ECE 333 – GREEN ELECTRIC ENERGY

11. Wind Status

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THE DEFINITIVE WIND STATUS REPORT

Source: *Land-based Wind Market Report*: 2021 *Edition, Berkeley Lab*; *https://eta.lbl.gov/publications/land-based-wind-market-report*-2021

The *US Department of Energy* publishes every two years the *Land-Based Wind Market Report.* The text of the 2021 edition has been prepared by the staff of *Lawrence Berkeley National Laboratory* and is available at *https://emp.lbl.gov/wind-technologies-market-report*

The data on the developments on wind energy presented in *ECE* 333 make extensive use of the information presented in the 2021 edition of the *Land-Based Wind Market Report.*

2020 *US* WIND STATUS

- Wind power grew at a record pace in 2020: 16,836 *MW* of new capacity was added – an 84 % increase over the wind capacity added in 2019; the added capacity
  - is circa 42 % of the 2020 *US* capacity additions – the largest single technology share
  - increases the 2019 cumulative wind capacity by 15 %
  - keeps *US* as the second largest wind nation

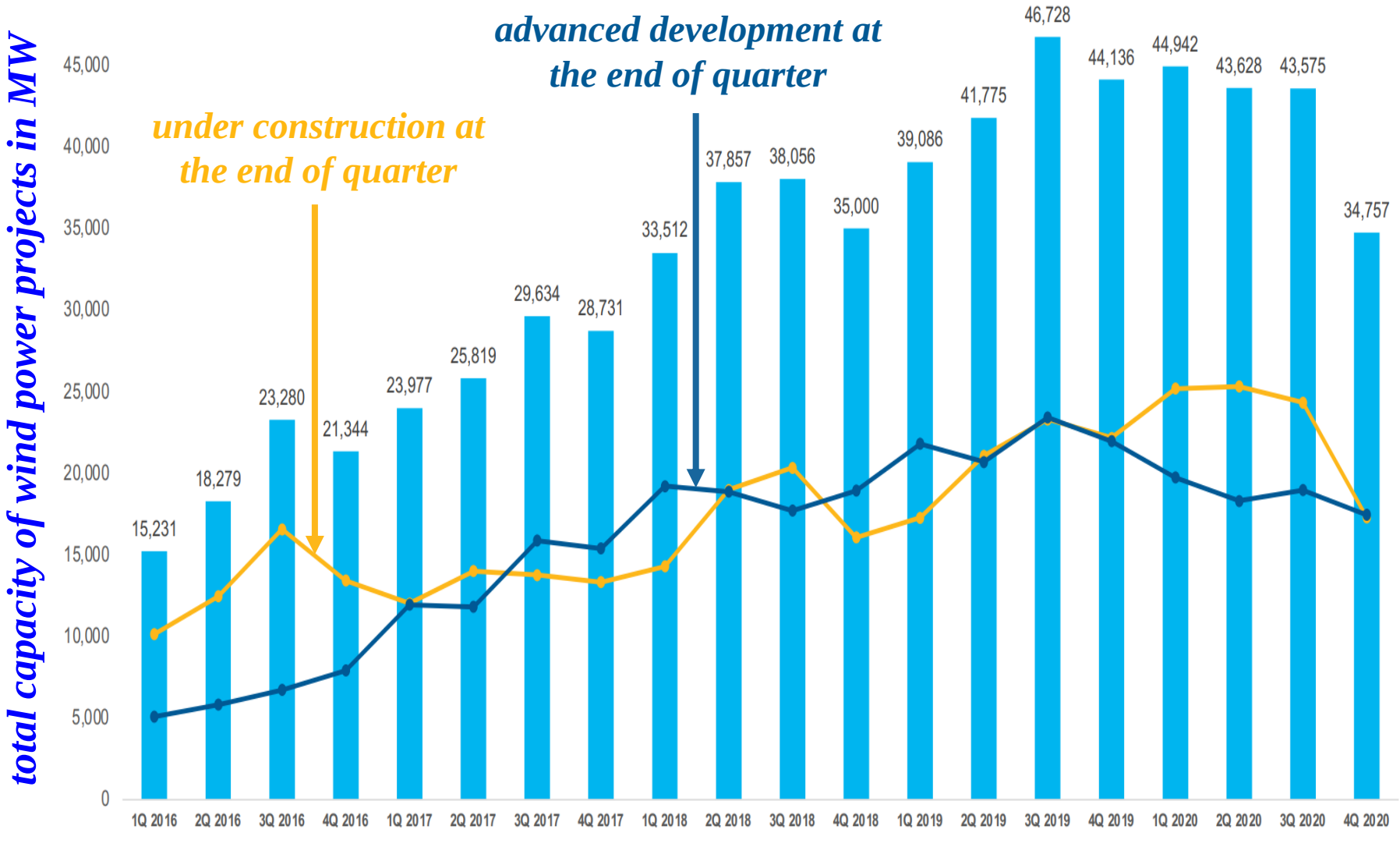
2020 *US* WIND STATUS

- The cumulative *US* wind capacity by the end of 2020 reached 121.98 *GW*
- *TX* remains the leading state in cumulative wind capacity:
  - *TX* added more capacity in 2020 – 4,138 *MW* – than every other state
  - *TX* share is above 25 % of the total *US* installed wind capacity

2020 *US* WIND STATUS

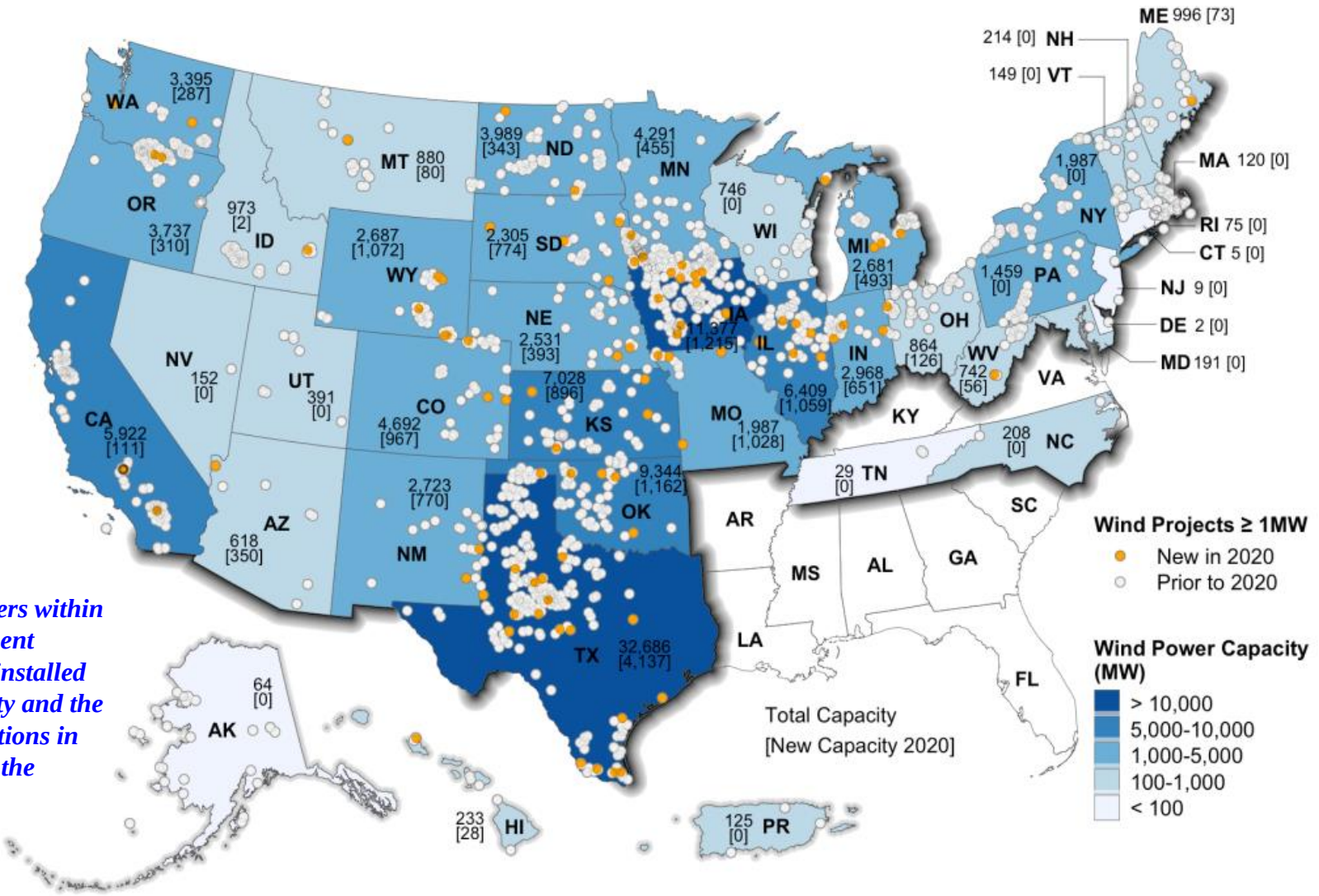
- Overall, wind ranked as the largest source of new *US* generation capacity added in 2020, ahead of solar with 8,542 *MW* and followed by natural gas with 6,259 *MW*
- *EIA* reports wind energy continues at a steady pace in 2021, with approximately 12.2 *GW* of wind projects scheduled to come online in 2021

