Syllabus: Planning & Construction of Wind Farms


Pre-requisites

There are no pre-requisites for this course.

Instructors

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Seminar 1
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Course overview & introduction to project development

Content

Because the planning of wind farms is a discipline for which few textbooks exist, this course is based heavily on our own experience as consultants, including many examples. Therefore, we have opted to structure the course around weekly online lectures and to use extensive reading material to support the topics covered in class. Readings for the respective week should be completed before class starts, as the class will begin with a discussion of the reading material.

Today in class we will introduce ourselves as teachers, give an overview of the themes of the entire course and begin with our first topic: defining the planning phases of a wind farm project. The four phases of a wind farm are:

1. Development
2. Construction
3. Operation
4. Decommissioning

This course will cover three of these phases in chronological order; wind farm operation is offered as a separate course. We begin with the development phase of the project, which can be subdivided into 5 phases:

5. Development
   a. Scoping
It is important to know about the phases listed above that they are solely for the purpose of this course. There is no internationally accepted naming of development phases, as wind farm projects and owners differ so wildly. The important thing is that the tasks contained in each phase can be recognized in almost all projects.

The first of these sub-phases, scoping, is a quick investigation of potential wind farm sites according to major positive or negative criteria. These criteria should be easy to check without time-consuming consultation with governmental authorities. For example, you could check which sites are within a 10 km radius of a high-voltage network, but would not consult with the grid operator about where the exact connection point could be for each site.

Often difficult locations for wind farms, which should be considered during the scoping process are:

- Protected areas – natural and cultural
- Grid congestion
- Existing wind farms
- Military areas
- Airports

On the other hand, the following aspects should be seen as positive in the scoping stage:

- Near to grid
- Available transportation infrastructure
- Far from houses
- High wind speeds
- Topography
- Legally designated areas for wind power

To evaluate potential sites according to these and other criteria, three main methods can be used: pro/con list, matrix comparison and GIS-based mapping. With the use of one of these methods, you can narrow down a list of potential sites to a set number of interesting sites. With these sites, you proceed to the feasibility study phase.

**Homework**

Project Management Body of Knowledge (PMBOK) Guide, Chapter 3: Project Management Processes (16 p.) and
After discussing the first development phase, scoping, last week, we will continue with the rest of the phases of wind farm development today (b-d):

a. Scoping
b. Feasibility study
c. Economic calculation
d. Preparation for permitting process
e. Reception of building permit

A **feasibility study** is, in our definition, a detailed investigation of and planning for a wind farm, including consultation with authorities and a preliminary wind farm layout. The goal of the feasibility study is to gather enough information for a reasonable economic calculation.

The first task of the study, which often takes several months to complete, is to investigate the possibilities for land acquisition. In addition to the locations of the turbines themselves, it is important to remember to secure all areas of the wind park: access roads, crane pads, cable routes and temporary areas.

The next task is to construct a working layout for the wind farm, which is needed to determine how many turbines can be realistically erected on the site. To do this, a constraints map is made of the wind farm through consultation with authorities and the turbines are placed on the remaining land at least 5 x 3 rotor diameter apart from each other.

Potential turbine types for the site are determined through the IEC class of the site and preliminary energy prognoses for fitting types. Finally, the anticipated location of all auxiliary areas (roads, crane pads, transformer station, cabling, temporary areas) are carefully drawn onto a technical plan.

With this information as a basis, the next step of project development: **economic calculation.**

Economic calculation models vary widely between project owners, but generally take into account expected revenue from the wind farm versus capital expenditures (CAPEX) and operational expenditures (OPEX) over a 15-20 year operational period. As one of the largest CAPEX costs, offers from turbine manufacturers should be carefully compared. Only after knowing
the price of the turbine and all associated maintenance costs can make a decision be made on which turbine is most economical for the site. Turbine offers should be compared with their predicted production and reduced to an investment cost per kWh, while the completeness and content of other submitted documents, such as the service contract, must also carefully be reviewed for risk and hidden costs.

If the economic calculation is positive, meaning that the expected return on investment is acceptable to the project owner, the project continues into the next development phase: **preparation for the permitting process.**

The tasks of this phase are very similar to those in the detailed feasibility study. The major difference in this phase is that all consultation with authorities and all offers should be binding. This is the phase where the studies and planning are done to fulfill all the legal requirements to submit a building permit. This often includes a full environmental impact statement.

After the **building permit is received**, there are typically several conditions in the permit (such as a monetary deposit guaranteeing the decommissioning of the turbines), which must be fulfilled before construction. These are completed in this phase. Often parallel to this phase, the pre-construction activities are started.

**Homework**

Four full EIAs from various countries will be posted on Moodle. Choose two of these reports and skim them (including auxiliary documents). Pay attention to the scope of all topics and the mitigation measures taken; how are the reports different?

**Short assignment #1:** research and write a 400-word essay comparing the environmental impacts of wind farms with conventional energy sources (nuclear, coal, gas) on one of the following topics:

- Birds and bats
- Visual Impact
- Noise

**Final Exam  Seminar 11-15**

The final exam will be a mock project development, a several-week project in four sections. Each section will be graded individually. You may work on this project with a partner of your choice, or alone.

There will be extensive support provided for this project in the form of ongoing weekly meetings at normal lecture time where we discuss progress and inputs.
Q&A session dates for final project:
- Feb 27
- March 6
- March 13
- March 20

The project sections are as follows:

**Section 1: Scoping (due March 4th)**

**Task:** You will be given maps and site boundaries of two potential wind farm sites. Your task is to use the internet to go through the scoping criteria we learned in class and compare the sites. Choose one site with which to proceed in the rest of the project. Research and suggest three possible turbine models for the site.

**Graded assignment:** 3-page report comparing the two sites and explaining which site you chose to proceed with and why and which turbine models you suggest and why. (15% of exam grade).

**Section 2: Layout (due March 11th)**

**Task:** Using the software WindPRO and some given constraints of the site and the given turbine types, investigate the different possibilities for placing turbines on the site. This should include a prediction of energy production, noise impact and shadow flicker impact. Decide on a turbine model for the site out of the models given.

After the turbine model and layout are determined, make a construction layout including roads, crane pads, electrical systems and all other necessary components. You can do this using the Draftsight software or by hand.

**Graded Assignment:** The layout itself and WindPRO results for production, noise and shadow flicker will be graded. Write a 3-5 page paper describing your steps in creating the layout, including a list of all constraints which you considered (30% of exam grade).

**Section 3: Calculation of investment costs (due March 18th)**

**Task:** A large part of a wind farm financial model is calculating the investment costs, which you will do in this section. You will be given a comprehensive list of unit inputs (i.e. cost of road with bearing capacity x per square meter), from which you must select the inputs that are relevant for your own planning and organize these inputs in Microsoft Excel to come up with a cost
of investment (€/kWh) for the 15-year life of the wind farm.

Graded assignment: Excel calculation and a 3-5 page paper, explaining the structure of your financial model (30% of exam grade).

**Section 4: Update of layout, calculation of investment costs and final turbine choice (due March 25th)**

Task: During project development, new information often changes the current planning. In this section, you will receive some new information about each of the two sites. You must update your layout and economic calculation to reflect this information. You are free to change the turbine model or any other aspect of the layout.

Graded assignment: Final layout and economic calculation, plus 10 minute oral exam on results (25% of exam grade).

**Oral exams will be held on March 27-29.**