Introduction to Offshore Wind Energy

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PDH: 1

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Module 1: Offshore Wind Energy

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the primary technological components and structural base requirements for offshore wind turbines.
- **Evaluate** the regulatory framework and the diverse roles of federal and state agencies in the U.S. permitting process.
- **Analyze** the environmental, economic, and social impacts of offshore wind development on local communities and national energy goals.

Executive Summary: Offshore wind energy is a rapidly growing global resource that harnesses ocean winds to produce clean, renewable electricity. While the United States has a significant land-based wind presence, offshore development is currently in the project phase along the East Coast, Great Lakes, and Pacific Coast. Developing this resource is essential for reducing energy imports, curbing greenhouse gas emissions, and stimulating local economies through job creation and manufacturing.

Technology

Offshore wind turbines convert the kinetic energy of moving air into electrical power through a series of mechanical and electrical processes.

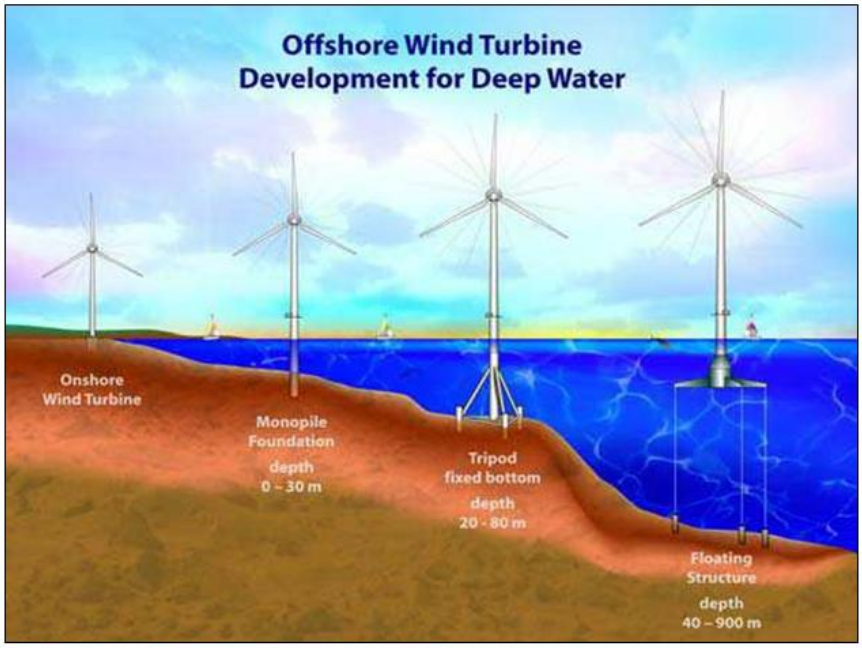
- **Aerodynamic Lift:** Air moving over turbine blades creates lift, which causes the rotor and blades to rotate.
- **Yaw Control:** Wind sensors detect optimal wind direction, allowing the yaw controller to turn the blades into or away from the wind.
- **Power Conversion:** A generator converts the mechanical power of the blades into electricity.
- **Transmission:** Power is transmitted to the grid through subsea cables.
- **Service Life:** Wind turbines typically have a service life of at least 20 years.

Image courtesy RenewableUK

Production Factors

The amount of electricity produced is governed by wind speed, turbine size, and the farm's arrangement.

- **Energy Density:** One megawatt (MW) powers approximately 750 American homes.
- **Comparison to Onshore:** Offshore turbines generally generate more energy per hour than land-based units due to larger sizes and higher, more consistent wind speeds.
- **Turbine Dimensions:** While towers are often 80 meters (262 feet) high, offshore rotors are larger than land-based ones, reaching 90–107 meters (295–351 feet) in diameter.



Stability and Foundations

Different water depths require specific base types for stability.