QUARTERLY DEVELOPMENT STATUS OF *US* WIND PROJECTS: 2016 – 2020



Source: American Clean Power, U.S. Wind Industry Annual Market Report Q4 2020, p. 12.; available online at https://cleanpower.org/resources/types/reports/

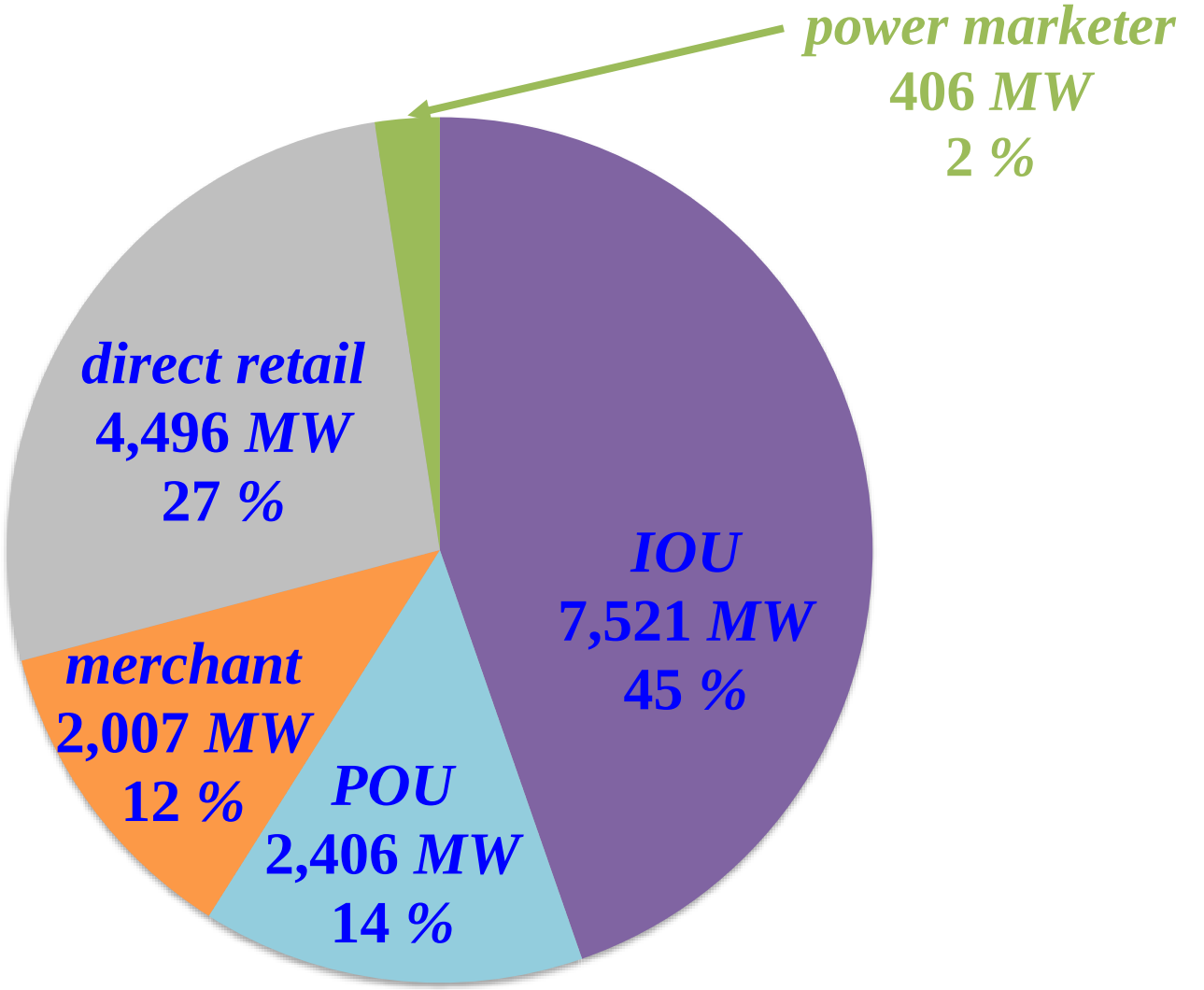
2020 *US* WIND POWER PROJECTS STATUS



Note: numbers within states represent cumulative installed wind capacity and the annual additions in 2020 within the brackets

Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 7; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

2020 WIND CAPACITY ADDITIONS BY OFF–TAKE CATEGORY



Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 22; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

IMPORTANT ECONOMIC INCENTIVES

- A critically important incentive in all wind projects is the production tax credit (*PTC*), whose level and duration is subject to Congressional actions
- The initial *PTC* in 2016 was set 0.015 *$/kWh* for the first 10 years of operation of all projects placed in service by that year, with 20 *% PTC haircuts* in each subsequent year

IMPORTANT ECONOMIC INCENTIVES

- For example, wind projects whose construction started by *January* 1, 2017 (2018) can get 80 (60) % of the full *PTC during* the first ten years of operation
- In *December* 2019, *Congress* extended the *PTC's* construction start deadline through 2020 and re-stored its level to 60% from 40% in 2019
- The *Internal Revenue Service* annually sets a multiplier to adjust the *PTC* for inflation

IMPORTANT ECONOMIC INCENTIVES

- In *May* 2020, pandemic-related supply chain disruptions led the *IRS* to extend the original 4–*year safe–harbor window* for projects that started construction in 2016 or 2017 to 5 *years*
- Those projects that started construction in 2016 (2017) had until the end of 2021 (2022) to be placed into service and to receive 100 (80) *%* of the full *PTC* during the first 10 *years* of operations

IMPORTANT ECONOMIC INCENTIVES

- At the end 2020, *Congress* again extended the *PTC* at the 60 % level for another year; under the new *PTC* legislation, wind projects whose construction is begun before *December* 31, 2021, qualify for the *PTC*
- In *June* 2021, the *IRS* extended the so-called *safe–harbor window* to 6 years for projects that started construction in 2016–2019 and to five years for those that initiated construction in 2020

