Offshore Wind Power: Science, engineering, and policy
MAST 628-010, Spring 2012

Tuesday, Thursday – 11:00-12:15, Robinson Hall 105 and (via ITV) Cannon Lab 203
Instructors:
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Class web site with lecture notes: www.udel.edu/sakai
UD offshore wind research: http://www.ceoe.udel.edu/windpower/

Topic and overview of course

This course will cover the multiple disciplines required to understand, plan, regulate, and develop offshore wind resources for large-scale power production. Offshore wind is quickly emerging as a critical technology for large reductions in CO₂ emissions, because the technology is available, proven, and cost-competitive, and the resource is close to population centers and, for many of the world’s populated coasts, a resource larger than all current CO₂-producing energy sources combined.

The course will integrate science, engineering and policy. We will draw on the three instructors and multiple guest lecturers to cover topics including:

• Geophysics of wind resources; understanding and assessing the offshore resource;
• Governing law for state, Federal and international waters; current policy (or lack thereof) for offshore development; policies to encourage and/or regulate the industry;
• Basic electrical and mechanical engineering aspects of wind turbines and power transmission;
• Connecting wind electricity to the electric grid; electric markets; relative electric costs; combining wind with other renewables; CO₂ displaced from large coal and gas generators;
• Storage of intermittent wind power--engineering and economics; the synergistic role of an emerging hybrid, fuel cell, and/or electric vehicle fleet;
• Geology and bathymetry of the continental shelf, as they constrain anchoring technology and thus the size of the accessible wind resource
• Environmental impact of large offshore wind developments; the EIS process;
• Public opposition to, and support for, wind power; communication strategies.

Students should be knowledgeable in at least one of the above policy, science or engineering areas, and expect to gain a working knowledge of the other areas.
Elective and Area Requirements Satisfied

This course can meet the Oceanography Program degree requirements for distribution, with the Oceanography Program Director’s approval. It satisfies 3 hours of the Mechanical Engineering Technical Elective Requirement (12ch). It is one of the additional area courses in the applied-for minor in the College of Engineering minor “Sustainable Energy Technology”. (Believed accurate as of time this was written, check with your program or department for confirmation.)

Credit and assignments

Students are expected to do readings prior to class, attend lectures and participate in discussion, and do occasional problem sets to apply what we are learning, plus complete a final project with a team.

Readings

Most readings will be either out of the books listed below, or on the class web site. Some lecture notes will also be on the class web site.


Outline of topics

Readings are to be read in advance of the class. Class sessions will often be divided into more than one topic. Readings are separately shown for each topic.

1) Introduction; Overview of offshore wind technology and industry, Wind Basics
   • Firestone, J. and J. Kehne, Wind Energy, in Michael Gerrard (ed.), The Law of Clean Energy: Efficiency and Renewables (to be published in Spring 2011), review from Class one, pp. 6-7, 14-20, and 23-24 only
   • Kump, Kasting and Crane, The Earth System, 2nd ed., Chapter 4.

(2) Climate Change, Ocean Acidification

(3) Wind Technology Survey
   • Manwell, McGowan and Rogers, Read all of Chapter 1; in Chapter 2, read Section 2.1 and 2.2, and look at Figure 2.25, Figure 2.30, Table 2.5, and Figure 2.36


(4) Offshore Wind Survey

• MMR, Section 10.4, “Offshore wind energy”. (If you are not a physical oceanographer, you don’t need to master the wave equations)


• Talisman Energy, 2006, Beatrice Wind Farm Demonstrator Project Scoping Report.” [Read through section 3 carefully (pp 1-18), skim through remaining sections so you know what is involved in impact studies for offshore sites.]

• REPower Systems AG, 2005, “5M” (product brochure). (File: 5m uk.pdf, previously available from www.repower.de) [This brochure has descriptions of their 32 major subcontractors, a revealing snapshot of supply chain and OEM coordination. (No longer available, the newer brochure drops the subcontractors.) Also, note the design of this machine in comparison to the Liberty: geometry, dimensions, and head mass.]

(5) Offshore Wind Policies - Federal Offshore Wind Policies


• Dhanju, A and J Firestone, A Framework for Regulation of Offshore Wind Power in Delaware State Waters, Final Report January 2008 (read main part of report only)


• Secretary of the Interior, Secretarial Order No. 3299, MMS Reorganization (May 19, 2009)


• MMS Alternative Energy Final Rule (April 29, 2009) (background)

(6) Offshore Wind Policies – State and International


(7) Wildlife and the EIS Process

• Cape Wind EIS, Executive Summary, (required)


• Offshore wind farms in the Belgian part of the North Sea State of the art after two years of environmental monitoring, Steven Degraer & Robin Brabant, eds. (2009),
http://www.mumm.ac.be/Assets/Misc/News/monitoring_windmills_2009_final.pdf,

**background**


**background reading**


(8) **Public Opinion and Siting Considerations**


(9) **Wind Resources**

- Manwell et al, Chapter 2

(10) **Wind Resource Assessment**

- David W. Keith, Joseph F. DeCarolis, David C. Denkenberger, Donald H. Lenschow, Sergey L. Malyshev, Stephen Pacala, and Philip J. Rasch, 2004, "The influence of large-scale wind power on global climate" *Proceedings of the National Academy of Sciences*, November 16, 2004 vol. 101 no. 46 16115 - 16120. (backup copy is on this site.)
(11) Wind Stability and Predictability


• Lew et al., 2012: “The Value of Wind Power Forecasting”

(12) High-level wind resources


(13) Practical power output for coastal states


• Blue Ribbon Panel on Development of Wind Turbine Facilities in Coastal Waters. INTERIM REPORT, November 2005. [The Kempton and Firestone letter was commenting on this. The most serious problems were fixed in the final report, available online.] *Optional reading.*


(14) Wind Resource Exercise

(15) Distributed wind sites and smoothing; transmission


• Oswald J, Raine M, Ashraf-Ball H, 2008: Will British weather provide reliable electricity? *Energy Policy* 36:3202–3215. [Note that this study finds less smoothing effect than others.]

• Willett Kempton, Felipe M. Pimenta, Dana E. Veron, and Brian A. Colle, 2010, Electric power from offshore wind via synoptic-scale interconnection, *Proceedings of the National Academy*


(16) Storage

- Dhanju, Kempton, and Pearre, 2010, Using Responsive Heat Storage to Level Offshore Wind. Submitted for publication

(17) UD Wind Turbine

- US DOE Environmental Assessment of UD Lewes Campus Wind Energy Project, pp. (note final EA not yet issued, but expected before October 28)
- http://www.ceoe.udel.edu/lewesturbine/ (view turbine website)

(18) UD Wind Turbine visit

(19) Gear Box and Wear Issues (guest, Prof. David Burris)

(20) Continental Shelf Geology


(21) Vibrations and Towers (guest, DeAnna Sewell)

- Petersen et al., 2010: Evaluate The Effect of Turbine Period of Vibration Requirements on Structural Design Parameters:Technical Report M10PC00066-8, BOEMRE

(22) Corrosion and the Marine Environment (guest, Prof. Steve Dexter)

(23) The Danish Wind Industry

[A bit awkward to read, as it is poster format. But has a summary of Denmark’s wind power goals and some ideas for meeting them.]


(24) The Economics of Offshore Wind (guest, Andrew Levitt)


(25) Student Presentations

(26) Student Presentations

(27) Wrap-up