COWI WIND

A DESIGN HOUSE FOR THE FUTURE

COWI

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A DESIGN HOUSE FOR THE FUTURE

Wind power is one of the most important renewable energy sources, worldwide. The installed wind power capacity is set to continue its growth in the coming years, decarbonising energy systems and reducing air pollution. COWI is a key player in the green transition. Since 1980, we have been involved in the development of more than 1,000 wind power projects in 70 countries and the development continues.

COWI's mission in the industry is, through state-of-the-art engineering, environmental and financial advice, to reduce the risks involved in the projects, reduce the costs of the projects and create reliable and innovative solutions for the industry.

Fundamental for bringing down both cost and risk is the experience that skilled people bring to the projects. In a carefully weighted balance with the power of innovation to drive new solutions forward, this is the consultancy we provide in COWI. It is how we aim at providing reliable cost-effective solutions for your projects.

PROJECT DEVELOPMENT

SELECTED REFERENCES

- EU Delegation to India – Technical assistance including cost-benefit analysis, coastal surveys and environmental assessments for setting up the first offshore wind farm, India.
- Energistyrelsen – Comparisons and economic ranking of potential sites for offshore wind farms for the Danish Energy Agency, Turkey.
- Energistyrelsen – Fine screening of areas for new offshore wind farms for the Danish Energy Agency. Analysis of seabed conditions, environmental analysis, wind resource assessment, conceptual design of electrical layout, calculation of levelized cost of energy, Denmark.

SITE PROSPECTING

Site investigation services identify the sites that have the lowest costs of energy. The 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 to identify 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.)
- Defining a 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 of 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 ranks the potential sites.

The final ranking of the sites is based on preliminary feasibility assessments, presenting the technical and financial evaluation of each 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 to be used in a bankable wind study.

FEASIBILITY AND GRID STUDIES

Selection of an appropriate site and a suitable turbine are key issues for the viability of a wind power project. However, many other issues also influence the development of a project, for instance environmental impacts, transportation challenges and regulatory framework but also the conditions for connecting to the transmission system and the other power plants on the grid. Grid studies are therefore recommended at an early stage as electrical infrastructure costs can be extremely high if not recognized and dealt with in due time.

The feasibility and grid studies generally cover the following, but they can of course be tailored to meet the client's 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 and licenses
- Estimation of capital CAPEX and operational OPEX expenditure
- Financial and economic analysis
- Assessment of the project organization.

SELECTED REFERENCES

- Inter-American Development Bank – Feasibility studies of two wind power projects, Colombia.
- Elektr oprivreda RS/KfW – 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. 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.

OWNER'S AND LENDER'S PREFERRED ENGINEER

Whether you are experienced or not in the wind farm development as developer or financing institute, you may need a supporting engineer to protect your interest. We support as owner's or lender's engineer from the earliest stages until later stages of the development, during the construction phase, and all the way through end of supplier's warranty and during the operation of the wind farm.

