Reliability and precision of modelling are key to the success of a project. This applies for the wind resource and wind energy yield, as well as for wave and current data when it comes to foundation design.

The highest quality standards in wind measurements and wind modelling are ensured by our accreditation in accordance to DIN EN/ISO/IEC 17025:2005, 25 years of experience and strict compliance with German Technical Guideline 6 (FGW), and where applicable, MEASNET and IEC standards. Our active participation in guideline committees and R&D projects enables us to define which is state-of-the-art within wind resource modelling - proven in close to 4,000 energy yield assessments so far. Our wind measurements and energy yield assessments are a solid base for your investment decisions, worldwide.

Wind, waves, water levels and currents are the main environmental factors subject of Metocean studies, and prerequisites for the successful and optimised structural design of any offshore project. Our excellence in Metocean studies is one of the reasons why we are world leading in offshore wind foundation designs. Our many years of experience in offshore wind foundation design combined with having wind consultants, Metocean and steel designers under the same roof, make a shorter line for communication. This leads to more efficient workflows and ensures a mutual understanding of the data requirements for each design stage resulting in a smooth and best-in-class design progress.

**Wind measurements**

Based on hundreds of analysed mast measurements and more than 100 LiDAR measurement campaigns, we provide our clients with a unique expertise, covering sophisticated and efficient measurement concepts, support in procurement of measurement hardware or provision of complete high-quality mast measurement and/or LiDAR systems ensuring lowest data uncertainty. Our in-house measurement monitoring system enables a 24/7 monitoring of any kind of measurements and achieving up to 99% of technical data availability. Our dedicated measurement experts provide our client with precisely the level of support required, from certifying IEC compliance of measurement stations to advanced data analysis and modelling.

**Energy yield assessments and wind farm layout**

Whether simple or highly complex sites, we provide the full range of wind resource modelling: wind resource maps for site identification, preliminary energy yield estimations, turbulence and site compliance studies and bankable energy yield assessments based on reference turbine masts, LiDAR or SoDAR measurements. Ramboll combines perfection in gross energy yield modelling with precision in net energy definition by our unique time series based loss modelling. We apply several state-of-the-art software and simulation models, choosing the most appropriate(s) (WAsP, CFD, WindPro) according to the site-specific conditions. Due to our combined expertise in resource modelling and project development, design and permitting, we provide our clients with optimised and the most competitive wind farm layouts.
Performance analysis
There are many reasons as to why a project might be underperforming, and manifold possibilities to identify the underlying cause. At Ramboll we have developed a 3-staged, cost optimised approach, allowing to identify/exclude the most frequent reason for underperformance (stage I and II) with limited efforts:

I) Analysing production data in comparison to previous energy yield assessments
II) Advanced performance and loss analyses on basis of 10 min SCADA data
III) Performance measurements with nacelle based LiDAR

A temporary wind measurement with nacelle-based LiDAR is an efficient way to verify the power curve of wind turbines and detect yaw misalignment; however it allows us to detect and visualise the wakes and turbulence intensity and thus to fine-tune and optimise operation of major wind farms and/or projects on complex sites. Ramboll’s performance optimisation analysis provides detailed recommendations for specific improvement measures. The subsequent adjustment of the turbine’s integrated sensors and amendment of control settings, increases the yields considerably and reduces the operational loads on the components, thereby extending the turbine’s lifetime.

Our experience with waves
Ramboll carries out Metocean studies, ranging from fast and simple site assessments for preliminary foundation design or feasibility studies to numerical modelling studies and hurricane assessments for detailed structure design. Field data is rarely available, hence data selection from highly experienced data-suppliers, numerical modelling and calibration with local measurements provide a good compromise. For the data analysis, Ramboll makes use of the recognised DHI Mike package and in-house software.

Metocean assessment
Offshore wind turbine foundations are sensitive to loads at the sea surface. In order to provide reliable assessments and site selection, Ramboll established a numerical model, driven by global boundary data calibrated with local field measurements. Boundary wave data is provided from state-of-the-art global numerical models by highly experienced data suppliers. Project-specific requirements, such as geographical locations and data resolution, are considered carefully so the most suitable product can be chosen. Ramboll sets up numerical models covering spectral and Boussinesq wave modelling and flow modelling. Based on the obtained wind, wave and water level time series, statistical analysis are carried out to provide extreme and operational values for the foundation design.

BINHAI NORTH PHASE 2
FULL-BLOWN METOCEAN STUDY
CLIENT
Powerchina Huadong Engineering
LOCATION
Yellow Sea, China
PERIOD
2016
SERVICE PROVIDED
A complete Metocean report including numerical modelling and post-processing.

HOLANDSE KUST ZUID – ENERGY YIELD ASSESSMENT
CLIENT
Shell International Exploration BV
LOCATION
North Sea, Netherlands
PERIOD
2017
SERVICE PROVIDED
Full bankable energy yield assessment including layout optimisation.

WIND FARM PROJECT BAD HERSFELD PERFORMANCE OPTIMISATION ANALYSIS
CLIENT
Stadtwerke Stuttgart
LOCATION
Bad Hersfeld, Germany
PERIOD
2016
SERVICE PROVIDED
Power curve measurement campaign, wind and operational data analysis (SCADA), identification of performance optimisation tasks.