- **Monopile Base:** A single column, six meters (20 feet) in diameter, used in water up to 30 meters (98 feet) deep.
- **Tripod or Steel Jacket:** Used for stabilization in water depths between 20–80 meters (66–262 feet).

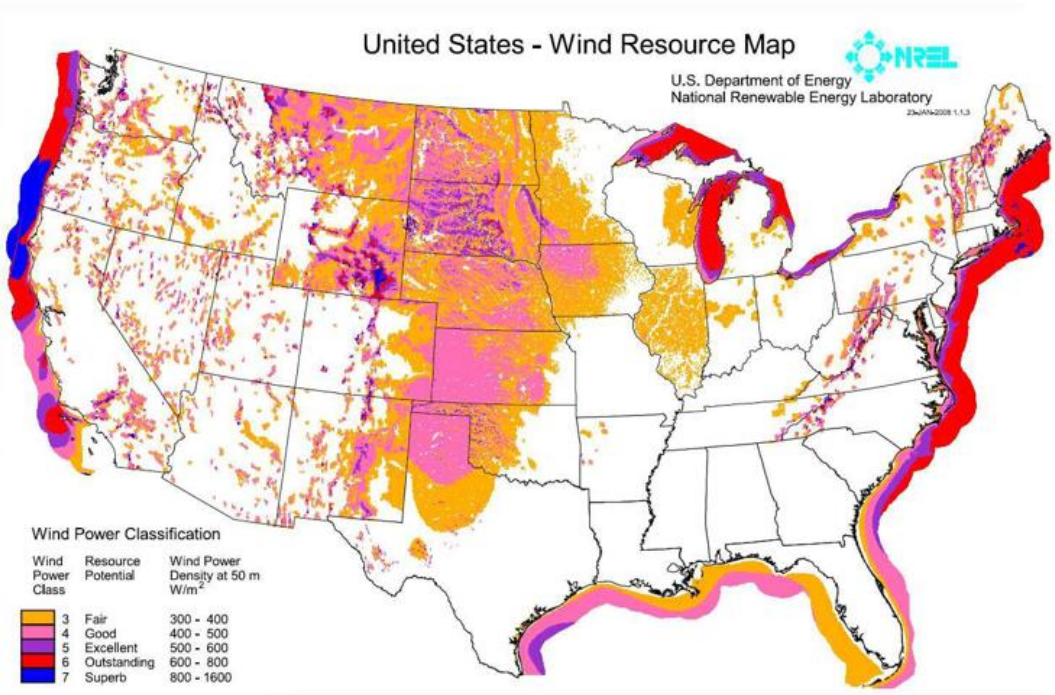
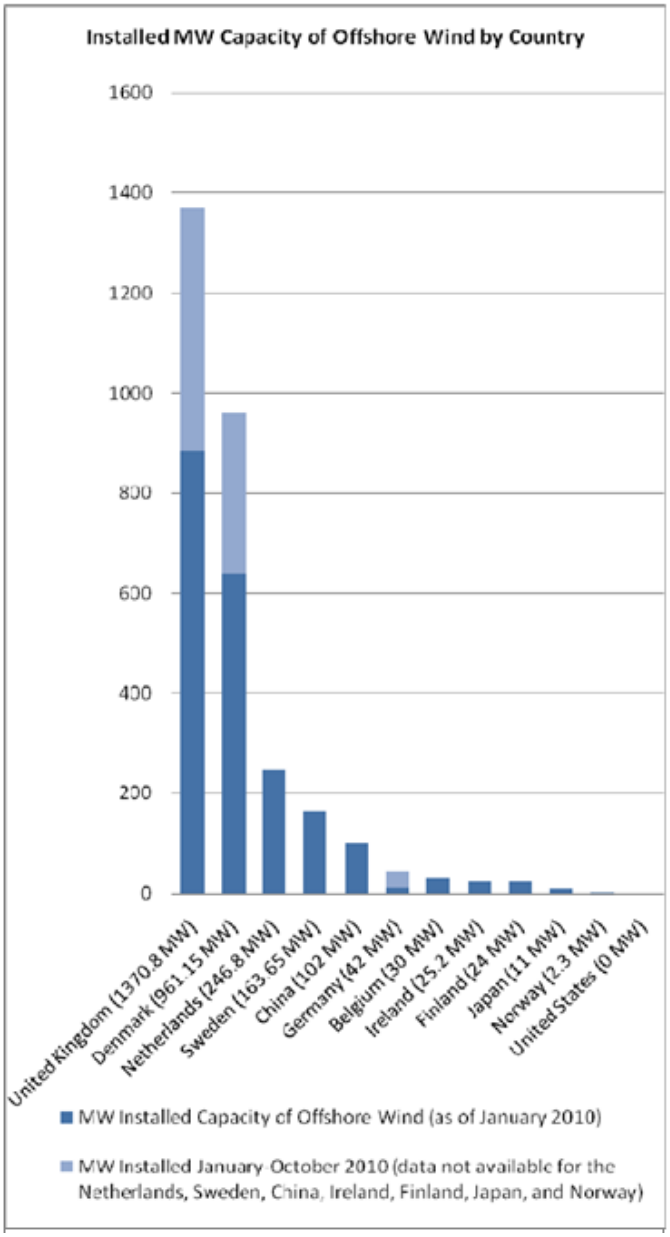