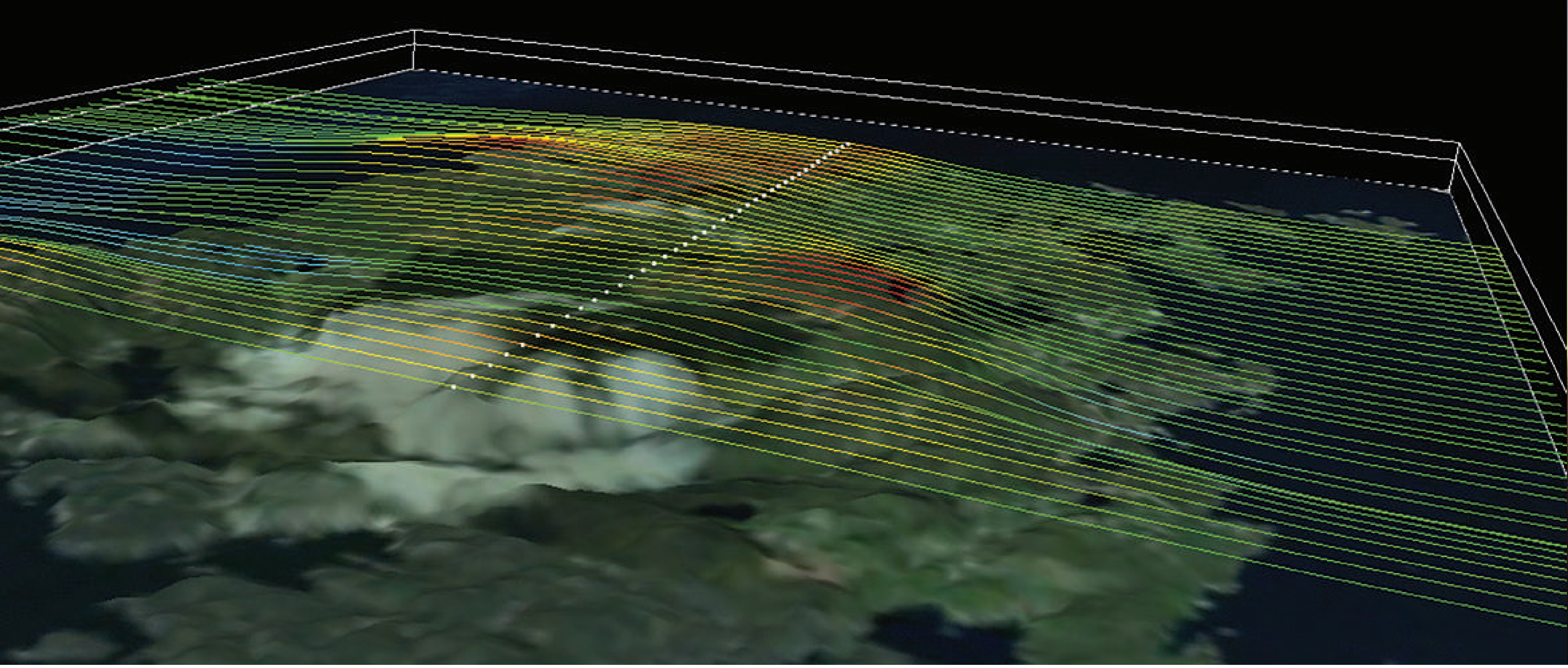
As owner's engineer we prepare tender documents for design and for supply of all project components: micro-siting of wind turbines, roads, foundations, substations, electrical network and overhead lines. Furthermore, our specialists in commercial conditions provide advice on contract formats, structuring of guarantees, etc. During the construction phase we can among others review the supplier's design, and check if the proposed health and safety measures comply with best industry practice. 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 defect's remediation period. Managing contractors and suppliers can be part of our assignment, and we can assist in all aspects of project development, execution and completion.

As lender's engineer for development agencies, institutional investors and financial institutions we emphasise the interests of the investor and keep focus on the viability of the investment.

SELECTED REFERENCES

- Asian Development Bank – Mannar 100 MW wind farm, Sri Lanka Assistance with the EPC contract for the supply and construction.
- 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, Kenya.
- Korea Electric Power Corporation – Fujeij 90 MW wind farm. Project management, planning and construction supervision, design review and technical assistance during the defect liability period, Jordan.

DESIGN BASIS



SELECTED REFERENCES

- 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, 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 RESOURCE MEASUREMENTS

High quality wind resource measurements are crucial when developing wind power projects. Therefore, we start identifying of the best location for the met mast to optimize the site-specific wind resource measurement, and determine the optimal met mast instrumentation.

COWI has installed and monitored met masts in climates from the cold climates of Norway, to the warm climates in the Kingdom of Saudi Arabia, and from Latvia and to the complex terrain in Bosnia. We have provided wind data measurement and analysis either by renting or procuring all kind of masts with or without measuring equipment. In addition to traditional wind resource measurements from met masts, COWI also offers remote sensing measurements with Lidar.

The offshore wind resource has traditionally 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 installed and tested in recent years.

Along with the measurements come comprehensive documentation and reporting in accordance with the Measnet recommendations. COWI is actually co-founding member of Measnet, the international network for harmonised and recognised measurements in wind energy and is one of the few companies accredited for IEC 61400-003 and Measnet quality measurements.

WIND STUDIES

In both onshore and offshore wind projects the impact of wind on the design must be thoroughly uderstood. We offer both first-hand assessment for financing and second opinions for due diligence.

The wind studies comprise:

- Screening and analyses of wind data,
- Wind resource assessments,
- Micro-siting of turbines
- Annual energy production (AEP) calculations.

The AEP calculations use 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. For offshore projects, we use the FUGA wake loss model.

As a least-cost alternative, COWI has developed a mesoscale-based approach to establish wind data for offshore wind farm sites. The mesoscale model is validated against existing met mast measurements from the mesoscale domain area, located both onshore and offshore. 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. 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 bankable wind resource assessments.

SELECTED REFERENCES

- European Commission – Study for the Baltic Offshore Wind Energy Cooperation initiative.
- 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.
- 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.
- 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.