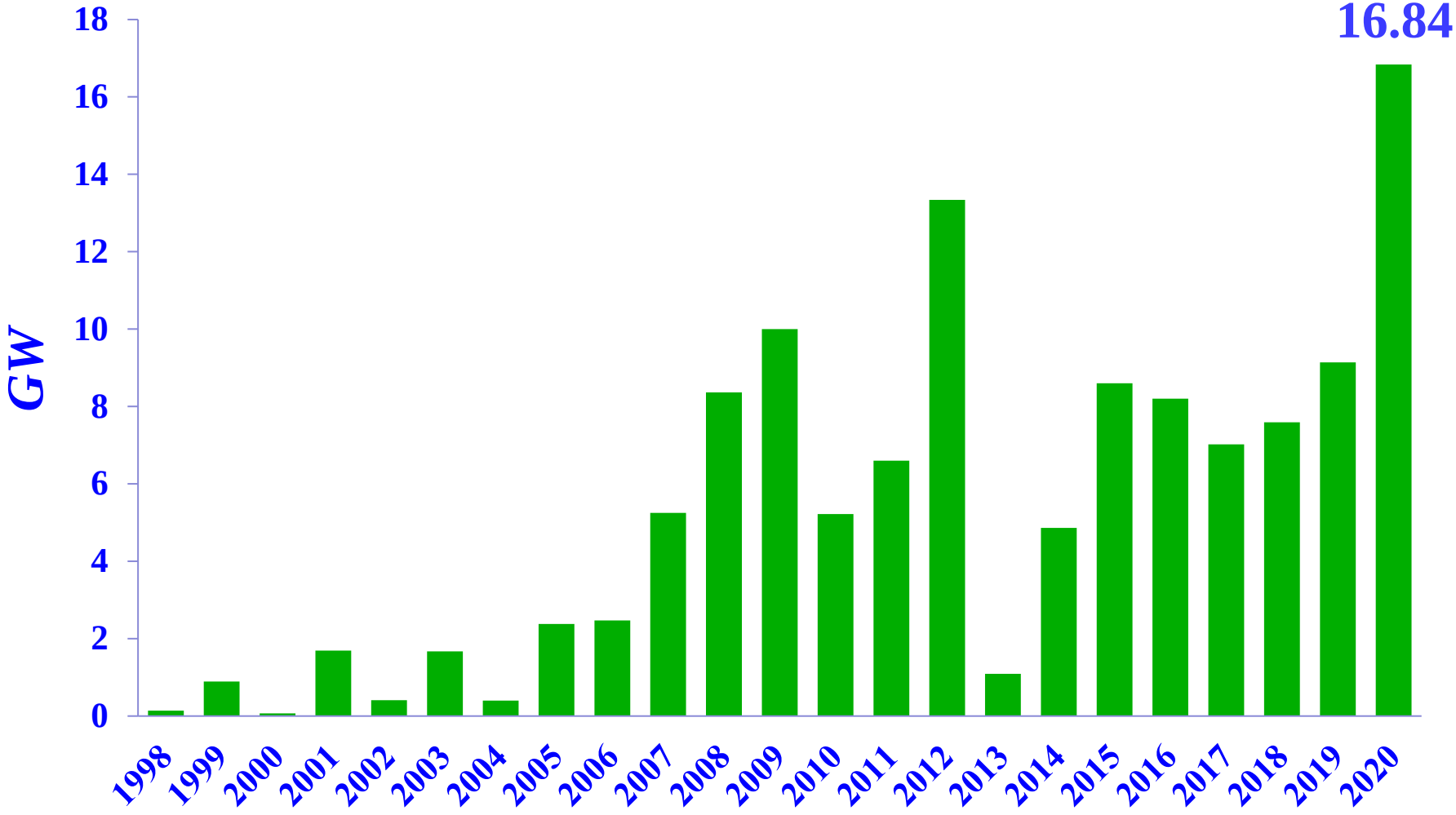
US WIND DEVELOPMENTS IN 2020

- Wind installed power capacity exceeds the *US* hydro capacity since 2016; moreover, wind became in 2018 the *largest capacity RER* in the *US*
- Added wind capacity in 2020 was 16,836 *MW* and the total installed wind capacity at the end of 2020 was 121,985 *MW*
- The *US* wind industry employed 116,801 people in 2020

US WIND DEVELOPMENTS IN 2020

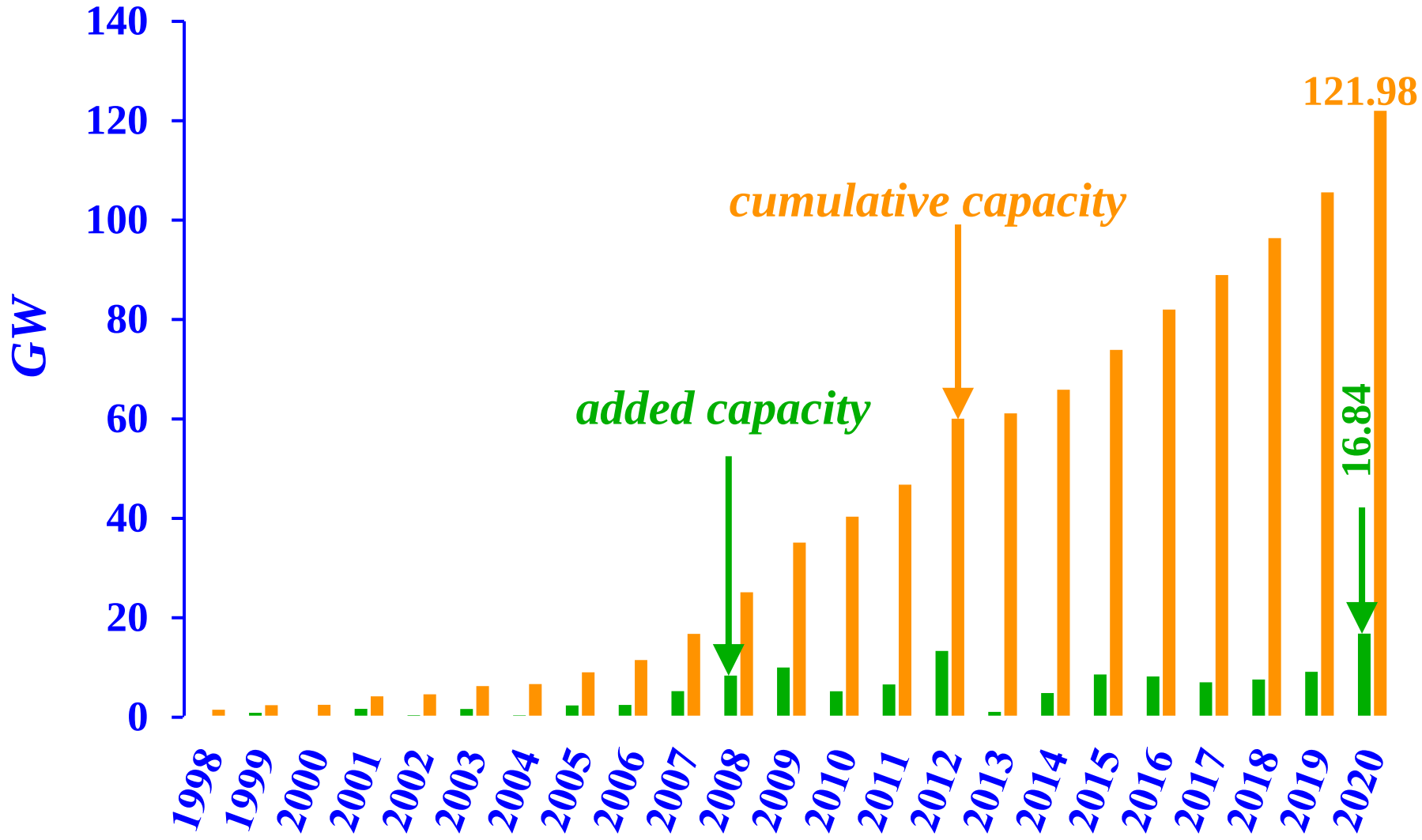
- The Biden Administration announced a targeted 30-*GW* offshore wind capacity by 2030
- *Bureau of Ocean Energy Management* (*BOEM*) created 5 new wind energy areas in the *New York Bight*
- *Vineyard Wind* 1 became the first fully approved *US* commercial offshore wind energy project

1998 – 2020 ANNUAL INSTALLED *US* WIND CAPACITY ADDITIONS



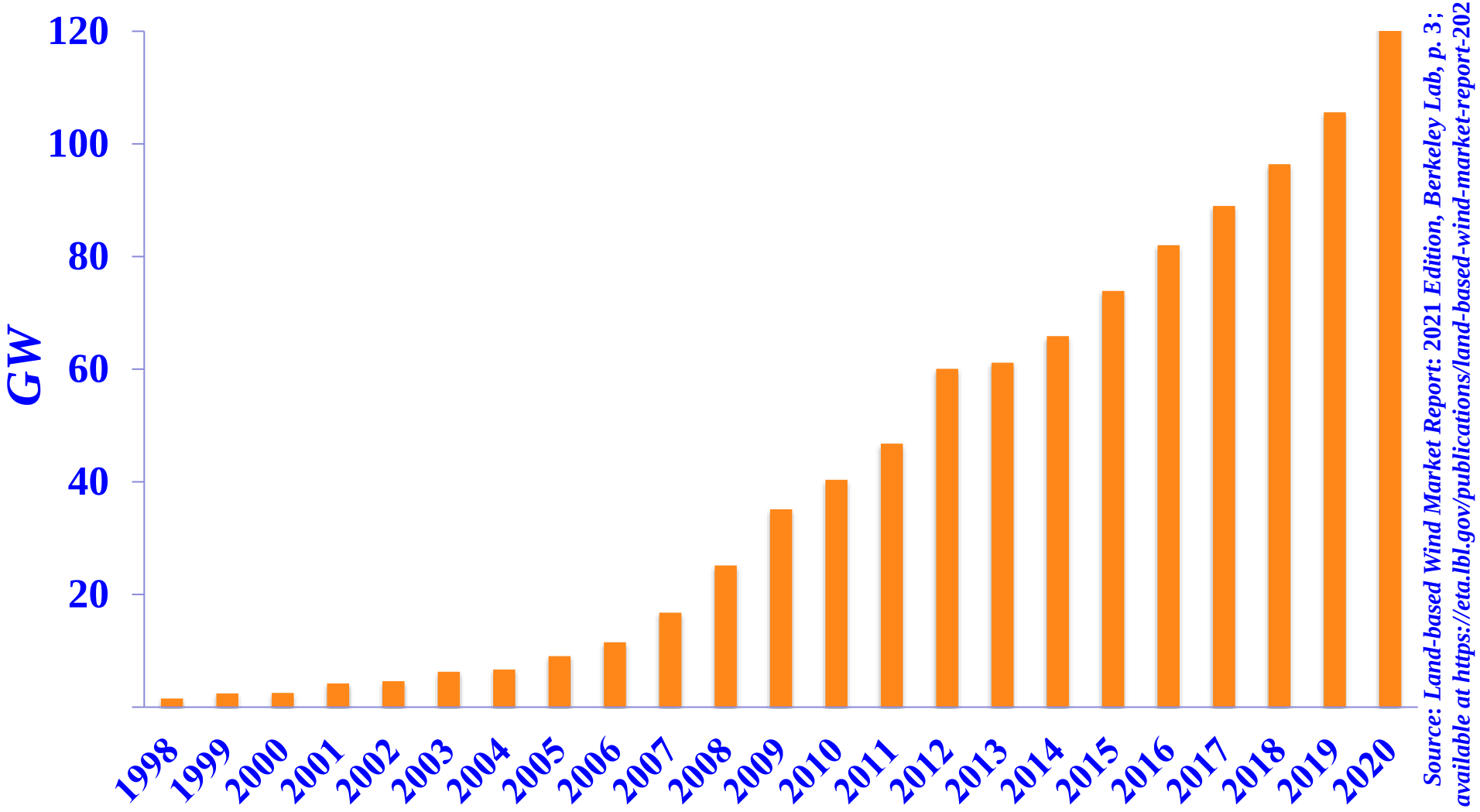
Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 3; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

