
- **Iberdrola – Wikinger Offshore Wind Farm:**
Conceptual electrical, mechanical and structural design of topside and jacket foundation for the offshore substation, Germany.



MEASUREMENTS ON TURBINES

COWI has more than 35 years' experience in conducting measurements and calculations for design and approval of wind turbines.

The measurements provided by COWI cover the requirements for a type test needed for the approval of wind turbines including power curve, structural loads, functional and safety tests and noise. All tests are accredited by DANAK according to IEC standards.

The calculations provided by COWI include full set of design loads using recognized aeroelastic software according to IEC standards and design calculations of all turbine sub-elements, e.g. blades, steel parts and concrete towers using detailed FE analyses.

We provide services to manufacturers in assessing their wind turbine design and sub-elements with respect to strength, lifetime and dynamic behaviour etc. COWI's in-house expertise in both load measurements and load calculations makes us specialists in comparing and verifying calculated and measured loads in connection with certification and/or calibration of load modelling software.

Furthermore, COWI has thorough experience with certification institutions and provides all necessary design documentation for the type approval of wind turbines.

COWI OFFERS THE FOLLOWING ACCREDITED MEASUREMENTS:

- › Power curve
- › Site calibration
- › Structural loads
- › Noise
- › Determination of mechanical properties:
 - › Measurement of yaw efficiency
 - › Determination of natural frequencies
 - › Turbine operational conditions
 - › Wave loads
- › Functional and safety test.

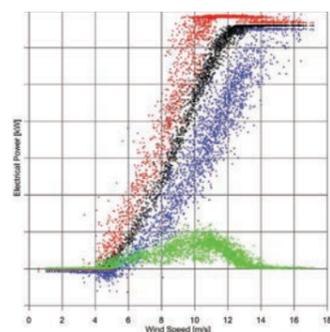
COWI OFFERS THE FOLLOWING CALCULATION SERVICES:

- › Aeroelastic load simulations according to IEC
- › Strength calculation of turbine components, including FEM calculations
- › Design calculations of foundations.



REFERENCE PROJECTS

- › **DONG Energy – Westernmost Rough Offshore Wind Farm:**
Strain gauge installation on a monopile foundation for a 6 MW turbine, United Kingdom.
- › **Wind World India:**
Blade root load measurement, aeroelastic calculations and FEM calculations for type approval of two 850 kW turbines, India.
- › **Pioneer Wincon Ltd:**
Aeroelastic calculations, FEM calculations and full load measurement according to IEC 61400-13 for type approval of 250 kW, 750 kW, and 850 kW wind turbines, India.



POWER CURVE VERIFICATION

COWI acts as a neutral and independent third party, providing power curve verifications to wind turbine suppliers or project owners to verify contractual warranted power curves.

The warranted power curve is the starting point for selecting a specific turbine and is a central parameter in determining the economy of the project. An accredited measurement of the power curve after installation of the project proves whether or not the turbine conforms to the warranty issued by the manufacturer.

We are accredited by DANAK according to the requirements stipulated in DS/EN ISO/IEC 17025 to carry out power curve measurements on wind turbines and site calibration in accordance with the IEC 61400-12-1 and MEASNET procedures. A detailed filtering procedure is used to ensure the quality of the results, and an analysis report according to IEC standard is provided.

We own a range of masts and have an in-house laboratory for the calibration of measurement instruments. COWI provides the full package, including rent or procurement of masts and equipment, installation, data analysis, reporting, mast maintenance, and dismantling. Furthermore, COWI offers power curve measurements based on nacelle Lidar, nacelle anemometer and ground based Lidar.

REFERENCE PROJECTS

- › **Siemens Wind Power:**
Site calibrations and power curve verification. Stamåsen – Björkhöden – Mörttjärnberget – Ögonfågeln, Sweden.
- › **Suzlon:**
Site calibrations and power curve verifications on three turbines. Cook House, South Africa.
- › **Vattenfall:**
Site calibrations and power curve verification. Höge Väg, Sweden.

COWI is a member of Measnet and accredited by DANAK, Danish Accreditation to carry out the measurements.

DANAK has evaluated and confirmed that COWI is impartial, in possession of the required technical know-how and operates under a quality control system in accordance with the DS/EN ISO/IEC 17025:2005 criteria.



MORE THAN 800 WIND POWER PROJECTS IN 68 COUNTRIES

- 
- African Continent:** Egypt, Eritrea, Kenya, Malawi, Morocco, Somalia, South Africa, Swaziland, Uganda.
- Asia:** Malaysia, China, India, Japan, Pakistan, South Korea, Philippines, Sri Lanka, Thailand.
- Middle East:** Oman, Jordan, Saudi Arabia.
- Australasia:** Australia.
- Central and South America:** Bolivia, Brazil, Colombia, Costa Rica, Dominican Republic, El Salvador, Grenada, Guatemala, Jamaica, Nicaragua, Peru, Uruguay.
- Europe:** Belgium, Bosnia, Bulgaria, Croatia, Denmark, England, Estonia, Faroe Islands, Finland, France, Georgia, Germany, Greece, Ireland, Italy, Latvia, Kosovo, Lithuania, Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Russia, Scotland, Serbia, Spain, Sweden, Turkey, Wales.
- North America:** Canada, Mexico, USA.

ADDRESS COWI A/S
Parallelvej 2
2800 Kongens Lyngby
Denmark

PHONE +45 56 40 00 00
FAX +56 56 40 99 99
EMAIL cowi@cowi.com
WWW cowi.com

CONTACT PERSON:

NAME Marc Normann
POSITION Vice President
DEPARTMENT Wind and M&E

PHONE +45 23 38 38 91
EMAIL mano@cowi.dk

COWI