AGENDA

Introduction
- COWI as Design Consultant

Offshore Wind Farms
- Foundation Design - BTM

Offshore Wind
- Processes - Energy & Industry
ABOUT US

COWI IN NUMBERS

- 709 MILLION EUR IN TURNOVER
- MORE THAN 80 YEARS OF HISTORY
- WORKING IN 124 COUNTRIES
- OVER 6,100 EMPLOYEES
- 17,000 ONGOING PROJECTS
OUR SERVICES

360

WORLD-CLASS COMPETENCIES

INDUSTRY AND ENERGY (1000)

BUILDINGS (1000)

RAILWAYS, ROADS AND AIRPORTS (800)

WATER AND ENVIRONMENT (600)

PLANNING AND ECONOMICS (300)

BRIDGE, TUNNEL AND MARINE STRUCTURES (1000)
OUR SERVICES IS DELIVERED IN TWO WAYS

REGIONS
› Denmark
› Sweden
› Norway

INTERNATIONAL BUSINESS LINES
› Tunnels
› Major bridges
› Marine structures
› Airports, roads and railways
› Mapping
COWI projects
Doha metro, Qatar

Design of Doha metro Red Line North

› The Red Line North is the first of four underground packages which is a part of a wide-ranging plan to realize a new transportation infrastructure in Qatar.

› The Red Line North extends over a distance of approximately 13 km from Mushaireb station in the Qatari capital.

› The scope of work includes design of 11.6 km of twin bored tunnels and design of 7 new underground stations.
Salvador - Itaparica bridge, Brazil

Design of the second longest bridge in South America

› The 12 km long Salvador-Itaparica Bridge will connect metropolitan Salvador with the island Itaparica

› Cable stayed bridge with 70 m clearance and a main span of nearly 600 m.
The Blue Planet, Denmark

Client consultancy on Northern Europe's largest aquarium

› With its 9,000 m², the Blue Planet is Northern Europe's largest and most modern aquarium

› The Blue Planet is one of the few aquariums in the world that can show wildlife from all around the world. This is due to the extensive water treatment systems that can deliver hot and cold saltwater as well as freshwater

› The visitors can therefore experience changing organic expressions as they move through the vortex building, with a variety of exotic themed exhibitions.
Oslo International Airport, Norway

COWI in a Joint Venture designs a major expansion of the Oslo International Airport.

› The Gardermoen airport is extending the passenger terminal building, and building a new pier with 19 new aircraft stands, a new taxiway system and a redesign of the forecourt areas.

› The major expansion brings the capacity from 20 to 28 million passengers in the first phase and further.

› The requirement regarding energy consumption is a 50% reduction compared with the existing passenger terminal from 1998.
Marine market segments

- Marine Terminals
- Ports and Harbours
- Coastal Engineering and Waterfront Development
- Offshore Wind Farms
- Cooling Water Systems
- Locks and Dams
COWI's key marine and coastal engineering offices
Our OWF services
Different services

- Hydraulic Studies
- Geotechnical Design & Investigations
- Feasibility Studies
- Design (Feed, Prelim, Basic, Detailed)
- Preparation of Tender Documents
- Construction Supervision
- Construction Management (PMC)
General offshore wind foundation
OFFSHORE WIND FARMS

- London Array offshore wind farm, UK
- Wikinger offshore wind farm, Germany
- Rentel offshore wind farm, Belgium
- Thornton Bank offshore wind farm - phase 1, Belgium
- DanTysk offshore wind farm, Germany
- Horns Rev C, Kriegers Flak A and B, Transformer platforms, Denmark
- Formosa 1 offshore wind farm, Taiwan
- Rødsand 1 and 2 offshore wind farms, Denmark
London Array 630 MW offshore wind farm, UK
London Array 630 MW offshore wind farm, UK
Wikinger 400 MW offshore wind farm, Germany
DanTysk 288 MW offshore wind farm, Germany
Thornton Bank 30 MW offshore wind farm,
Belgium
Kårehamn 48 MW offshore wind farm, Sweden
Rødsand 1&2 372 MW offshore wind farm, Denmark
Horns Rev C, Kriegers Flak A and B, Transformer Platforms, Denmark
XL Monopiles
XL Monopiles

Can thickness vs. Time

D/t ratio vs. Time

Norsok N-004: D/t_{\text{max}} = 120
ISO 19902: D/t_{\text{max}} = 120
DNV OS-J101: D/t_{\text{max}} = 100 (ref to Norsok, EC3, API only)
XL Monopiles

› Upending tool under development by IHC (during Race Bank OWF)
  › Designed for 6.5m MPs, what's next?

