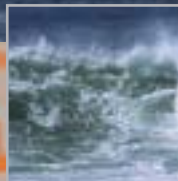


# Offshore Renewables

Harnessing the energy at sea



Habitat impact



Metocean conditions



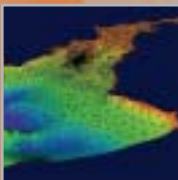
Model testing



Environmental impact



Survey and monitoring



Forecasting



Energy resources



DHI is an independent, international consulting and research organisation represented in all regions of the world.

Our objectives are to advance technological development and competence in the fields of water, environment and health. We provide a wide range of solutions within consultancy, policy services and leading edge technologies.

DHI works with governmental agencies and authorities, contractors, consultants and a wide range of industries.



## Offshore renewable energy

Climate change is the most serious environmental challenge which we face today - a challenge with a direct impact on social, economic and ecological issues.

Adaptation or successful mitigation of the potential impacts of global climate change – on species, habitats and biodiversity, as well as on people and their livelihoods – requires sustainable solutions.

Technologies, which provide renewable energy, attract increased interest from industry and governments as a way to cope with climate change. In many places large wind farms have already been erected and the offshore wind industry plans to increase the number of installations significantly within the next decade.

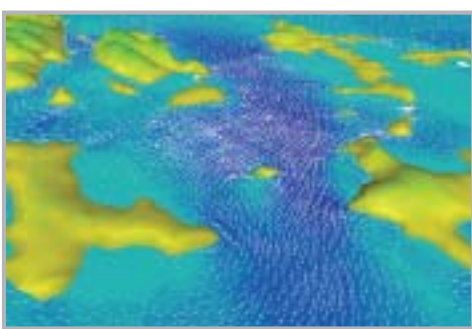
Prototypes and small scale testing facilities, which can exploit wave energy or tidal current, are under development worldwide. A development which ultimately will pave the way for future commercial power production from these inexhaustible resources.

DHI contributes to the development of offshore wind farms and marine renewable energy installations worldwide. We have more than fifteen years of experience as a provider of integrated services within this field. This experience knowledge is turned into solutions for our clients.

**At DHI we are committed to provide customised solutions - solutions which make a real difference. We do this based on our proven methods and technology – and in close collaboration with our clients.**



## Wind, waves, current, sediments



### Planning and design phase

- Strategic marine spatial planning
- Strategic environmental assessment
- Feasibility studies
- Environmental baseline investigations
- Environmental impact assessments
- Metocean design data
- Scour protection optimisation
- Hydrodynamic loads and motions
- Applications for environmental clearance/licences

### Construction phase

- Operational hydrographic water forecasting for construction and navigation
- Optimisation of installation procedures
- Environmental management and monitoring of marine construction

### Operational/maintenance phase

- Hydrographic water forecasting
- Decision support systems
- Environmental monitoring

### Decommissioning phase

- Operational hydrographic water forecasts for dismantling and navigation
- Optimisation of removal procedures
- Environmental management and monitoring of operations

Offshore wind farms and marine installations are exposed to a harsh environment. A thorough understanding of the metocean conditions enables qualified decisions on structural design and project feasibility to be made. This understanding is also central in establishing the implications, which man-made constructions may have on the surroundings.

### Design tools

A detailed understanding of the design conditions and criteria is crucial in any successful development. DHI has therefore developed standards and tools to optimise the design, ensure safe construction, operation and maintenance of fixed or floating structures at sea.

At DHI we provide high quality solutions to the challenges in close collaboration with planners, designers and operators. These solutions are based on a combination of field data collection, numerical modelling and physical model tests.

### Metocean data

The provision of high quality metocean data is fundamental for the success of marine projects. Metocean services are based on numerical models developed by DHI. The numerical modelling – be it in forecast, nowcast or hindcast mode – is often supplemented by online and offline measurements made by our experienced surveyors and data analysts. Other data sources, for example from satellites or radars, can be incorporated to further enhance quality and resolution.

### Survey and monitoring

We carry out surveys and establish short term or long term monitoring systems of physical, chemical or biological parameters. The surveys provide essential input for subsequent studies such as planning, design, EIA or environmental clearance. Furthermore, the monitoring systems offer valuable support in the management of construction impacts and in the day to day operation of the project.

### Seabed and coast

Installations at sea are often subjected to the risk of seabed scour and therefore require adequate protection and control. Both numerical modelling and physical model tests are used to simulate the installations in their environment. This ensures reliable identification of design or mitigation measures to address the scour risk.