1998 – 2020 *US* ANNUAL AND CUMMULATIVE INSTALLED WIND CAPACITY



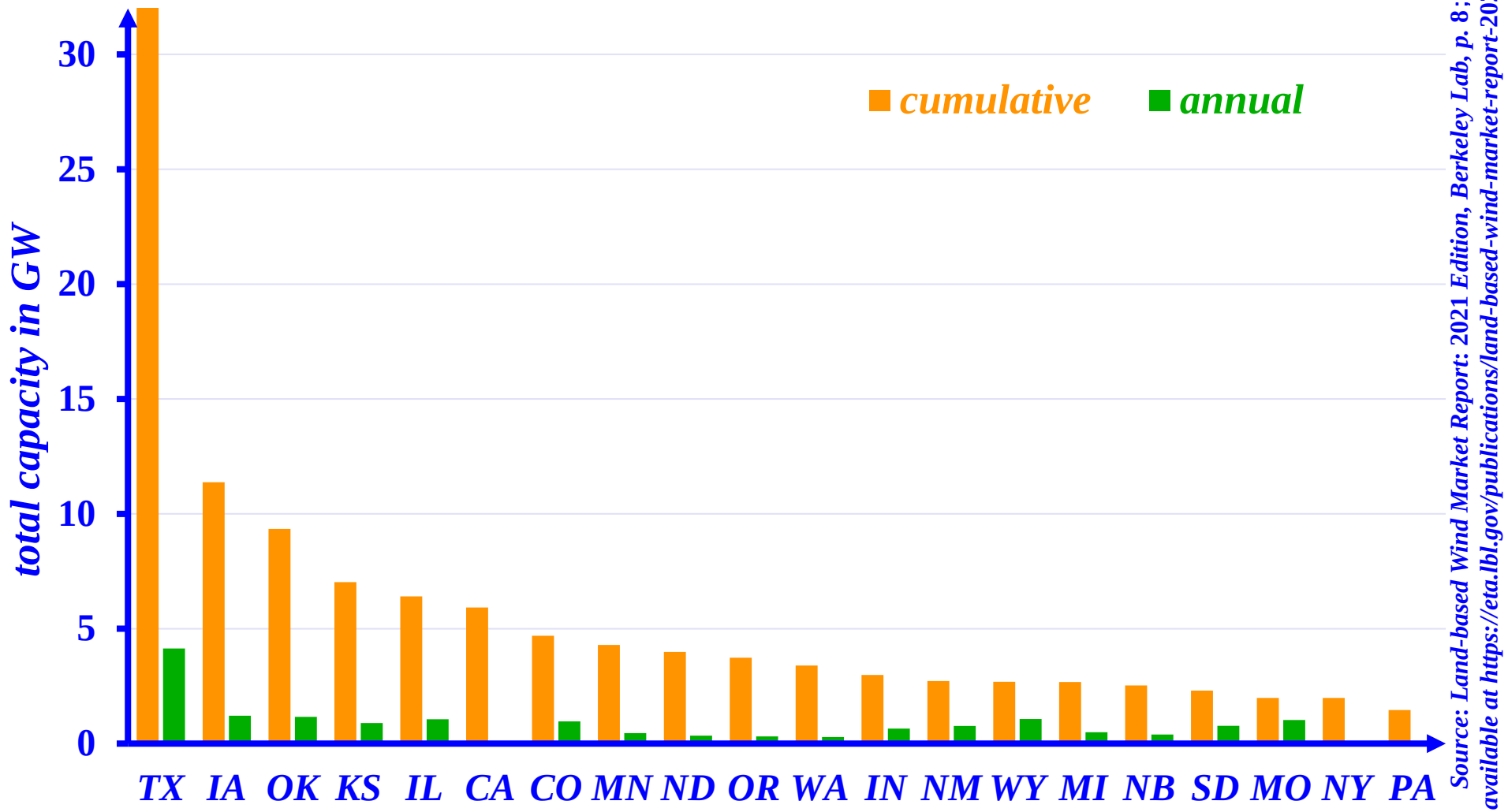
Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 3; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

US CUMMULATIVE WIND CAPACITY

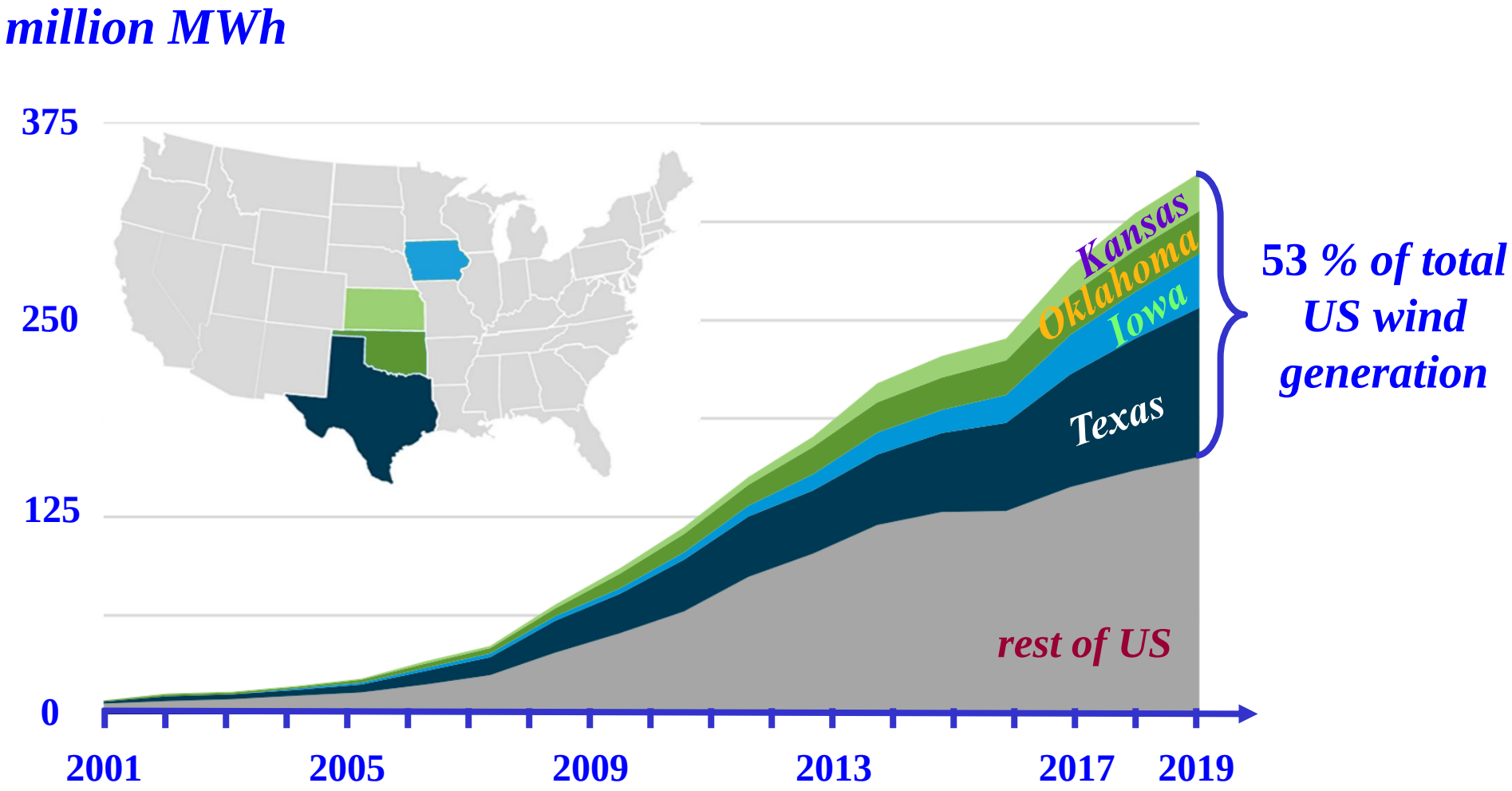


Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 3; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

