Offshore Wind Farms –
The Need for Metocean Data

Vagner Jacobsen and Morten Rugbjerg

DHI Water & Environment

Agern Allé 5, DK-2970 Hørsholm, Denmark

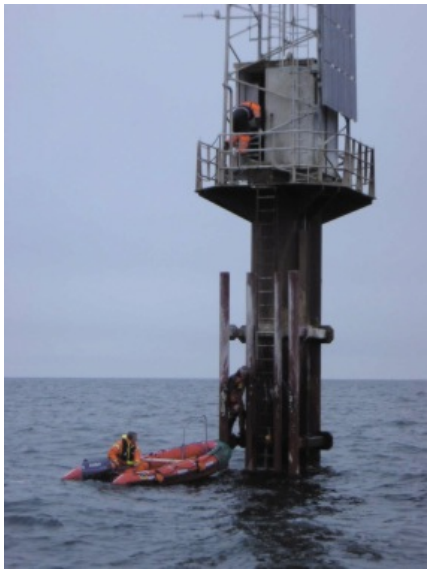
presented by Morten Rugbjerg

Copenhagen Offshore Wind, 26 – 28 October 2005

Background

Wind farms have moved offshore

- Many similarities with traditional oil/gas offshore structures
- Benefit from knowledge about traditional offshore structures
- Same requirements to high quality **met**eorological and **ocean**ographic data



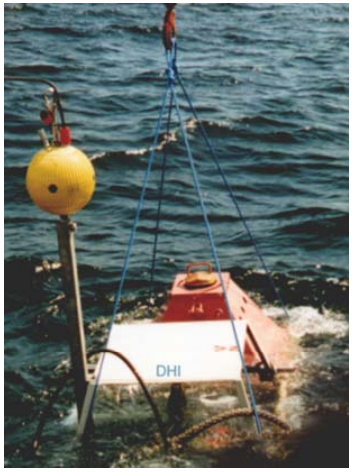
This paper presents

- Methodologies for establishing the **metocean** data basis

Overview

Overview of Presentation

- Metocean data – a definition
- Application areas for metocean data
- Main sources of metocean data
- Measurements and types of sensors
- Hindcast models and types of models
- Tasks in a typical hindcast study
- Design data and operational data
- Examples
- Concluding remarks



Metocean data – a definition

Meteorological parameters

- Wind, atmospheric pressure, air temperature etc.

Oceanographic/hydrographic parameters

- Waves, currents, water levels, salinity, water temperature, ice etc.

This paper

- Oceanographic/hydrographic parameters
- Ice treated differently (not mentioned further)

Application areas for metocean data

Project stages

- Feasibility study (medium quality)
- Final design (high quality)

Project tasks

- Design loads on foundation units
- Design of scour protection
- Fatigue of foundation units
- Installation planning
- Maintenance planning

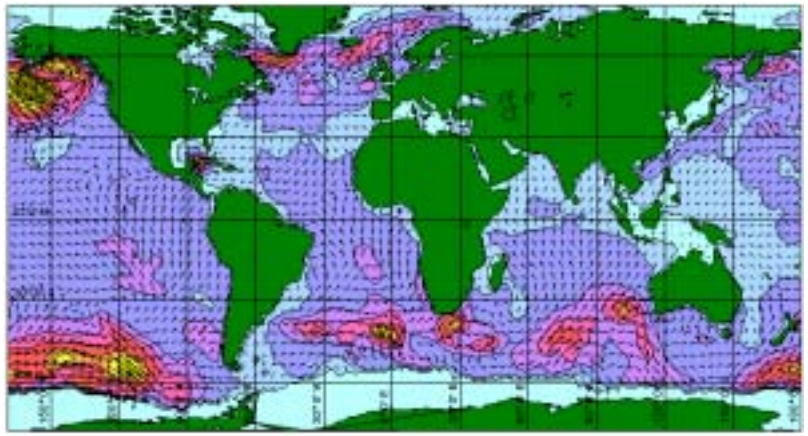
Main sources of metocean data

Metocean data sources

- Measurements
- Numerical model hindcast data

Level of accuracy

- Public data
- Nearby measurements
- “Global” hindcast model data



Measurements and types of sensors

What should be measured?