SITE CONDITIONS AND WTG SUITABILITY

In addition to wind studies, we carry out site condition studies in accordance with IEC 61400-1 Ed. 3. We assess the following elements:

- Extreme wind conditions
- Ambient and effective turbulence in order to assess the wind class throughout the site
- Design load drivers such as inflow angles and wind shear
- Risk of lightning
- Probability of earthquake
- Estimation of seismic ground acceleration.

Once the elements have been assessed, the optimum wind turbine class can be selected in particular the optimal rotor diameter ratio in order to extract as much energy as possible from a given site.

In extreme climatic conditions the suitability of a wind turbine for the specific conditions is extremely important. In cold climates ice formation on turbines and its consequence for energy production is assessed as well as 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 optimal wind turbine.

SELECTED REFERENCES

- 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 – Vlašic 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.

AEROELASTIC LOADS ANALYSIS SERVICES

Modern offshore wind farms are feats of engineering with sophisticated support able to withstand wind and wave forces. Accurate determination of wind loads is essential to the efficient and safe design of foundations that can withstand decades of wind and wave action at sea.

We use state-of-the-art aeroelastic computer software, e.g. Bladed and Flex5, to perform comprehensive loads and structural response analysis of support structures for offshore wind turbines according to IEC standards. Using software that incorporates turbine and foundation components into one integrated model, COWI can handle not only the entire structural design, aerodynamics, and hydrodynamics but also wind turbine controller and soil behavior as a whole. This allows a precise determination of loads and responses throughout the support structure that captures all the relevant parameters for each of the tens of thousands of combinations of environmental loads the turbines will be exposed to during their lifetime.

The aeroelastic software is also used for optimizing support structures to extend their operating life. Based on the original design and the actual site and operational conditions and combining operational data with aeroelastic modeling, COWI's specialists can accurately determine the accumulated fatigue in foundations and components in operation. This information, together with O&M strategies, onsite inspections, and financial modeling, lets us provide a 360 degree view of the feasibility and benefits of lifetime extension projects.

SELECTED REFERENCES

- 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 measure-ments", 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 ifinancial bid to the Danish Energy Agency, Denmark.

SELECTED REFERENCES

- Analysis of metocean conditions including wind, waves, currents and water levels and preparation of the preliminary design basis for the gravity based foundation for the Storgrundet offshore wind farm located in Swedish territorial waters in the southern part of the Gulf of Bothnia. For the given site three layouts of turbine positions, comprising 46, 56 and 70 wind turbine generators located in water depths from 10.5 m to 27.5 m are envisaged with 3 MW to 5 MW wind turbines.
- Metocean study for the offshore wind farm ARCADIS Ost 1 in Germany included salinity, temperature, density, seasonal variations, wind, wave, water level time series, misalignment plots and extreme analysis.
- As metocean consultant carried out the meteorological and oceanographic studies for six locations in Denmark.
- Metocean study and preliminary design basis for Suurhiekka Offshore Wind Farm in Finland.

METOCEAN STUDIES

COWI offers the full suite of metocean studies for offshore wind developments and gathers the required site-specific meteorological and oceanograpic data. Furthermore, we evaluate the effets of expected climate changes (e.g. sea level rise due to global warming) as part of the metocean study. Our services include:

- Analysing meteorological and oceanographical data.
- We apply the DHI MIKE hydrodynamic modelling suite to model waves, current and water levels – a key part of the metocean study.

We use MIKE21 SW to model wave conditions, typically for durations of 10 to 20 years to allow a full statistical analysis of design conditions. Normal and extreme current speed, as well as tidal levels and storm surges, are derived from the hydrodynamic modelling MIKE21 HD for periods covering a full year and selected storm events.

As the second major part of the metocean study, carrying out statistical analysis. This includes extreme statistics, scatter tables and joint probability analysis directly applicable to the load cases of the IEC 61400-3 standard.

We apply time and spatially distributed wind and pressure fields for forcing of the models. Wave boundary conditions are collected from regional/global wave models and model bathymetry is derived from the global sea chart database, MIKE C-MAP, combined with site specific surveys.

Combining this data allows us to carry out metocean studies for any site, typically within three months from receipt of client-specific data.

DUE DILIGENCE

In due diligence of wind power projects, COWI identifies and assesses all technical, environmental and financial issues. The core of our due diligence services is to assess various uncertainties 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 diligence for numerous commercial and multilateral development banks and financial institutions, development agencies, and investors, among others Pension Danmark, BNP Paribas, Nordea, and Arctas Capital Group, Danida, International Finance Corporation (IFC), Asian Development Bank (ADB) and European Investment Bank (EIB).