Offshore installations may also have an influence on the surroundings. Coastal erosion, sedimentation and changes in sediment pathways may have significant impact on the environment, navigation and coastal infrastructure. Changes in flow from estuaries and salinity may result in increased flooding risk and habitat stress.



## and the environment

In the last decade, the massive development of offshore wind farms has provided substantial knowledge with regard to the potential impacts of marine facilities on species and habitats. This knowledge has changed the scope of environmental impact assessment from a broad scaled approach to a more focused investigation strategy. Particularly birds and marine mammals are vulnerable to the construction and operational phase of offshore wind farms. Most likely this will also apply to other marine renewable energy installations.

Today, it is generally accepted that habitat modelling is a reliable and cost-effective approach, which supplements traditional sampling. DHI is a key player in this context by offering state-of-the-art habitat modelling tools as well as traditional habitat monitoring.



### **Marine mammals and construction noise**

DHI has extensive experience with the assessment of habitat displacement of marine mammals due to noise and human intervention during the construction of marine installations.



Assessments are based on a combination of habitat and impact models, in which models of key habitats are linked to detailed investigations of noise-related disturbance. This is done by using in situ measurements together with frequency related impact assessments, which integrate models for attenuation of, for example, pile driving noise and audiograms for cetaceans.

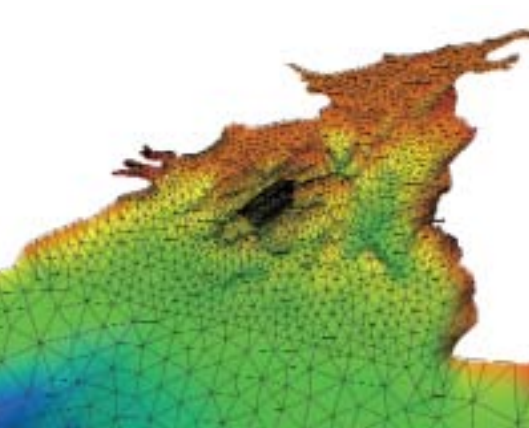
### **Modelling seabirds and habitat exclusion**

Mounting evidence from existing wind farms indicate that disturbance is the main reason for habitat displacement. This has a major impact on seabirds.

The challenge at new development sites is to distinguish between habitat exclusion and natural variation in the local food supply for seabirds and thereby quantify the impact on the birds.

DHI has developed - and successfully applied - an innovative approach to separate habitat exclusion from natural variability. This is done by using a combination of benthos and seabird survey data as well as dynamic habitat models of the carrying capacity of potential prey species.

Advanced radar based surveying techniques for recording bird migration have replaced traditional techniques used for the estimation of offshore wind farm impacts on birds due to barrier effects and collision. Automated detection routines enable 24-hour recordings of bird movements, which give a more reliable basis for the accurate quantification of the associated impacts.



### Thornton Bank Offshore Wind Farm, Belgium

One of the major hydrodynamic challenges for offshore wind farms is the impact of large breaking waves in complex and harsh environments. DHI is one of the CFD (computational fluid dynamics) pioneers within calculation of wave forces and run-up heights. DHI also provided added value to this project on optimisation of safe transportation and installation of the large gravity based foundations (GBF) through physical model tests of the dynamic response of GBF and the heavy-lift barge RAMBIZ.



### Horns Rev Offshore Wind Farms, Denmark

The Horns Rev complex with its 171 turbines is one of the largest renewable energy production areas in Denmark. This location is also an important resting and feeding area for the sea bird, Common Scooter, on the route of the western flyways. Furthermore, it holds a dense population of harbour porpoises. With its habitat modelling and advanced radar surveys, DHI has been able to provide reliable and cost-effective baseline surveys and biodiversity impact assessment as part of the Environmental Impact Assessment.

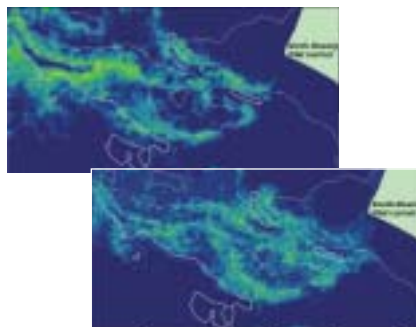
### Robin Rigg Offshore Wind Farm, UK

DHI's comprehensive expertise and experience in metocean and seabed changes in relation to offshore wind farms has supported the installation of one of the largest of its kind in the world. Our knowledge of current, water level, waves and seabed changes - obtained using a combination of field measurements, physical model testing and advanced numerical modelling - was successfully transferred in hindcast, nowcast and forecast mode to the client.