- Requirements:
  ISO, WMO, API, DNV, NORSOK

Types of sensors

- Waves: ADCP, wave buoy,
  radar, laser, wave staff
- Currents: ADCP,
  current meter (acoustic, electronic)
- Water levels: pressure gauge, step gauge, radar

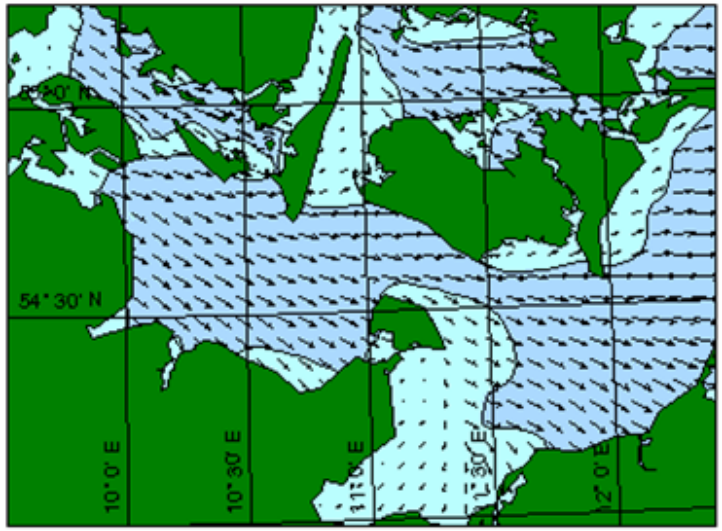
Hindcasts and types of models

What is a hindcast model?

- Simulation of historical metocean data

Types of metocean hindcast models

- Flow/hydrodynamic models
- Wave models
- Examples: MIKE 21 / 3
- Regular / unstructured computational grid
- Can also be used for forecasts



Hindcast flow models

Types of models

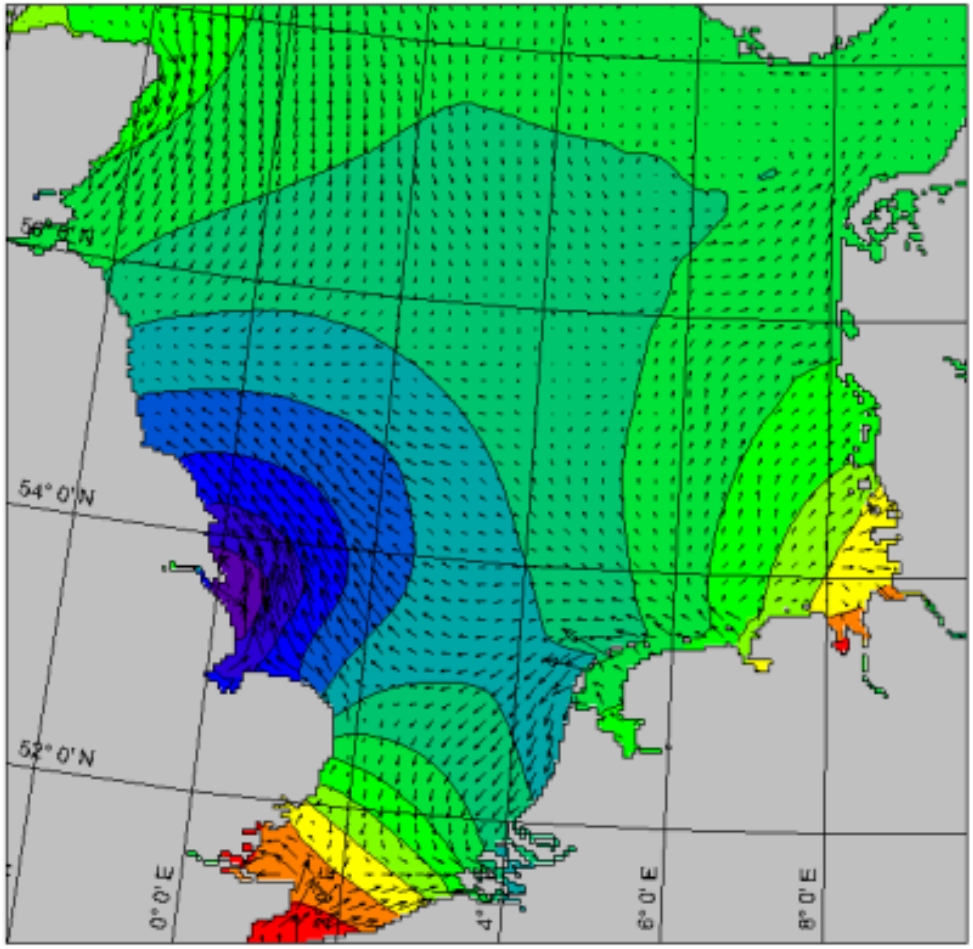
- 2-dimensionel: depth averaged
- 3-dimensionel: depth varying

