Offshore Wind Energy

An Online Continuing Education Course for Engineers

Course Number: R-3017

Credit: 3 Hours / 3 PDH / 3 CPD

Offshore Wind Energy

Lee Layton, P.E.

Table of Contents

Introduction

Offshore wind has the potential to deliver large amounts of clean, renewable energy to help meet the growing need for clean, safe energy sources. The U.S. National Renewable Energy Laboratory (NREL) estimates that the technical resource potential for U.S. offshore wind is more than 2,000 gigawatts of capacity or 7,200 terawatt-hours per year of generation. Most land-based wind resources are stronger at night when electricity demands are lower. In contrast, offshore winds are typically stronger during the day, allowing for more stable and efficient production of energy when electricity demand is at its peak. This makes offshore wind a good fit with traditional generation resources. Fortunately, almost 80 percent of U.S. electricity demand occurs along coastal areas and the Great Lakes regions, which makes offshore wind a viable proposition.

Technological advances constantly improve the economic feasibility of offshore wind farms, and monthly capacity factors are approaching 40%. And while construction costs of offshore wind farms can be twice that of equivalent onshore wind farms because of the increased complexity of foundations, installation, and grid connections, the costs are declining.

Higher wind speeds are available offshore compared to on land, so offshore wind power's electricity generation is higher per amount of capacity installed. The wind turbines tend to be larger in offshore installations providing the capability to generate more power than their onshore counterparts. Figure 1 shows the enormous scale of some of these turbines and their capacity.

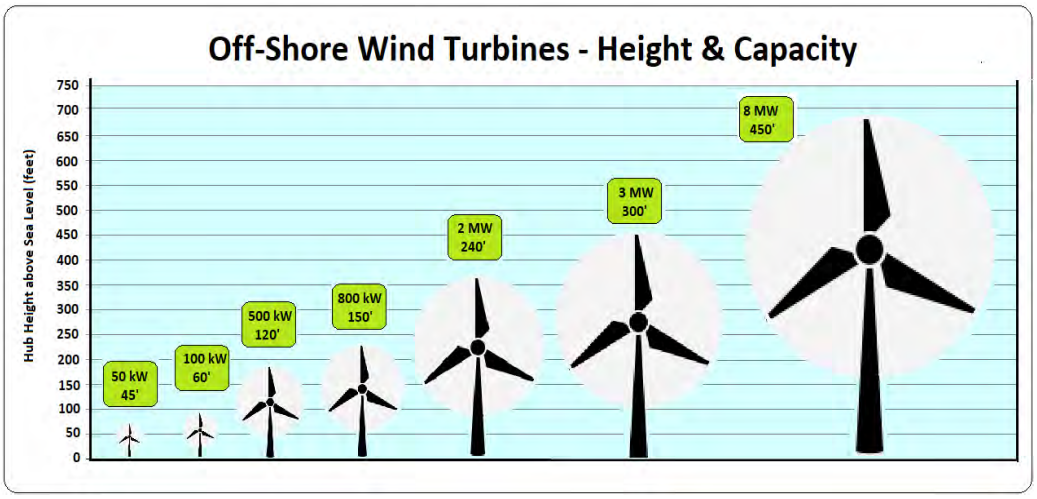

Figure 1

As you can see in the figure above, some of these units have hub heights of 450 feet and can generate up to eight megawatts of power per turbine. The wind turbine blades may be up to 300 feet in length. Power from these offshore turbines is connected to the mainland electric grids through power cables buried in the sea floor.

Worldwide most offshore wind turbines are built in shallow waters. However, about 60 percent of the U.S. wind resources are in deep water. This makes the use of conventional foundations impractical. There are numerous technical solutions to this issue, including floating offshore wind platforms for use in deep waters. These solutions are discussed in detail in Chapter 3.

Another benefit of offshore wind is fewer environmental concerns than onshore wind, though there is opposition due to viewshed impacts and impacts on marine life.

The U.S. lags far behind the rest of the world in the use of offshore wind. In 2020, there were almost 30 gigawatts (G.W.) of wind energy worldwide. The majority is in northern Europe, especially in the United Kingdom and Germany, which together account for over 60% of the total offshore wind power installed worldwide. China is rapidly increasing its use of offshore wind and is now the third-largest user of offshore wind and represents 21% of all offshore wind. See Figure 2.