SELECTED REFERENCES

- 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 confdential – Portfolio of onshore wind turbines. Technical due diligence of a portfolio of onshore wind turbines with a combined capacity of nearly 200 MW, Denmark.

DESIGN

SELECTED REFERENCES

- Aarsleff – Bilfinger- Berger Joint Venture – Rødsand II, detailed design of 90 gravity based foundations, Denmark.
- Balfour Beatty Civil Engineering – Foundation pile ground design for 24 WTG foundations, UK
- Brockloch Rig Wind Farm Limited – Detailed design of turbine foundations, UK.
- Stenger & Ibsen Construction A/S – Vardafjellet – Foundation design and detailed design of gravity-based foundation on rock for an onshore wind turbine, Norway.
- Swancor Enterprise Inc – Formosa I and II Detailed design of 20 monopile foundations, Taiwan.
- Iberdrola Renovables – Wikinger, detailed design of 70 jacket foundations, Germany.

ALL TYPES OF FOUNDATIONS

COWI develops the foundation designs from the initial conceptual stages when the optimal foundation type is determined, through to the detailed design phase to the supervision and monitoring of the installed and completed structures. COWI has undertaken detailed designs of monopile, jacket and gravity based foundations for numerous contractors and developers worldwide. Not to forget design and development of all other variants of gravity based, piled, hybrid and rock-anchored foundations.

Optimizing the design of foundations requires being fully acquainted with the wind climate, soil conditions, turbine loads and structural design potential. For instance geotechnics, COWI is a frontrunner in innovative geotechnical design having developed fast and reliable software to push the boundaries of geotechnical design. Soil responses, stiffness and strength evaluations drive the optimisation of structures for installation and operation, and we support the analysis using our extensive knowledge database from projects all over the world.

Foundation design is to provide the client with the optimal design in terms of feasibility, cost and robustness.

ROADS FOR WIND FARMS

COWI has an understanding of where wind turbine generator (WTG) components can and cannot be delivered, in some cases unlocking a site for development and in other cases saving developers from the risk of problematic deliveries. For instance the UK landscape presents severe challenges to delivery vehicles. Then we aim at working alongside specialist hauliers and WTG manufacturers to get the most out of delivery routes, tracks and entrances, sometimes going far beyond the limits of the WTG manufacturer's standard specification, to produce inherently low risk designs.

SELECTED REFERENCES

- Sørfjorden – Review of road design for wind farm with SGRE turbines, Norway.
- Arcus Renewable Energy Consulting Ltd. – Carland Cross wind farm, 20 MW. Geotechnical engineering design, feasibility study, UK.
- Arcus Renewable Energy Consulting Ltd. – Ashmark Hill wind farm. EIA and planning, geotechnical desk study and conceptual infrastructure design, UK.
- Balfour Beatty – Keadby wind farm, 34 foundations, design of highway bridge, site track and hard standing design on soft ground, foundation design, UK.
- Brockloch Rig wind farmlimited – Wind standard II wind farm. Detailed design of foundation and site supervision, access bridge design and building design, UK.

OFFSHORE SUBSTATIONS AND ELECTRICAL SERVICES

The output cables from the turbines are linked to an offshore transformer station called a substation from where a high voltage cable leads to the power ashore.

The entire structure and all low voltage installations are designed in 3D, ensuring full coordination with all other disciplines and with special focus on accessibility, clash check and requirements for safe operation of the facility.

Our design team works in close collaboration with all project stakeholders to ensure that the design satisfies the requirements.

ELECTRICAL SERVICES

Providing electrical services for onshore and offshore wind farm projects, requires up to date knowledge with the latest developments in technology and technical requirements to the electrical components. We therefore ensure you a design in compliance with the latest standards and regulations.

Our electrical services cover:

› Array and export cable systems
› Onshore cable connection
› Onshore and offshore substations
› Power system integration.

SELECTED REFERENCES

› Vineyard Wind LLC – Technical assistance for developer's construction of power system infrastructure in respect to a 800 MW offshore wind farm, USA.
› ONG 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.
› Petro Green Energy Corporation – Nabas 50 MV onshore windfarm. Conceptual design of the power systems interconnecting the wind turbines with a utilty substation, Philippines.

HSE AND RISK ASSESSMENT

As part of our project execution an HSE management system will outline a health and safety action plan – a living document that is maintained and revised during the project to ensure that HSE considerations are a part of all project phases.

