

A photograph of an offshore wind farm in the ocean. Several wind turbines are visible, with their blades extending into the sky. The water is a deep blue-grey color. In the foreground, a large blue rectangular box contains white text. To the right, a portion of a crane or construction rig is visible, extending from the edge of the frame into the water.

MITIGATING THE RISK IN WIND POWER

RISK ANALYSES IN WIND POWER
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MANAGING THE RISKS IN WIND POWER

THE DEPARTMENT OF RISK AND SAFETY IN RAMBOLL SPECIALIZES IN ALL ASPECTS OF RISK MANAGEMENT IN WIND PROJECTS

Projects related to wind farms and wind turbines are very complex and all aspects of wind projects are associated with risks. Ramboll has great experience in evaluation and management of risks during wind projects and offers different kinds of analyses.

Technical financial risk

Ramboll has developed a set of probabilistic models to give a complete, but simple overview of wind projects, to large benefit for politicians, authorities, developers, investors and power companies. A hazard identification is carried out based on basic project information. The result of this is used for a financial model set-up with modelling of the uncertain parameters. The risk results are achieved through Monte Carlo simulations, which give probability distributions of e.g. NPV and IRR. Further, the simulations reveal which parameters are the most important for the economics of the wind farm project (Tornado graph).

Marine safety

The marine safety analyses focuses on both the navigational safety of the shipping traffic and on the structural safety of the wind farm structures.

In relation to the authority requirements Ramboll has great experience in performing Formal Safety Assessments (FSA) according to IMO guidelines involving e.g. hazard identification, risk assessment, risk control options and cost-benefit analyses.

Marine safety analyses with focus on structural safety are used both in connection with design loads for structural analyses of wind farms and in connection with geotechnical calculations of wind farms.

Availability and reliability

Ramboll carries out analyses regarding Reliability, Availability, Maintenance and Safety (so called RAMS analyses). The RAM part is related to the daily operation and

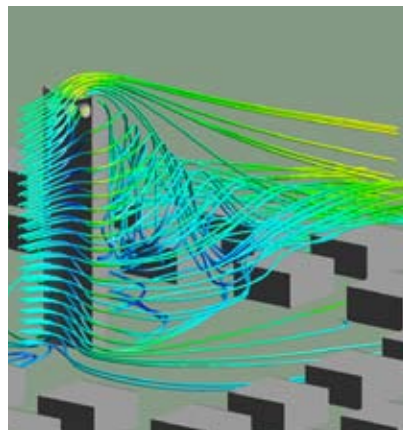
efficiency of the system whereas the S (Safety) part concerns requirements to failure rates in order to minimise critical dangerous system errors.

The availability of the entire system is dependent on the availability of system components and subsystems. These availabilities depend on e.g.:

- Component failure rates
- Component down times
- Sub system redundancies
- Human errors during operation
- Maintenance intervals
- Availability of external systems (utilities)

Computational fluid dynamic (CFD)

Ramboll provides consultancy services in CFD modelling related to wind power engineering. CFD can be used for detailed modelling of the aerodynamic performance of wind turbines as well as complete modelling of the interactions between turbines and their surrounding environment.



Visualization of CFD results showing the very complex flow patterns around a high rise building. The three circular openings at the top of the building will each house one wind turbine and CFD simulations have been used to determine their performance at these unusual operating conditions.

Prediction of wind flow around buildings and terrain enables optimum positioning of wind farms or of openings in building envelopes with respect to separation and vortex shedding. The wind forces on the building structures can be assessed and the interaction can be coupled to structural simulation (Fluid Structural Interaction), enabling improved structural design and fatigue prediction.

Project risk management

The evaluation and management of risks during the construction and implementation phases includes a systematic identification and assessment of hazards that may lead to risks of:

- Quality - project objectives not met
- Project delays
- Additional costs
- Human safety
- Environmental impact

The aim of the risk assessment is to identify, assess and reduce. An identification of the overall hazards is followed by an estimation of potential consequences and expected frequencies. The need of risk reducing measures is then assessable on this basis.

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REFERENCES

- LM Glasfiber, wind turbine blades (DK)
- Dubai Lighthouse Tower, building integrated wind turbines (Dubai)
- Castle House, building integrated wind turbines (UK)
- Bahrain World Trade Centre, building integrated wind turbines (Bahrain)
- Walney Offshore Wind Farm (UK)
- Barrow Offshore Wind (UK)
- Long Islad Offshore Wind Park (USA)
- Arklow Bank Wind Park (Ireland)
- Rødsand, Omø, Læsø, Horns Rev and Samsø Offshore Wind Farms (DK)



WHO WE ARE

The Department of Risk and Safety in Ramboll is one of the leading proponents of risk analysis. The references cover a broad range from the development and implementation of overall risk management systems to minor analyses.

The Ramboll Group employs 9.000 ambitious experts. We are a leading knowledge-based company operating in a broad international context from close to 200 offices around the world. We provide engineering, consultancy, project development and operating services within the areas of: Buildings and Design, Infrastructure and Transport, Energy & Climate, Environment & Nature, Industry & Oil/Gas, IT & Telecom, Management & Society.



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