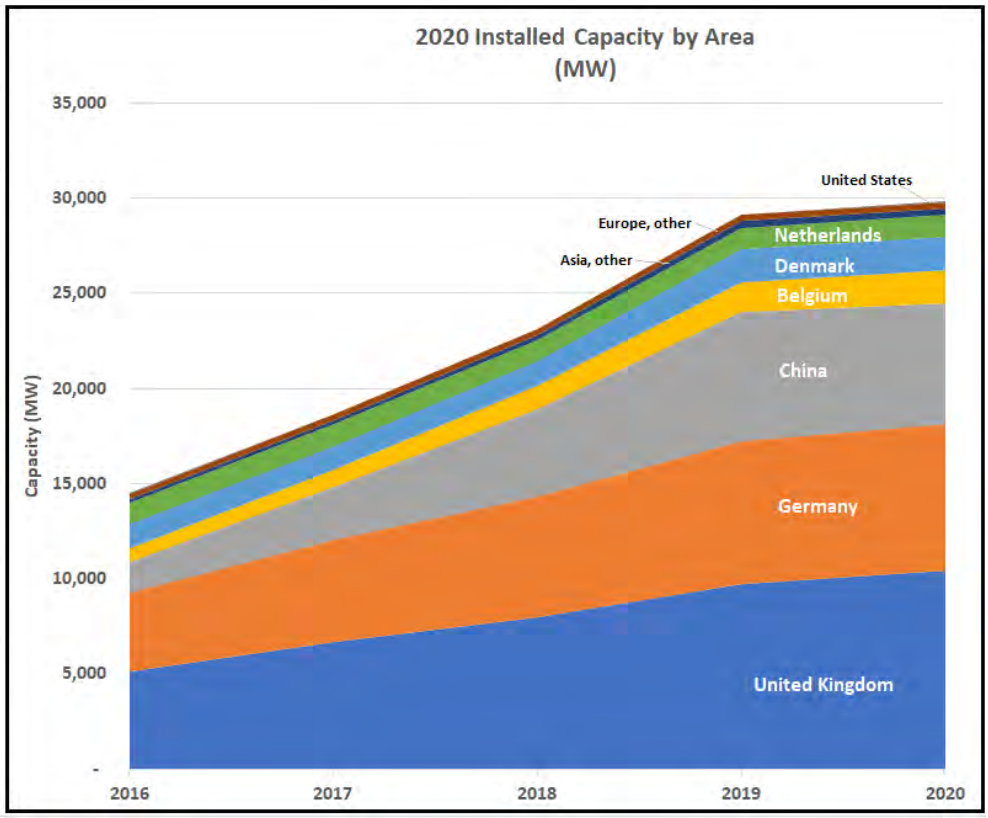

Figure 2

The cost of offshore wind power has historically been higher than that of onshore wind generation, but costs have been decreasing rapidly in recent years to $78/MWh in 2019. Offshore wind power in Europe recently became price-competitive with conventional power sources. Offshore wind generation grew at over 30 percent per year in the last decade, though it remains less than 1 percent of overall world electricity generation.

In the United States in 2016, Deepwater Wind completed the commissioning of the Block Island Wind Farm, marking a milestone as the nation's first commercial offshore wind project. The 30-megawatt (M.W.) project comprises five 6-MW G.E. wind turbines installed off the coast of Block Island.

The project included laying a power cable connecting the grid on Block Island, which only uses a small fraction of the power generated, to the mainland grid.

Table 1 shows a list of the largest offshore wind farms in operation worldwide in 2020. This list only includes farms of 500 MW or more, none of which are in the U.S.

Table 1
Offshore wind farms with a capacity of at least 500 MW

Wind farm	Location	Capacity (M.W.)	Number of Turbines	Turbine Type	Operation Date
Hornsea 1	United Kingdom	1,218	174	Siemens Gamesa SWT-7.0-154	2019
Borssele 1 & 2	Netherlands	752	94	Siemens Gamesa 8MW	2020
Borssele 3 & 4	Netherlands	732	77	MHI Vestas V164 9.5MW	2021
East Anglia ONE	United Kingdom	714	102	Siemens Gamesa SWT-7.0-154	2020
Walney Extension	United Kingdom	659	87	40- MHI-Vestas 8.25 MW 47- Siemens Gamesa 7 MW	2018
London Array	United Kingdom	630	175	Siemens Gamesa SWT-3.6-120	2013
Gemini Wind Farm	Netherlands	600	150	Siemens Gamesa SWT-4.0	2017
Beatrice	United Kingdom			iemens Gamesa SWT-7.0-154	2019
Gode Wind (phases 1 & 2)				s Gamesa SWT-6.0-154	2017
Sea Wind (Gwynt y Môr)				Gamesa SWT-3.6-107	2015
Race Bank				Gamesa SWT-6.0-154	2018
Greater Gabbard				amesa SWT-3.6-107	2012

Chapter One of this cou ide and in the United States. Chapter T entially the same as for a land-based wind t the types of wind turbine foundations and describes the costs and operational factors o costs and operating parameters. Chapter Five looks at the considerations in siting offshore wind farms.