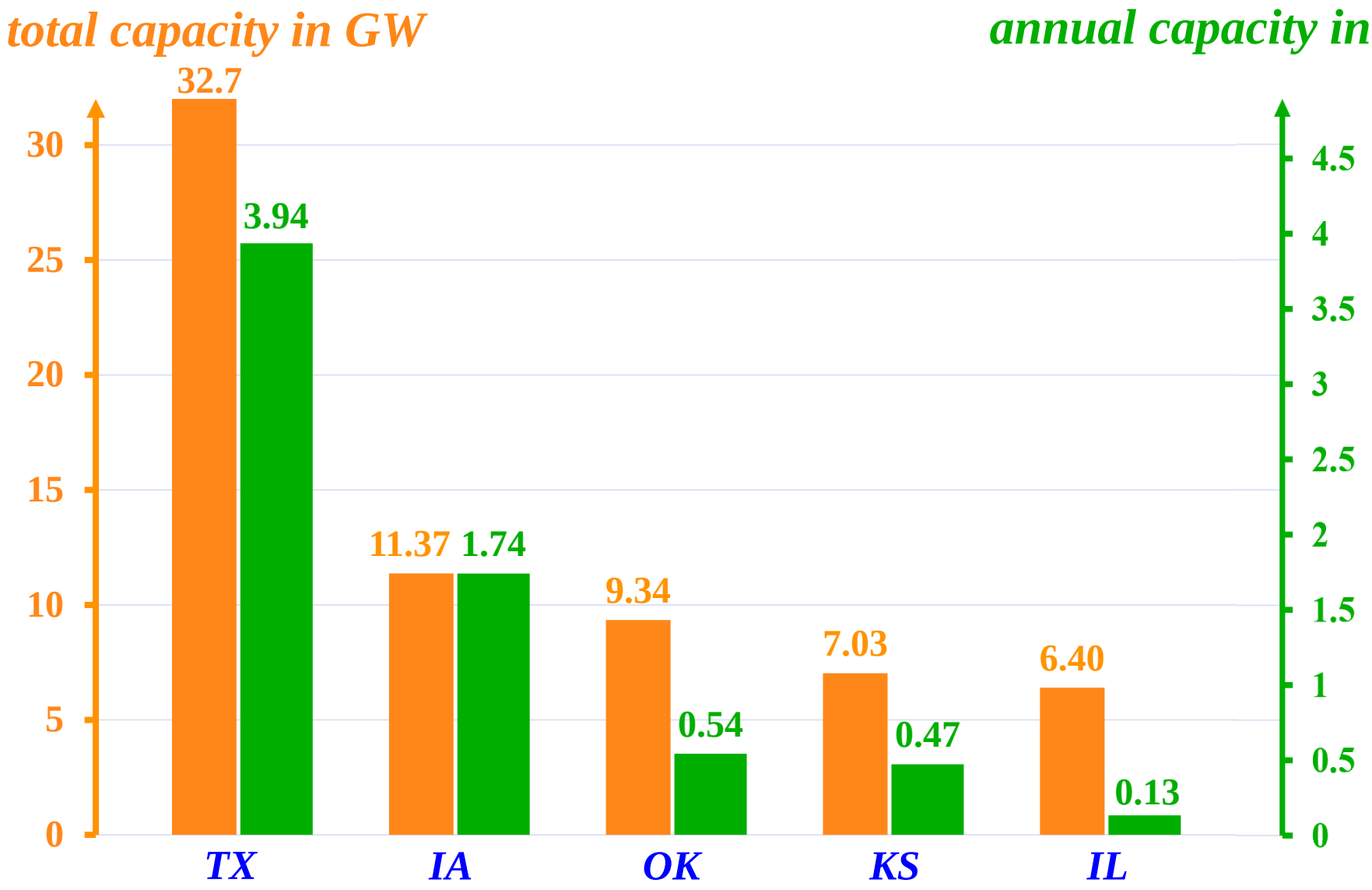
2020 : TOP 20 *US* STATES IN INSTALLED WIND CAPACITY