### Rødsand Offshore Wind Farms, Denmark

Two major wind farms have been established close to barrier islands, which protect the shallow 250 km<sup>2</sup> Rødsand Lagoon from the Baltic Sea. The sandy barrier islands are active morphological features. The slight damping of the waves behind the wind turbines and the effect on the littoral drift was quantified by DHI's wave, sediment transport and morphological models as part of an extensive Environmental Impact Assessment.



## Selected recent projects

*Thornton Bank Offshore Wind Farm, Belgium.* Calculation of wave forces on GBF foundations. International Marine & Dredging Consultants, Belgium. 2008.

*Environmental Impact Assessment for Tidal Power Generation, Singapore.* Atlantis Resources Corporation, Singapore. 2008.

*Robin Rigg Offshore Wind Farm, UK.* Scour analysis, physical model tests, field measurements and operational metocean forecast services. MT Højgaard, Denmark. 2008.

*Thornton Bank Offshore Wind Farm, Belgium.* Model tests on installation of GBF foundations. Dredging International, Belgium. 2008.

*Tidal Flow and Wave Modelling, Orkney Islands, UK.* Model setup, analysis and technology transfer. European Marine Energy Centre (EMEC) Ltd, UK. 2008.

*Rødsand 2 Offshore Wind Farm, Denmark.* Loads on gravity based wind turbine foundations and monopiles. E.ON, Sweden. 2008.

*Modelling of Wave Load and Motions for a Wave Energy Converter.* Floating Power Plant A/S, Denmark. 2008.

*BALTIC 1 Offshore Wind Park, Germany.* Scour assessment. Offshore Ostsee Wind AG, Germany. 2008.

*Sprogø Offshore Wind Farm, Denmark.* Metocean conditions, environmental impact assessment, macro vegetation, bottom fauna, fish and water quality. Sund & Bælt A/S, Denmark. 2008.

*DanTysk Offshore Wind Farm, Germany.* Metocean operational forecast. Vattenfall Europe New Energy, Germany. 2008.

*DanTysk Offshore Wind Farm, Germany.* Metocean design data. Vattenfall Europe New Energy, Germany. 2008.

*Baltic 1 Offshore Wind Farm, Germany.* Assessment of scour and scour protection. Offshore Ostsee Wind AG, Germany. 2008.

*Resource Planning for Tidal Power Generation in Singapore and Asia Pacific.* Atlantis Resources Corporation, Singapore. 2007-2008.

*Sandbank 24 Offshore Windfarm, Germany.* Metocean design data. Hochtief Construction AG, Germany. 2007.

*London Array Offshore Wind Farm, UK.* Study of wave kinematics using CFD. London Array Ltd, UK. 2007.

*Borkum Riffgrund West Offshore Wind Farm, Germany.* Metocean design data. Energiekontor AG, Germany. 2007.

*Rødsand 2 Offshore Wind Farm, Denmark.* Statistical evaluation of bird impacts. DONG Energy A/S, Denmark. 2007.

*Lillgrund Offshore Wind Farm, Sweden.* Monitoring of currents and waves. Vattenfall, Sweden. 2006-2007.

*Horns Rev 2 Offshore Wind Farm, Denmark.* Metocean conditions and environmental impact assessment. DONG Energy A/S, Denmark. 2005-2006.

*Burbo Bank Offshore Wind Farm, UK.* Operational forecast for marine operations and monitoring of current and waves. DONG Energy A/S, Denmark. 2006-





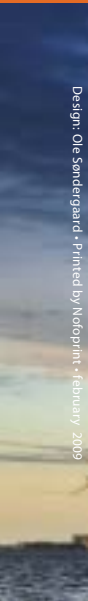
## DHI OFFICES AROUND THE WORLD

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- Romania
- Singapore
- Slovak Republic
- South Africa
- Spain
- Sweden
- Thailand
- Turkey
- Vietnam
- UK
- United Arab Emirates
- USA

Courtesy: EMEC

Our extensive experience and knowledge allows us to provide quantifications and innovative solutions to challenges faced by developers and operators of offshore renewable energy facilities.

We believe that close collaboration with our clients, technology and knowledge transfer as well as multidisciplinary expert teams are key parameters in ensuring the highest value for our clients on time and at cost.



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