Input

- Wind, pressure, bathymetry, tide

Output

- Levels, currents, (salinity, density, temperature...)



Hindcast wave models

Types of models

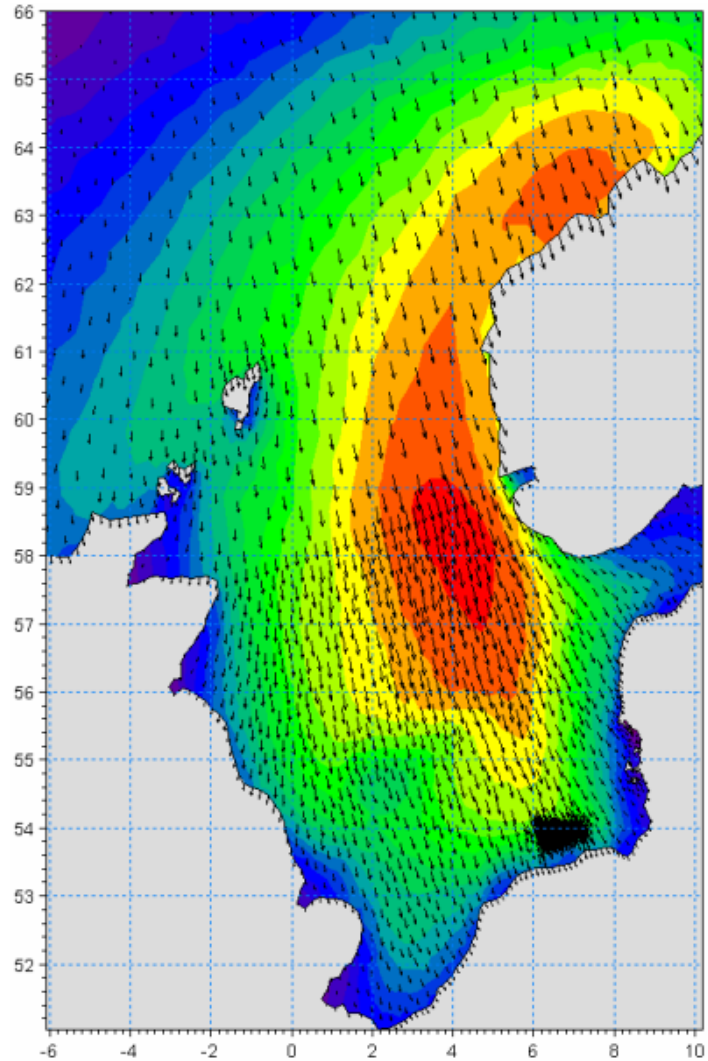
- Short wave models
- Spectral models

Input

- Wind, bathymetry, (levels, currents)