2020 *US* WIND ELECTRICTY GENERATION

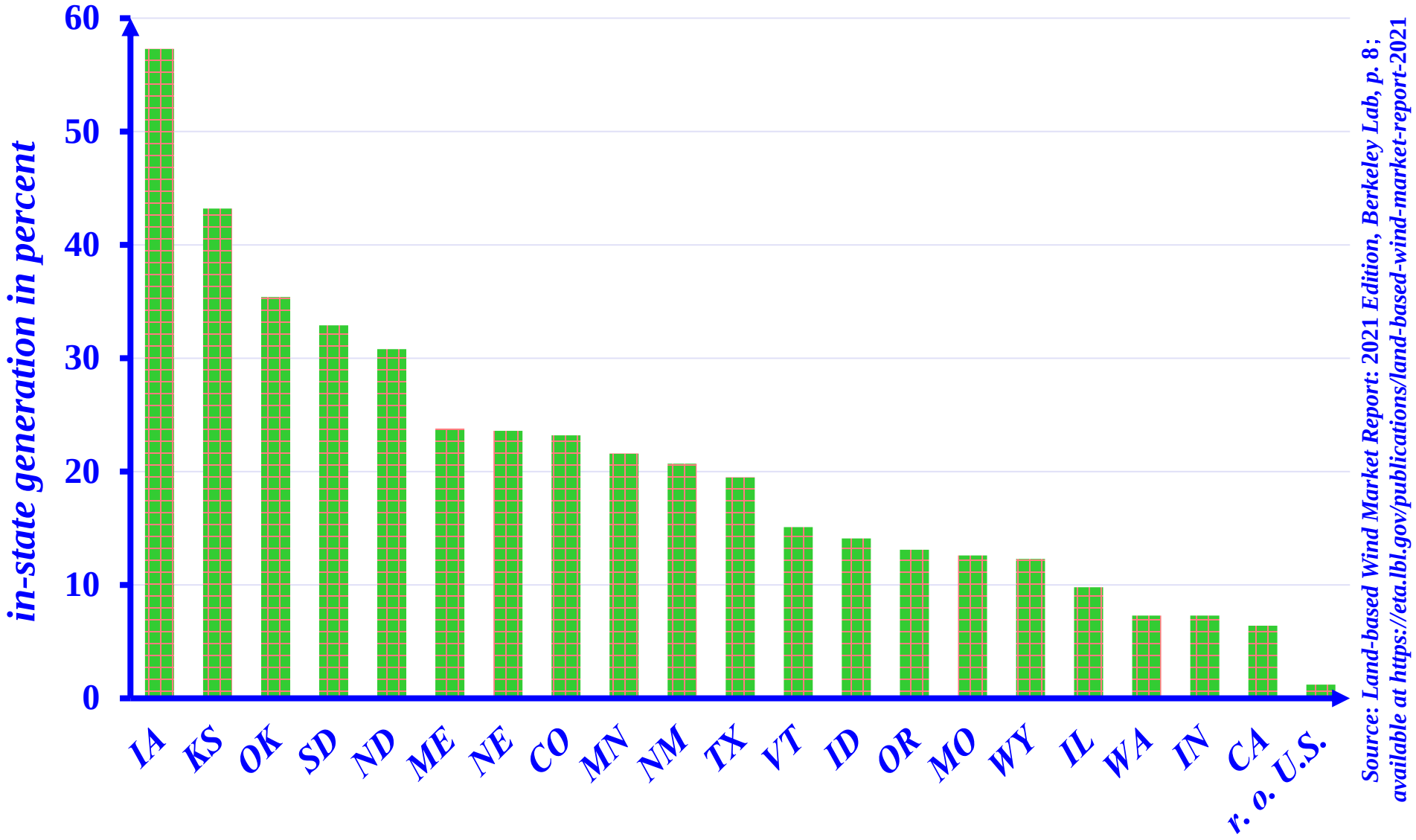


TOP 5 *US* STATES WITH INSTALLED WIND CAPACITY IN 2020

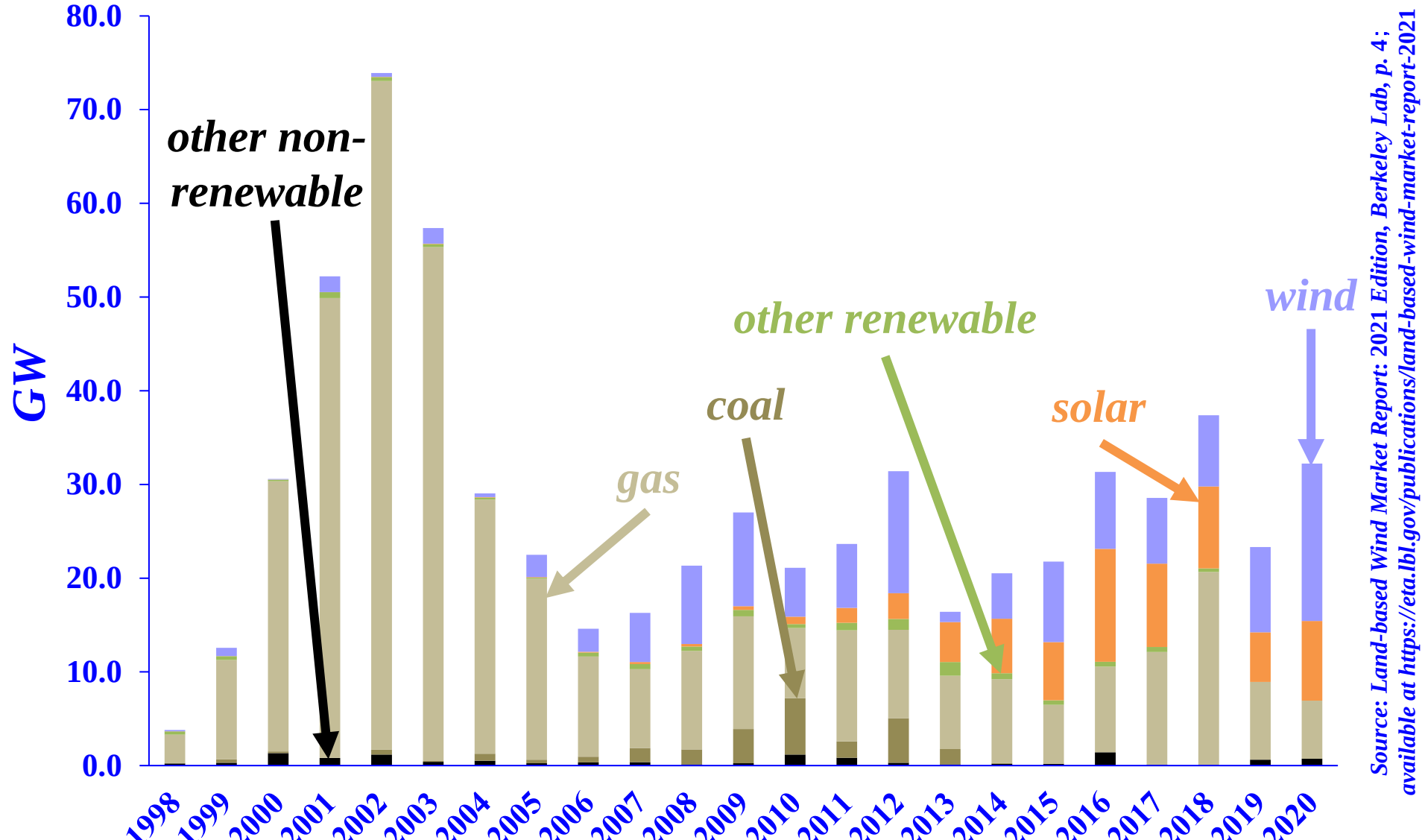


Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 8; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

2020: TOP 20 *US* STATES OF WIND GENERATED ENERGY SHARE

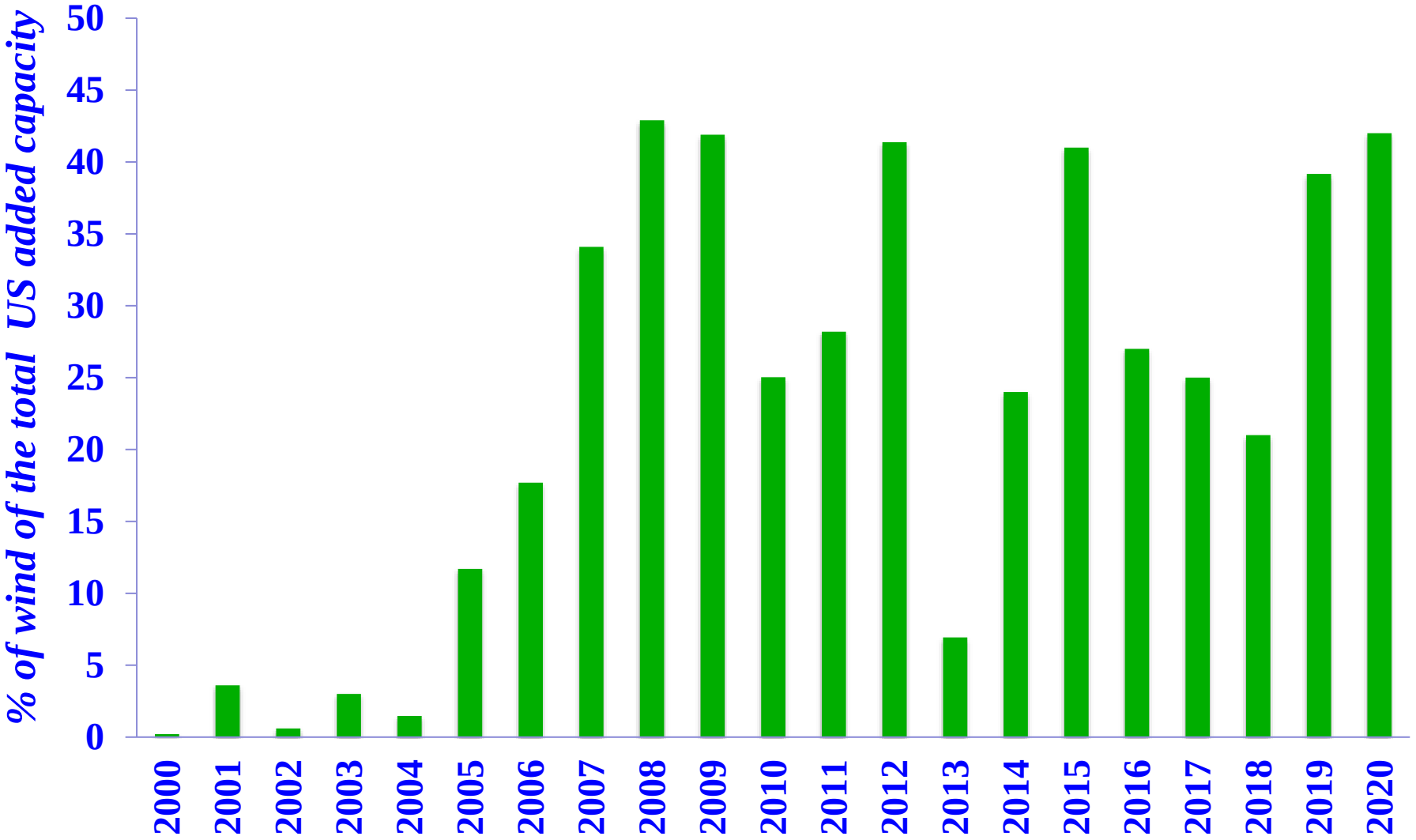


1998 – 2020 *US* CAPACITY ADDITIONS BY RESOURCE TYPE CATEGORY



Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 4; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

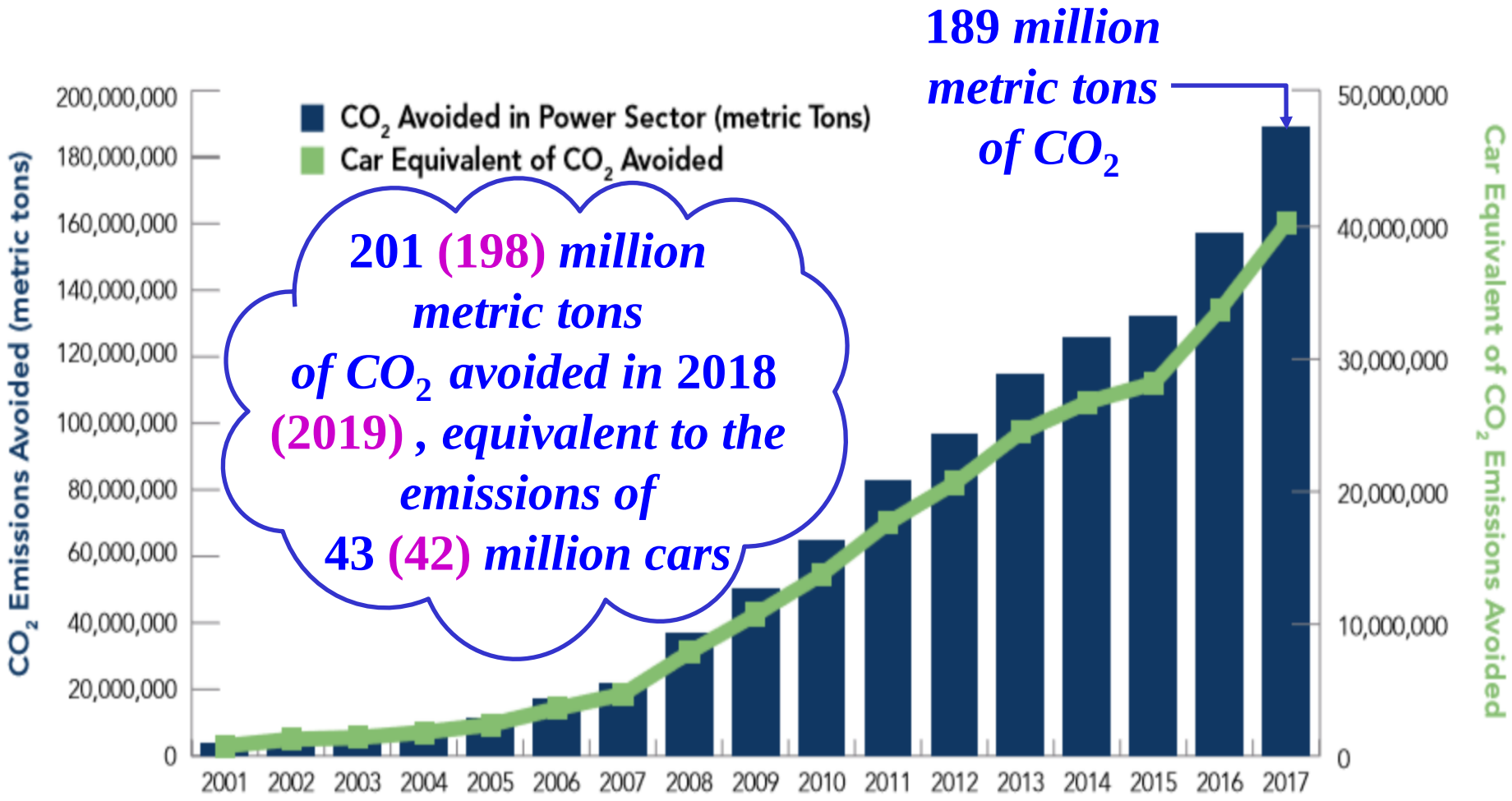
SHARE OF WIND OF THE TOTAL ADDED ANNUAL CAPACITY: 2000 – 2020



Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 4; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