Below: Lifting of MPs to shore onto multiwheelers.

Left: RB OWF, Upending tool from IHC developed for Race Bank (OD=6.8m).

Above: RB OWF, Upending tool from IHC developed for Race Bank (OD=6.8m).
Monopiles

Buckling analysis

- DONG asked COWI to investigate whether local shell buckling of MPs during installation (impact driving) was an issue
- Offshore guideline limitations:
  - NORSOK N004: D/t<120
  - ISO19902: D/t≤120
  - EN 1993-1-6: 20≤r/t≤5000
  - (LBA, MNA, GNIA, GMNIA)
Buckling analysis

- Non-linear geometry
- Elastic-perfectly-plastic material behaviour for structural steel
- Non-linear boundary conditions (soil) including viscous damping
- Imperfections explicitly modelled when applying GMNIA method
XL Monopiles
Offshore Foundation Driller (OFD)

under construction by Hochtief GmbH

Key Issues:
- Developed for MPs above OD=7.0m
- Reduction in noise compared to driving

Deeper waters seems to be required due to height of the OFD?

Alternative(upgraded) BSD3000 for soft soils?
Offshore Substations
Horns Rev C – Topside and Jacket (HRC Spin)

- 400 MW OWF
- Beam/Column concept
- External escape routes
- Jacket substructure
- Detailed Design
Kriegers Flak A Topside

▶ 200 MW OWF
▶ Beam/Column concept
▶ External escape routes
▶ Substructure (TBD)
▶ Detailed Design

*Kriegers Flak A Topside*  
*Copyright COWI A/S*
Kriegers Flak B Topside

- 400 MW OWF
- Beam/Column concept
- External escape routes
- Substructure (TBD)
- Detailed Design
Kriegers Flak A and B Substructures (KF_Spin)

- 200/400 MW OWF
- Beam/Column concept
- External escape routes
- Substructure (TBD)
- Basic Design
Rød Sand 2 - Topside

- OWF 200 MW
- Beam/Column concept
- External escape routes
- GBF substructure
- DD
Hohe See Topside and Jacket

- 492 MW OWF
- Beam/Column concept
- External escape routes
- Jacket substructure

Top: Typical elevation

Right: Iso view (ARSA)
Design Process
Design Process

› Objectives:
  › Consistent design
  › Data consistency
  › Reduction of time and resources needed for each location

› Solutions:
  › One central project database – only one reference source
  › CAQ-procedures to support standard QA
  › Automatic generation of input to design software
  › Automatic generation of documentation (design drawings, result sheets, overview maps/tables etc.)
OWF Galloper – Design Process

**Design Process**

**Tools:**

- Perl-scripts for generation of MP drawings
- Perl-scripts for generation of diagrams
- Perl-scripts for generation of result sheets
- Perl-scripts for generation of overview drawings
- Matlab routines for geotechnical checks / generation of p-y-curves

![Database](image1.png)

Perl-script

**Monopile drawing (PDF)**
Example for automatically generated drawing
WHAT IS COWI?

Experience, Reliability, Innovation
OUR VISION

WE WANT TO BE:

› A solution to your problem
› Our partners first choice for assistance
› The most skilled people
› World-class international specialists
› Excellent operations.

We create coherence in tomorrow’s sustainable societies.
Reducing Risk

Experience reduces risk

- Highly experienced people in all key positions with including experience in working with contractors
- Consistent data handling ensures consistent output and reduced time for computation
- Computer Aided QA of information ensures confidence in output, in particular with DB changes
- Automated drawing production reduces time and errors at time-critical project completion
Reliability

High reliability

- Highly experienced staff with broad and relevant working background
- Versatile background of staff with experience from contractors, utility companies and academia
- Company network ensures services within all adjacent areas
- Company set-up framed for large scale projects ensures appropriate processes and monitoring
Innovation

Optimizing design

- Project specific design solutions based on large and versatile experience
- Participation in broad range of innovation projects with multiple different OWF entities
- Flexible and open-minded approach to design – paradigms but no standard solutions
Thank You for your time