

# Danish Nearshore Windfams

## Introduction to results from seabed investigations

### 01 Introduction and Overview

Danish Energy Agency  
2014-11-27



# Seminar → Agenda

1. Welcome by the Danish Energy Agency (Energistyrelsen)
2. Activities and scope of investigations
  - Common to all six sites
3. Results from the individual sites
  - Vesterhav Syd
  - Vesterhav Nord
  - Sæby

----- COFFE BREAK -----

  - Sejerø Bugt
  - Smålandfarvandet
  - Rønne Banke
4. UXO conditions
5. End of meeting



## Seminar → Objectives

1. Introduction to results from seabed investigations 2013 – 2014
2. Aim to give an overview – focus on wind farm sites
3. Dialogue and Questions



# Seminar → Agenda → More details

1. Welcome by the Danish Energy Agency (Energistyrelsen)
2. Activities and scope of investigations
  - Common to all six sites
3. Results from the individual sites
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## TOPICS

- a. Bathymetry and surface geology
- b. Boulders, Seabed dynamics, Man-made objects
- c. Seabed geology, seismic results
- d. Geotechnical investigations: Boreholes, CPT, pressuremeter tests
- e. Geotechnical results: Geology, in situ tests, laboratory tests
- f. Experiences with jack-up



## The Nearshore Windfarm sites



Rønne Banke



# Seabed investigations for offshore wind farms

1. Geological Desk Study
2. Geophysical seabed survey
3. Preliminary 3D ground model
4. Preliminary Geotechnical Investigations
5. 3D Geological ground model
6. Main Geotechnical Investigations
7. Local engineering surveys (archaeology, benthic, UXO)

**BfH**  
BUNDESAMT FÜR  
SEESCHIFFFAHRT  
UND  
HYDROGRAPHIE

**Standard Ground Investigations**

Minimum requirements for geotechnical surveys and investigations into offshore wind energy structures, offshore stations and power cables



# Seabed investigations for offshore wind farms

1. Geological Desk Study *29/01/2013 Instruction to Energinet.dk*
  2. Geophysical seabed survey *22/05/2014 Results published*
  3. Preliminary 3D ground model
- 
4. Preliminary Geotechnical Investigations *12/11/2013 Instruction to Energinet.dk  
01/11/2014 Results published*
- 
5. 3D Geological ground model
  6. Main Geotechnical Investigations *To be clarified by Licensee*
  7. Local engineering surveys (archaology, benthic, UXO)



# Geophysical seabed survey

- Purpose
  - Ensure a basis for EIA and for archaeological assessments
  - Delimit the geographical extensions of the wind farm areas
- Methods

• Bathymetric mapping	Multi-beam echo-sounding
• Seafloor mapping	Side scan sonar & Grab sampling
• Geological investigations	Sub-bottom profiling
• Ferrous and Man-made-objects	Magnetometer
- Contract
  - EGS International (UK)





## Geophysical seabed survey



- EGS Pioneer (24 hour)
- Length = 24.4m
- Draught = 3.5m



- Føniks Miljø (12 hour)
- Length = 18.3m
- Draught = 1.8m



# Geophysical seabed survey

- Bathymetric mapping
  - Kongsberg EM2040 multi-beam echo-sounding
  - Full coverage → DTM with 25cm cellsize
  - Backscatter
- Side Scan Sonar
  - Klein 3000, dual frequency 445kHz and 125kHz
  - 100% overlap → 0.5m x 0.5m x 0.1m (height)
- Magnetometer
  - Geometrics G-882, Screening of ferrous targets in all survey lines



# Geophysical seabed survey

- Sub-bottom profiling
  - Single channel system:
    - Knudsen Pinger/Chirp (EGS Pioneer)
    - C-Boom system (Føniks Miljø)
    - All survey lines
  - Multi channel system:
    - Geospark 1000, 24 channel streamer (EGS Pioneer)



# Preliminary geotechnical investigations

Purpose:

Establish initial geotechnical data

General scope of investigations  
in each area:

- 2 sample boreholes and adjacent CPT to 70m
- 5 – 10 seabed CPT to refusal
- pressuremeter tests
- laboratory tests

Performed by:

Fugro Seacore

Period:

April – October 2014



## Preliminary geotechnical investigations

### Jack up Excalibur

### Boreholes and CPT

**Seacore** FUGRO SEACORE  
Excalibur jackup barge



#### Fugro Seacore, Excalibur:

- Drilling of sample boreholes
- Pressuremeter tests in sample boreholes
- 20t Top push CPT adjacent to sample borehole, including drillout (locally down the hole CPT)
- 20t single Top push CPT to refusal at CPT-positions in shallow water





## Preliminary geotechnical investigations

### Fugro Commander

### Seabed CPT



#### Fugro Commander:

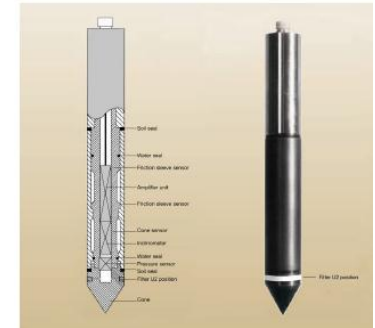
- Seabed CPT to refusal  
- 20t Frame



SEACALF

Seabed Frame

CPT Cone



## Preliminary geotechnical investigations

### Laboratory tests

#### Classification tests:

- Moisture Content
- Bulk Density
- Dry Density
- Atterberg Limits
- Particle Density
- Particle Size Distribution
- Maximum/Minimum Density
- Saturated Moisture Content

#### Chemical tests, etc.:

- Organic Content
- Sulphate Content
- Chloride Content
- Carbonate Content
- Thermal Resistivity

#### Advanced tests:

- Oedometer Test - Incremental Loading
- Undrained Triaxial Compression Tests without measurement of porewater pressure (UU)
- Anisotropically Consolidated Undrained Triaxial Compression with measurement of porewater pressure (CAUc)
- Isotropically Consolidated Drained Triaxial Compression with measurement of Volume Change (CID)

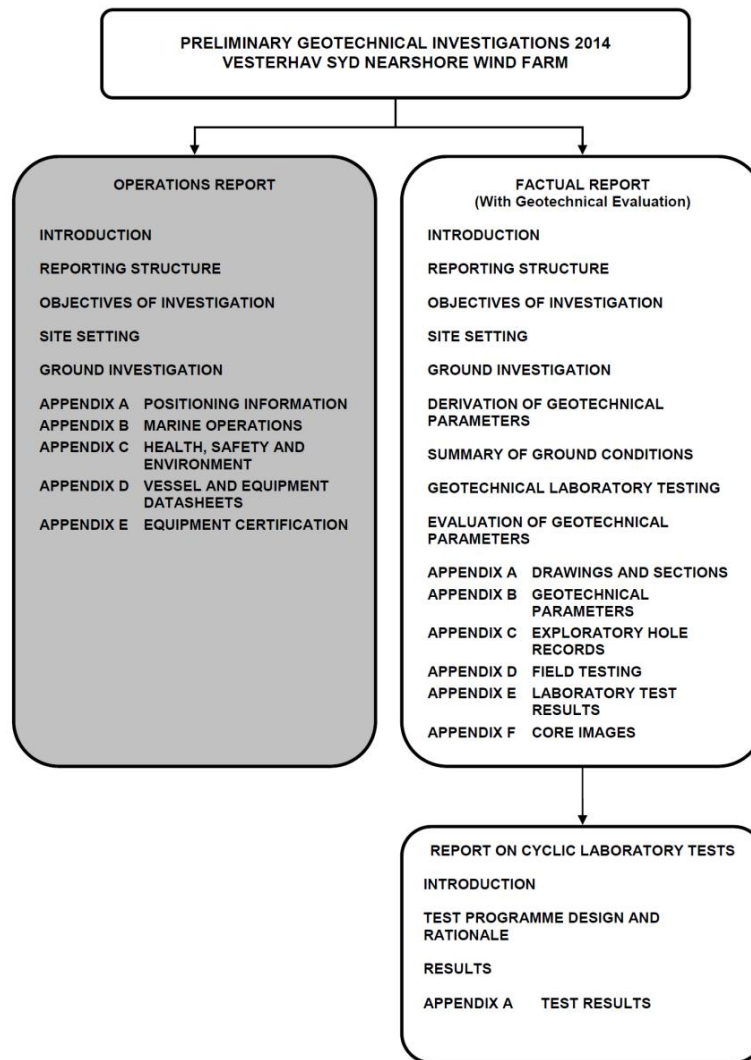
#### Cyclic tests:

- Cyclic Triaxial Tests
- Static DSS Tests (Direct Simple Shear)
- Cyclic CSS Tests (Cyclic Simple Shear)



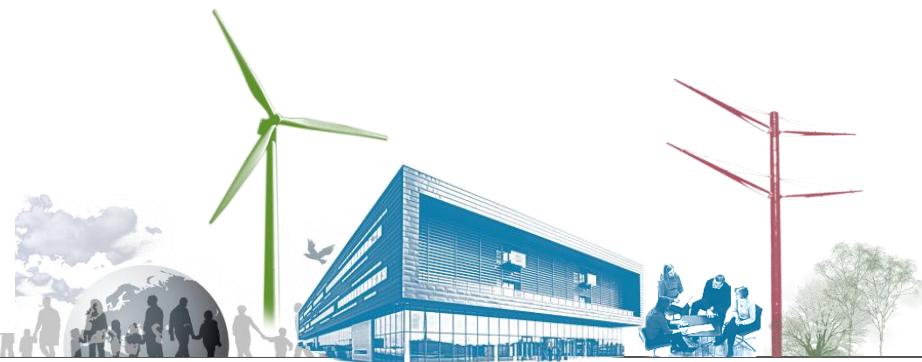
# Preliminary geotechnical investigations

## Reporting structure and digital deliverables



### Digital deliverables:

- AGS data
- CSV files
- Photos of samples





# All results published

ftp52090@ftp2.energinet.dk - FileZilla

File Edit View Transfer Server Bookmarks Help

Host: Username: Password: Port: Quickconnect

Response: 227 Entering Passive Mode (10,152,252,80,229,192).  
 Command: LIST  
 Response: 150 Opening BINARY mode data connection.  
 Response: 226 Transfer complete.  
 Status: Directory listing successful

Local site: \ Remote site: /Data/Nearshore Wind Farms/01\_Vesterhav\_Syd/02\_SEABED\_SURVEY/01\_Deskstudies

Local site: Skrivebord, Dokumenter, Computer

Remote site: Data, Nearshore Wind Farms, 01\_Vesterhav\_Syd, 01\_METOCLEAN, 02\_SEABED\_SURVEY, 01\_Deskstudies, 02\_Survey\_Park\_Area, 03\_Survey\_Export\_cable\_routes, 04\_PRELIMINARY\_GEOTECHNICAL\_INVESTIGATIONS, 02\_Vesterhav\_Nord, 03\_Sæby, 04\_Sejerø\_Bugt, 05\_Smålandsfarvandet, 06\_Rønne\_Banke

Filename

C:  
 D:  
 Q: (\\fs12\TESADok)  
 S: (\\fs12.energinet.local\RS07\_DTL\$)  
 Z: (\\energinet.local\endk\_alle)

Filename	Filesize	Filetype	Last modi...	Permissi...	Owner/G...
..					
01_Geology		Filmappe	19/03/2014...		
02_UXO		Filmappe	08/05/2014...		

Neighbour to our facilities  
 Safety  
 Information for suppliers

A report is available for each individual project site  
 2014-05-22  
 The data is available from Energinet.dk FTP server (\*).

3. Wind farm site, Published /