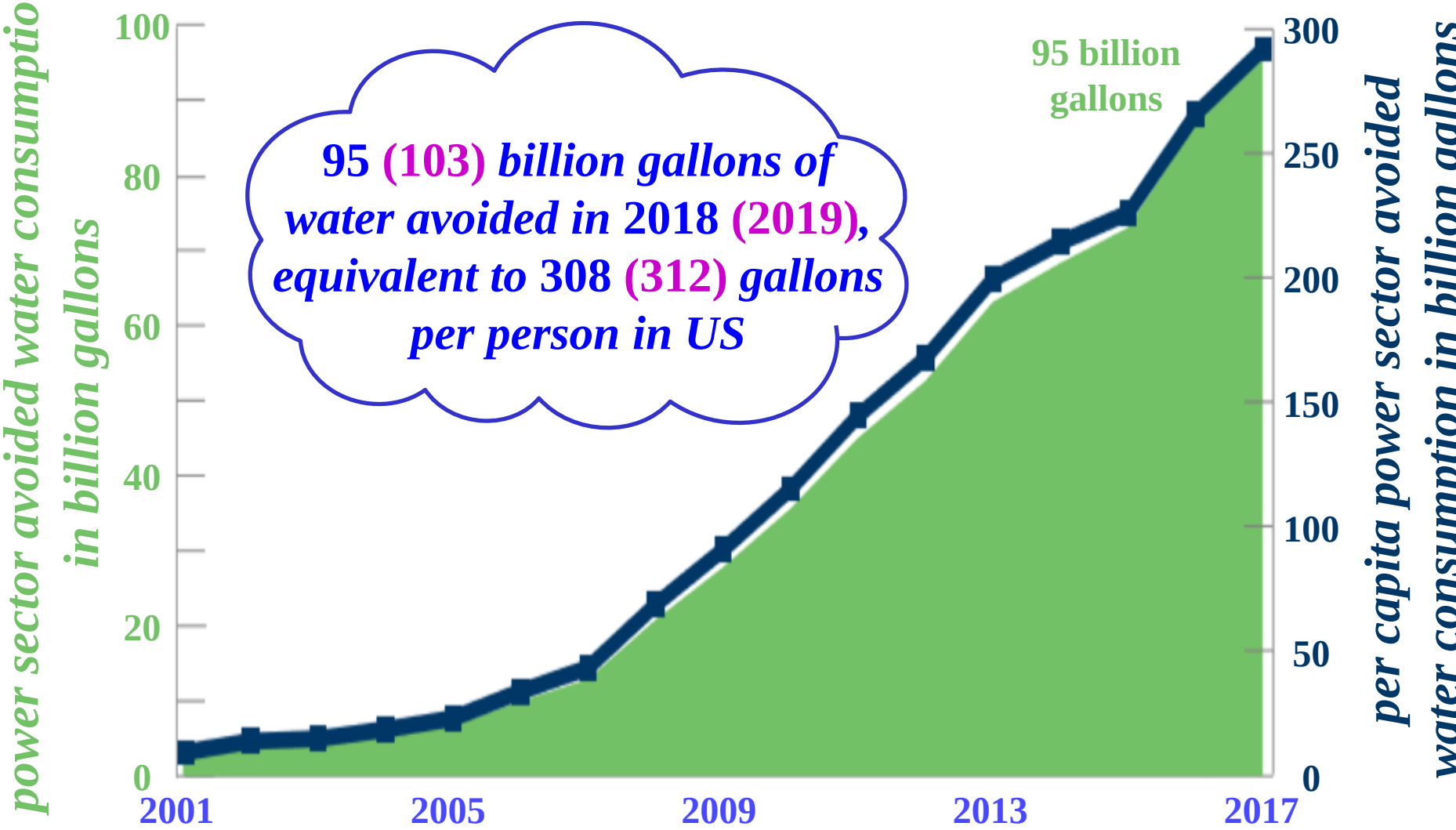
WIND ENERGY REDUCES *US GHG* EMISSIONS

source: American Clean Power WPA Executive Summary p. 5; available at https://cleanpower.org/resources/types/reports/

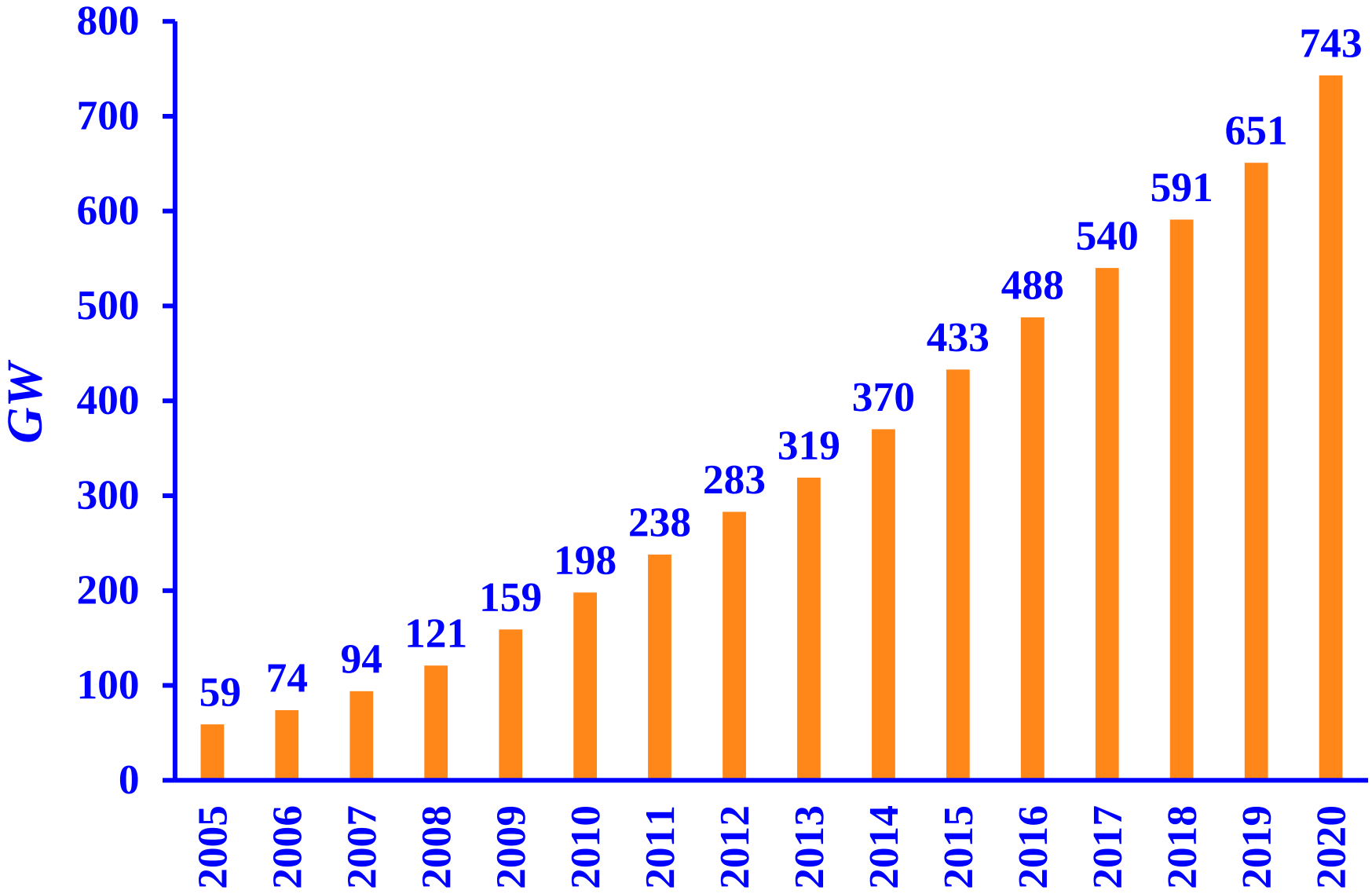


US WIND ENERGY IMPACTS: WATER CONSUMPTION SAVINGS

Source: https://cleanpower.org/facts/wind-power/



2005 – 2020 GLOBAL WIND CAPACITY



Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 5; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

