Design Exercise Offshore Wind Farm Design OT5662

Every team is asked to develop an offshore wind farm in the German sector of the North Sea. Size, location, turbine type is all up to the team to decide.

Phase 1 Site selection
Select an OWF site with regard to:
- General requirements
- Power production, based on general turbine characteristics
- Not disturbing other users of the North Sea
- Connection to grid and landfall location (s)
- Distance to port
- Pre-analysis of wave and current climate
- Pre-analysis of soil conditions

Phase 2 Data collection
Determine
- Sea bed profile
- Water depths
- Tidal and surge ranges
- Current velocities
- Wave and wind climate (Argoss)
- Extreme current, wave and wind (Argoss)

Phase 3 Preliminary design
- Selection of turbine
- Preliminary OWF layout
- Decide on shore connection type (is a transformer platform required)
- Establish spread water depth for turbine locations: tallest, shortest, mean
- Determine hub-height, platform location etc.
- Create a preliminary design of the support structure (monopile)
- Check extreme load cases and dynamics
- Check scour and need for protection

Phase 4 Detailing of subcomponents
- Devise an operation and maintenance philosophy, check implications for design
- Make detailed analysis of infield and shore connection cables: sizes, numbers of J-tubes
- Draft the installation sequence for OWT, cable and scour protection
- Summarize impact of these details on the preliminary design

Phase 5 Detailed OWT design
- Apply details from phase 4 on phase 3 design
- Make overview of requirements for longest, mean and shortest turbine (based on WD) or highest, mean, least load case (for instance number of J-tubes on OWT: 3,2,1)
- Every team member (3) makes detailed design of the support structure with regard to extremes and fatigue
- Comparison of 3 designs: will site specific structures be cheaper than 1 or 2 standards for the entire OWF?
- Add effects of detailed design on installation and O&M to reporting of phase 4

Phase 6 Reporting and presentation
- Create final report from different phase reports
- Give a presentation to the board of directors: short, emphasis on critical area’s

Books, Papers, Manuals, Information and Programs

Unless explicitly stated differently, these documents can be found in room 2.80. They should remain in the room so both groups can use them. Computer programs will be made available when they are needed during the project. Be advised that there is a lot more literature on offshore wind energy. This selection has been made to make this a design exercise, not a "find the book" exercise.

General

- API, recommended practice
- Germanischer Lloyd, Rules and Regulations for Offshore Wind Energy
- DNV/Risø, Guidelines for Design of Wind Turbines
- Wind Energy Handbook (the green book)
- Wind Energy Explained (the red book)
- Handbook for Bottom Founded Structures

Phase 1

- Study of Offshore Wind Energy in the EC (for first estimate of wind climate)
- Arthur Andersen, Gas and Power Infrastructure map of Europe (CD and map, for grid connection location)
- Admiralty Charts for location selection: in the library, ask the assistant
- Admiralty Charts for location selection digital: ask JvdT
- Check Internet for general turbine specifications
- We have created generic models for 2,3,5 and 6MW turbines

Phase 2

- Admiralty Charts for location selection: in the library, ask the assistant
- Admiralty Charts for location selection digital: ask JvdT
- Admiralty tidal current atlas
- www.waveclimate.com for wind and wave details (practice with "demo" first, then a licence is given to retrieve the site specific data)

Phase 3

- Turbine data from Internet
- Scour at Marine Structures

Phase 4

- Bladed for Windows, student edition + manuals.

Detailed description of deliverables per phase

General

The aim of this project is not to come to a perfectly designed offshore wind farm, well documented with 3D pictures and perfect design calculations. You are to deliver intermediate and final reporting that is:

- short,
- simple,
- crystal clear,
- to the point.

You will need to make fast decisions based always on too little information. This means that during the design process you will find out that previous decisions or choices were not ideal. Work around them by describing the way it should have been or, in case of catastrophic consequences for the rest of the project, devise a fitting solution.

Reports with endless calculation results are not welcome. Describe only the critical formulae and parameters and go straight to the answers you have found. Further detailing and checks of correctness can be added in appendices.

In the following descriptions days and weeks are given as a reference period to finish that part of the project. They add up to the one-month period reserved for this project. They do not necessarily represent 8 hours of work. In some parts the number of hours is mentioned. This is meant to restrict the group-thinking-process: you could also spend 2 years on this assignment.

Phase 1 Site selection

Base your site selection only on the limitations you can find on the charts you can find in less than 30 minutes. Grid connection can only be accomplished where big power lines are present on the shore. The size of a port does matter for the installation planning. Wave, current, wind and soil data should be based on sources found within 4 hours. For everything that cannot be determined from proper sources an assumption should be made with a proper explanation why.

The reporting comprises not more than 5 pages of main text, showing maps with all relevant information and preliminary considerations (described/summarized in words and drawn). Make a clear overview of the critical data on 1 or 2 A4's which can be used for the rest of the project.

This phase should not take more than 2.5 days.

Phase 2 Data collection

From the selected charts the bathymetry of the selected location can be studied in detail. Make sure a consistent A4 is drawn up showing the exact definition of water levels and tidal ranges. Include the sources from which these definitions were retrieved. This document should not be changed anymore during the project.

Wind and wave data will be retrieved from the waveclimate.com database. Record precisely what details were used to compile the data.

Report again some 5 pages. Make sure the layout is such that the different parts (extreme values/scatter diagrams) are grouped in such a way that they suit the calculations they are intended for.

Again 2.5 days.

Phase 3 Preliminary design

Turbine manufacturers mostly show all their newest turbines with general descriptions on Internet. Details about blade geometry and generator characteristics are usually not so readily available. Do not put time in trying to get it!

We have created 4 generic turbines in Bladed: 2, 3, 5 and 6 MW. Use one of these and tune it to your specific details.

Find all critical information to establish the layout and connection in 3 hours. Debate layout and connection in less than an hour and make a decision.

The other parts can be executed by single members of the team. Try to make crucial decisions as a team. Use the available literature to establish the criteria that should be checked. Have your criteria checked before you start doing numerous and long calculations.

In this phase, you will not yet be allowed to work with advanced software. Use back-of-the-cigar-box methods to establish order of magnitude answers.
The report will be about 10 pages, excluding appendices. Make a section for every bullet in the assignment. Make sure text and drawings are consistent throughout this part.
Take 1 week to complete this phase

Phase 4 Detailing of subcomponents
Task per bullet can be executed by team members separately. Try to disconnect from the previous actions. Look at the preliminary design only from the viewing point of the part you are trying to solve. Make a proper list of the impacts on the design.
These topics require some more text, drawings, flowcharts, say 12 pages in total.
3 days to finish this.

Phase 5 Detailed OWT design
Make a more detailed description of the OWT. Establish the different turbines required in the OWF. Make a very clear list of calculations through which the different options will be tested. The modelling of the turbine will be done as a team, so all members learn to work with Bladed. The design calculations can then be done separately.
The report shows the detailed OWT, a list of design calculations, comparison of the design calculation outcome and conclusions regarding that outcome. 8 pages in total, an appendix of 2 pages per member to describe the calculation method.
1 week to complete this task.

Phase 6 Reporting and presentation
The final report will be all previous reports including a general introduction and “lessons learned” conclusions. The board of directors will make a decision based on your presentation. They have limited time, are not entirely in favour of offshore wind energy but have been told by a consultant that it could make them money, understand technicalities but not too many. Convince them that you have come up with a doable design.