Furthermore, the HSE management system will describe targets and the basis of the HSE ambitions during design, execution and maintenance, including organisation, communication, distribution of work and responsibilities.

An HSE manager will be appointed to coordinate the project HSE activities.

Design risk workshops are conducted with various design groups, and designers will work together to point out parts of the project that need specific focus.

The design risk assessment will be documented in a design risk matrix.

The hierarchy of mitigation principles, as stated in EU Directive 89/391/EEC, will be used as a basis of mapping risks.

Execution of the issues listed in the DRA matrix are monitored regularly by the HSE manager and finally in each phase in combination with the HSE check of the design.

The HSE manager liaises with designers to carry out HSE design check of selected design documents, assessed to be significant in relation to HSE performance. The purpose is to follow up and check that HSE measures are properly integrated in the design and that the design is consistent with the objectives and success criteria for the project and with requirements of applicable occupational health and safety legislation.

EXAMPLES OF RELEVANT FOCUS AREAS FOR THE WIND FARM PROJECTS:

- Boat landing/access
- Rest platforms and other platforms
- Fall from height incl. fall arrest system
- Hazardous/toxic gasses
- Transportation and handling of heavy elements
- Evacuation and rescue.

PROJECT FOLLOW-UP

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 warranted power curves. The warranted power curve is the starting point for selecting a specific turbine and is a central parameter in determining the financial viability of the project. An accredited measurement of the power curve after installation of the turbine proves whether the turbine conforms to the warranty issued by the manufacturer.

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

COWI owns a range of masts and have an in-house laboratory for calibrating measurement instruments.

SELECTED REFERENCES

- Siemens Wind Power – Site calibrations and power curve verifcation. Stamåsen, Björkhöden, Mörttjärnberget, Ögonfägnaden, 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.

SELECTED REFERENCES

- Formosa – Integrated load analysis jacket structure with COWI generic model of SGRE turbines, Taiwan.
- Smøla I and II – Statkraft, Modelling of Siemens turbines for lifetime extension evaluation, Sweden.
- Ørsted – Installation of measurement systems Borkum and Race Bank, UK.
- Marubeni Corporation – Wind measurements for senor installation, data collection and handling. 35 MW wind farm at Aomori, Japan.
- DONG Energy – Westermost Rough Offshore Wind Farm. Strain gauge installation on a monopile foundation for a 6 MW turbine, United Kingdom.

MEASUREMENTS AND AEROELASTIC CALCULATIONS ON TURBINES

We provide services to manufacturers in assessing their wind turbine design and sub-elements with respect to strength, lifetime, dynamic behaviour, etc. This results in load measurements and load calculations comparing and verifying calculated and measured loads as required for certification and/or calibration of load modelling software.

The measurements comply with the requirements for a type test needed for the approval of wind turbines including power curve, structural loads, functional and safety tests, and noise. Power Curve verifications according IEC 61400-12 tests are accredited by DANAK and IECRE.

The calculations include full set of design loads using recognized aeroelastic software (FLEX/BLADED) according to IEC standards.

COWI provides with inhouse generic turbine models (any size) and calculations based on actual turbine designs using encrypted models in agreement with turbine manufacturers. COWI performs design calculations of all turbine sub-elements, e.g. blades, steel parts and concrete towers using detailed FE analysis.

COWI provides all necessary design documentation for type approval of wind turbines requested by certification institutions.

The accredited measurements will include:

- Power curve verification
- Site calibration
- Load measurements (non accredited but according to COWI Quality Handbook)
- Noise (non accredited but according to COWI Quality Handbook).

Determination of mechanical properties:

- Measurement of yaw efficiency
- Determination of natural frequencies
- Turbine operational conditions
- Wave loads
- Functional and safety test.

The calculation services include:

- Aeroelastic load calculations (FLEX and BLADED)
- Strength calculation of turbine components, including FEM calculations (SESAM, ANSYS, IBDAS a.o).

SELECTED REFERENCES

- 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.

Developing a wind farm starts by defining a basis and establishing a process whereby a concept is incrementally developed towards an actual project. We take part from the very beginning and use our experience to add value to the process while reducing risks – all the way from concept to operation, through lifetime extension to decommissioning.

www.cowi.com/tags/wind-energy

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POWERING YOUR 360° SOLUTIONS
COWI is a leading consulting group that creates value for customers, people and society through our unique 360° approach. Based on our world-class competencies within engineering, economics and environmental science, we tackle challenges from many vantage points to create coherent solutions for our customers – and thereby sustainable and coherent societies in the world.