Output

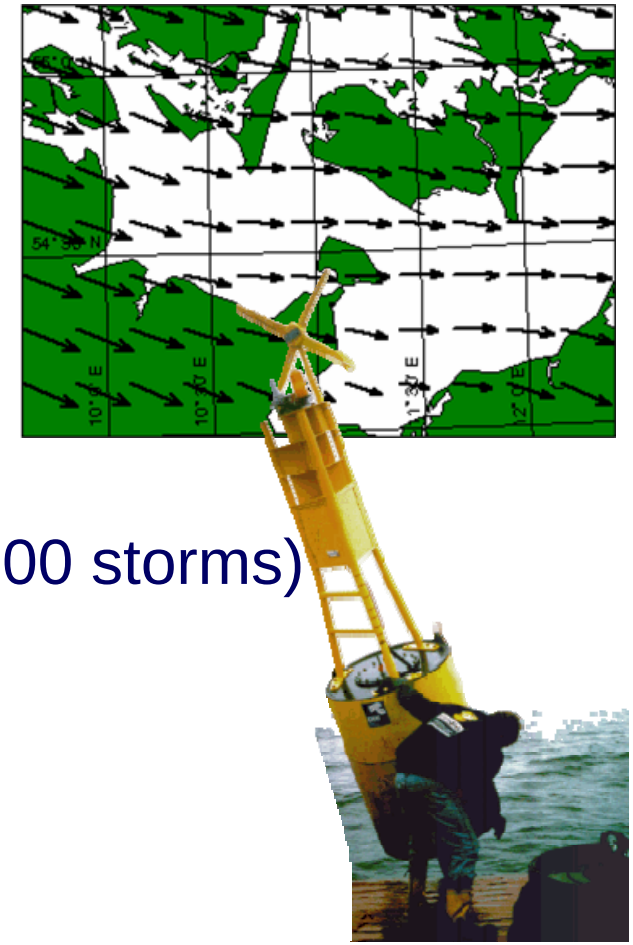
- Wave spectra, wave height, wave period, wave direction, swell parameters



Tasks in a typical hindcast study

A hindcast study step-by-step

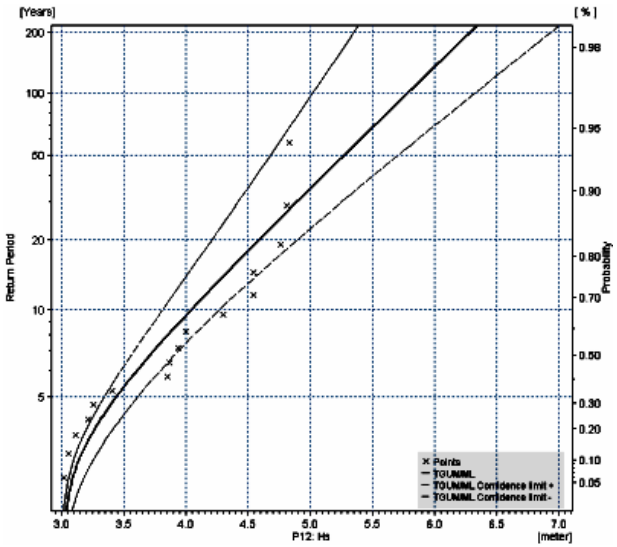
- Acquiring input data:
  bathymetry, wind, pressure,
  tide, measurements
- Set-up models
- Calibrate and validate models
- Production simulations
  (eg 10 or 20 years and/or 50-100 storms)
- Quality check
- Post processing
  incl. statistical analysis