Figure: Image courtesy National Renewable Energy Lab

Advancing Technologies

Floating turbines are under development to access wind resources in deeper waters.

- **SWAY:** Designed a floating turbine for depths of 100–400 meters (328–1,312 feet).
- **StatOil Hydro:** Testing turbines for waters up to 700 meters (2,297 feet) deep based on North Sea oil installation technology.



Europe and Asia

Several European and two Asian countries currently operate offshore wind farms, with a global growth rate of 30 percent installed capacity annually.

- **European Leadership:** Europe had an operating capacity of 2,396 MW as of June 2010.
- **Geographic Scope:** Farms are located off Belgium, Denmark, Finland, Germany, Ireland, the Netherlands, Norway, Sweden, and the UK.
- **Technical Range:** These projects exist in depths from 0.8 to 220 meters and distances from shore between 0.03 to 43 kilometers.

Case Study: Denmark

Denmark began the world's first offshore wind operations in 1991 and utilizes a "one-stop-shop" permitting framework through the Danish Energy Agency.

- **Public Support:** 91 percent of Danes believe the country should continue wind development.
- **NIMBY-ism:** 64 percent of Danes support building turbines in their own neighborhoods.

Case Study: United Kingdom

The UK overtook Denmark in MW capacity in 2008.

- **Thanet Wind Farm:** Online as of September 2010, this 300 MW farm brought the UK total to 1,341 MW across 13 operational sites.

Case Study: Germany

Germany utilizes a "feed-in tariff" to obligate utilities to purchase wind energy at premium prices for a fixed period.

- **Grid Connection:** The Power Line Expansion Law facilitates spreading the costs of offshore grid connections nationwide.

Case Study: China

China's first offshore farm near Shanghai (102 MW) was completed in early 2010.

- **Manufacturing:** China holds a 61 percent share of the $47 billion offshore wind technology manufacturing market.

United States

The U.S. currently has no offshore wind farms, with all wind power produced onshore.

- **2030 Goals:** The DOE suggests the U.S. could produce 20 percent of its electricity from wind by 2030, requiring 54 GW of offshore capacity.
- **Resource Potential:** Coastal and Great Lakes wind resources could provide 900,000 MW, nearly equal to current total electric capacity.
- **Regional Hubs:** Potential sites are near urban load centers where energy costs are high and land is limited.

Government Incentives

- **Renewable Electricity Standards:** 29 states and D.C. have laws requiring a minimum percentage of renewable energy.
- **Production Tax Credit (PTC):** This federal credit is set to expire at the end of 2012.

Purchase this course to see the remainder of the technical materials.