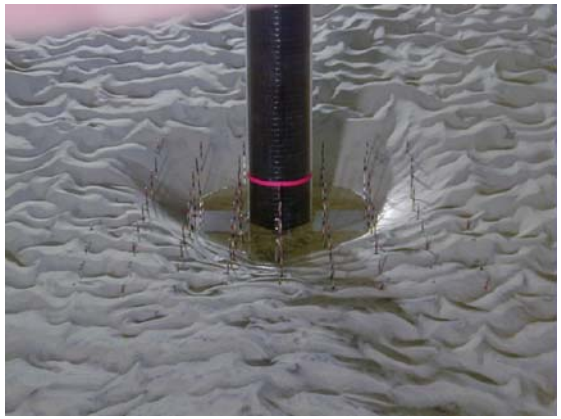


Design data

Analysis of results for design data

- Extreme Value Analysis: Peak-Over-Threshold
- Return periods of eg 100 years
- Fatigue data
- Used for foundation design

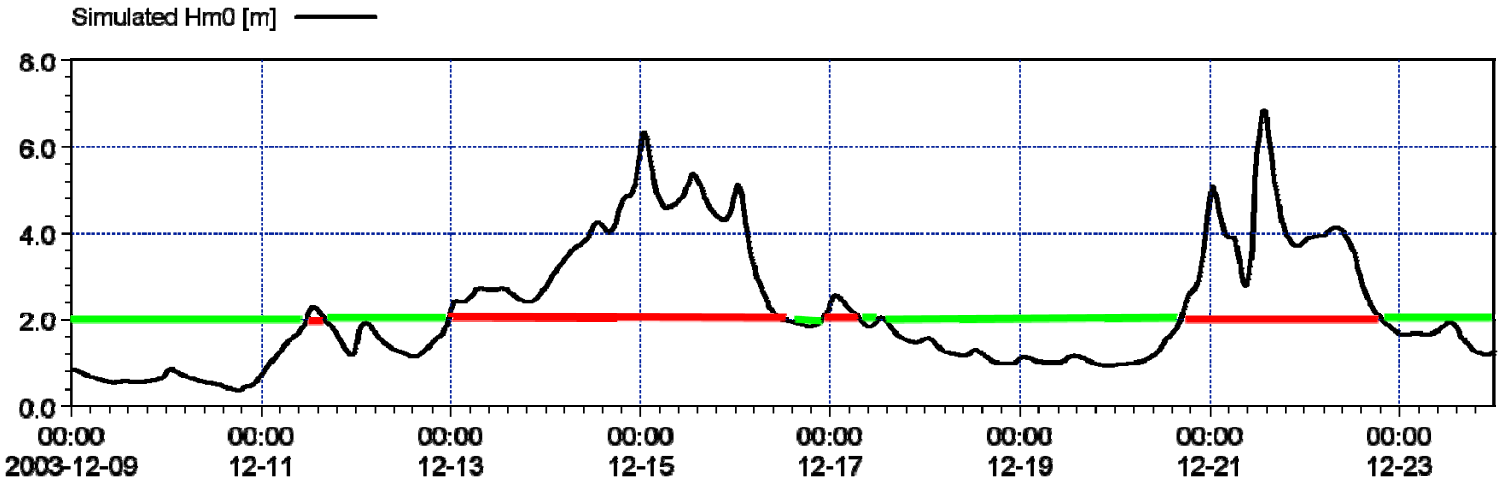




Operational data

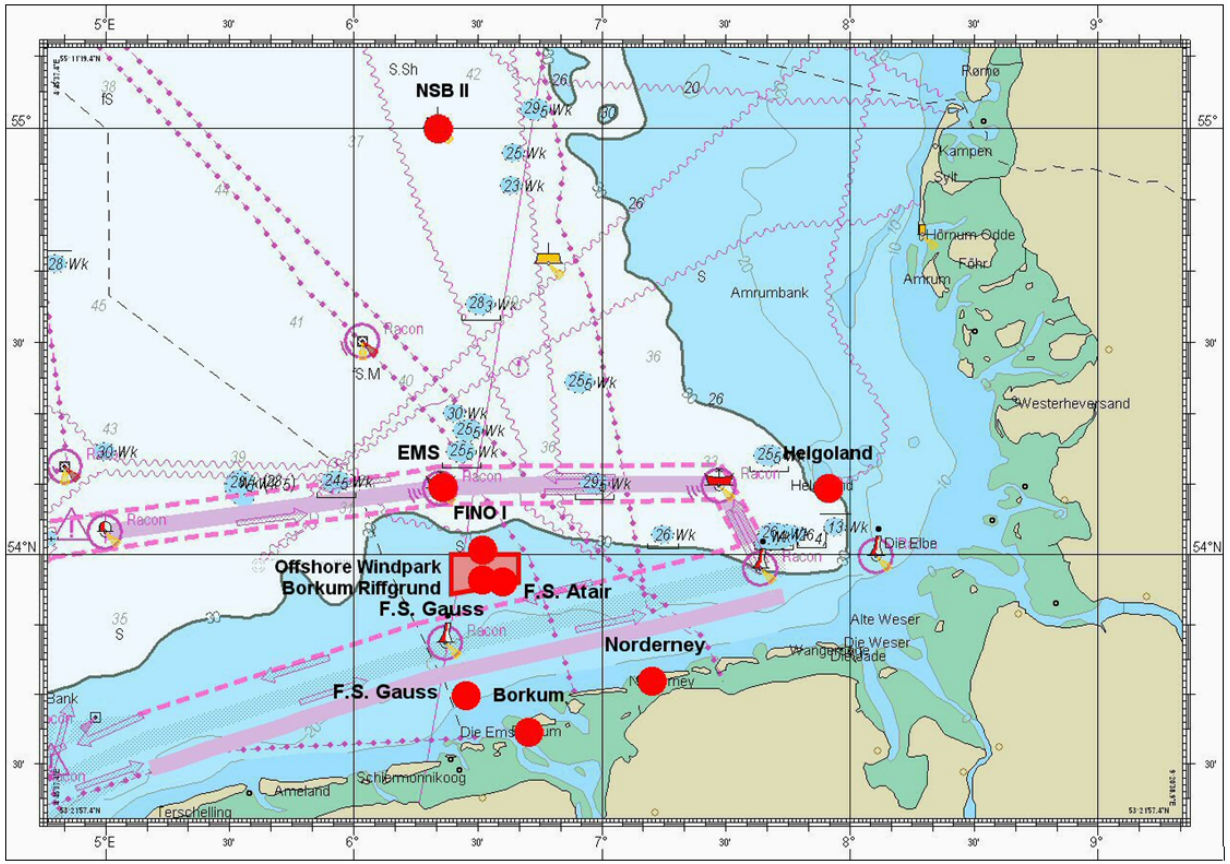
Analysis of results for operational data

- Weather windows and downtime analysis
- Used for installation, maintenance



Example: Borkum Riffgrund

Wind Farm Borkum Riffgrund I



courtesy of Energy E2 (Planbeck NeueEnergien AG and Energy E2 A/S)

Example: Borkum Riffgrund

Measurements available (part 1 of 2)

Parameter	Station	Duration	Instrument
wind	FINO I	7 months	Anemometer
wind	EMS	10 years	Anemometer
wind	Norderney	10 years	Anemometer
waves	Borkum	3 months	Wave rider
waves	NSB II	15 months	Dir. wave buoy
waves	Helgoland	17 months	Wave rider
waves	FINO I	5 months	Wave rider

Example: Borkum Riffgrund

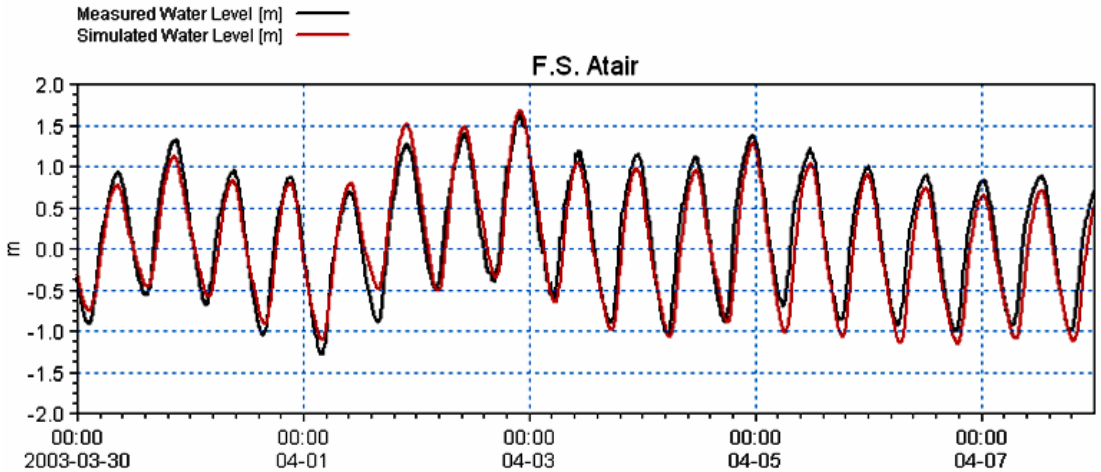
Measurements available (part 2 of 2)

Parameter	Station	Duration	Instrument
water levels	FINO I	1.5 months	Tide gauge
water levels	F.S.Gauss	1 month	Pressure cell
water levels	F.S.Atair pos 1	2.5 months	Pressure cell
water levels	F.S.Atair pos 2	1.5 months	Pressure cell
currents	FINO I pos 1	2.5 months	ADCP
currents	FINO I pos 2	3.5 months	ADCP
currents	F.S.Gauss	1 month	ADCP

Example: Borkum Riffgrund

Metocean data provided

- Directional design data based on measurements and hindcasts
- Operational data based on hindcasts
- Parameters: wind, waves, water levels, currents
- Cross correlations: wind / the other parameters



Example: Horns Rev 1

Horns Rev Offshore Wind Farm

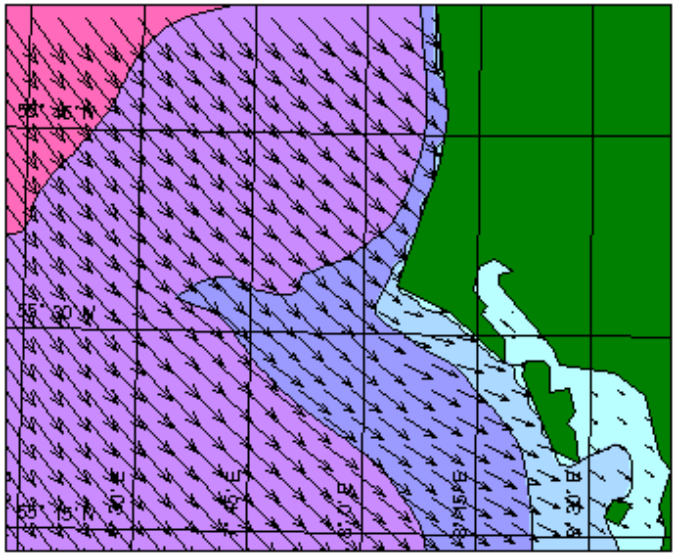
- Mast and buoys provided measurements
- Design and operational conditions based on hindcasts and measurements

Photo Elsam A/S

Example: Horns Rev 1

Forecasts

- Forecasts during installation and maintenance
- Same models as used for hindcasts
- Wave forecasts improved by assimilating online measurements (on-going)



Concluding remarks

Why acquire high quality metocean data?

- Reduce foundation costs with accurate and non-conservative design conditions
- Avoid costly surprises during installation and operation with accurate operational conditions

Therefore

- At an early stage plan for metocean measurements

Thank You

for Your Attention