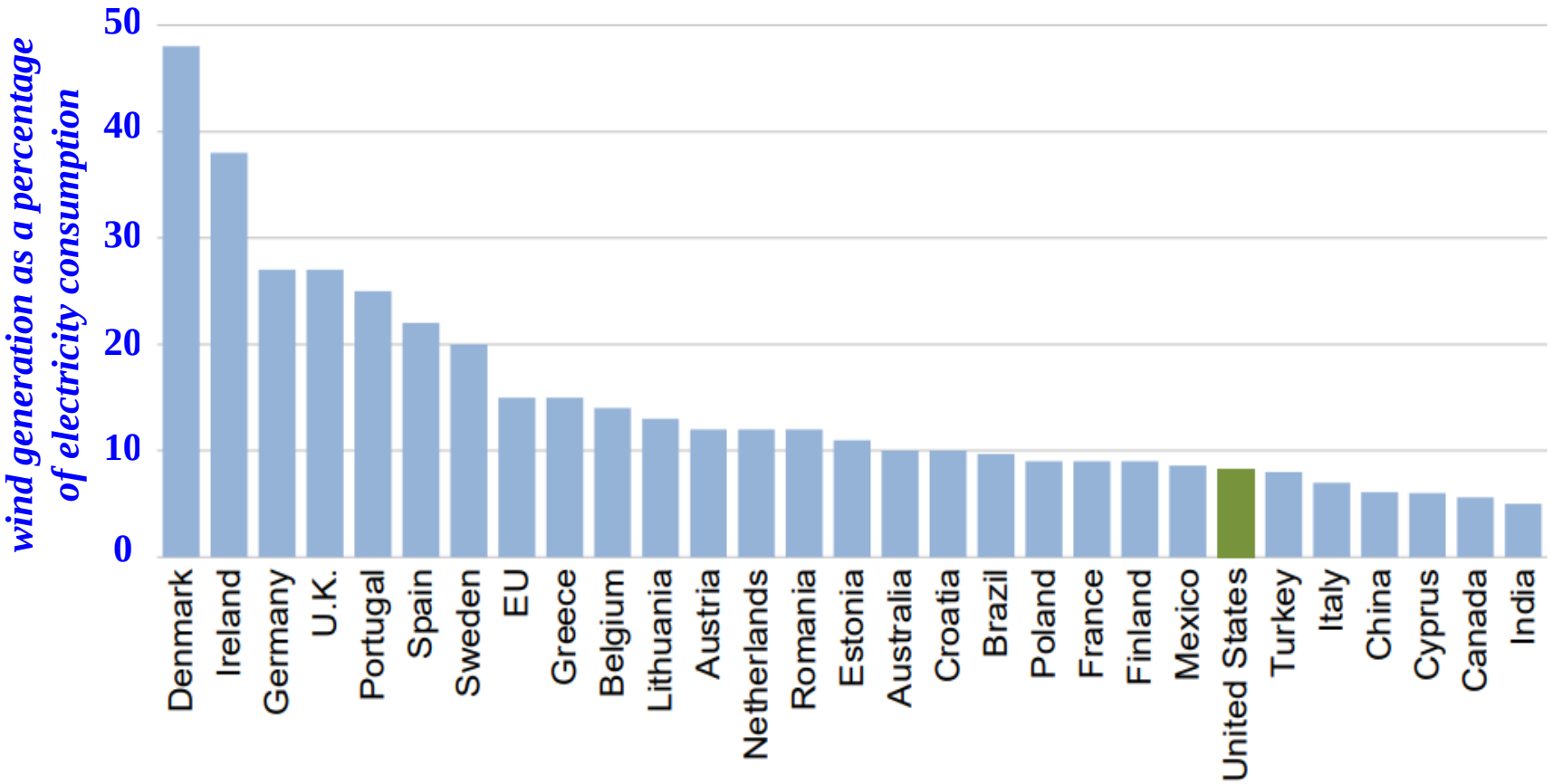
2020 WIND CAPACITY ADDITION AND CUMULATIVE TOTAL: TOP 10 NATIONS

2020 *capacity in MW*	
China	52, 000
United States	16, 836
Brazil	2, 297
Netherlands	1, 979
Germany	1, 668
Norway	1, 532
Spain	1, 400
France	1, 318
Turkey	1, 224
India	1, 119
rest of world	11, 538
total	92, 910

cumulative capacity in MW	
China	288, 320
United States	121, 985
Germany	62, 850
India	38, 625
Spain	27, 250
United Kingdom	23, 937
France	17, 948
Brazil	17, 750
Canada	13, 578
Italy	10, 543
rest of world	119, 572
total	742,357

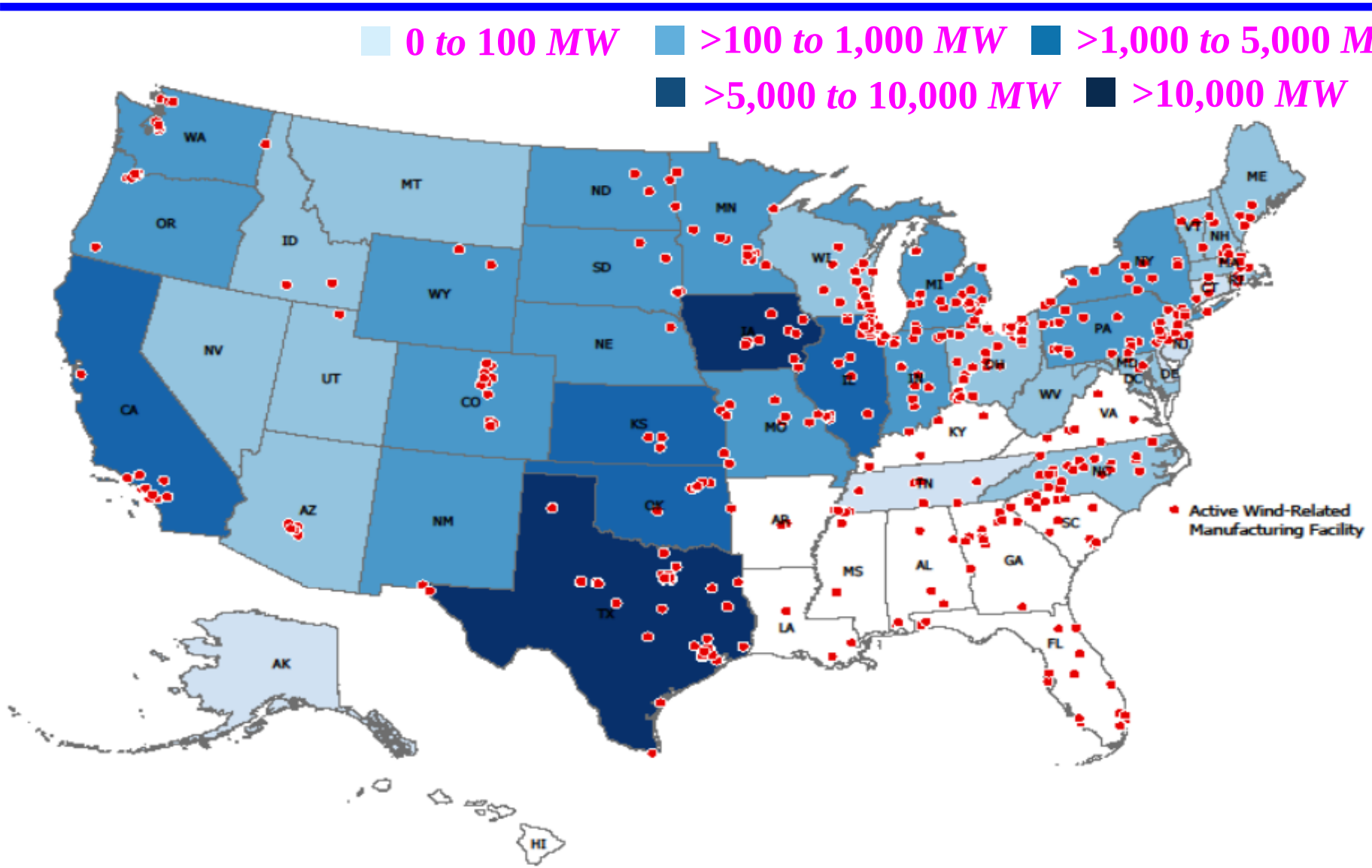
Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 6; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

LEADING NATIONS IN WIND ENERGY CONSUMPTION IN 2020



Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 6; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

2020 *US* WIND ENERGY INDUSTRY MANUFACTURING FACILITIES



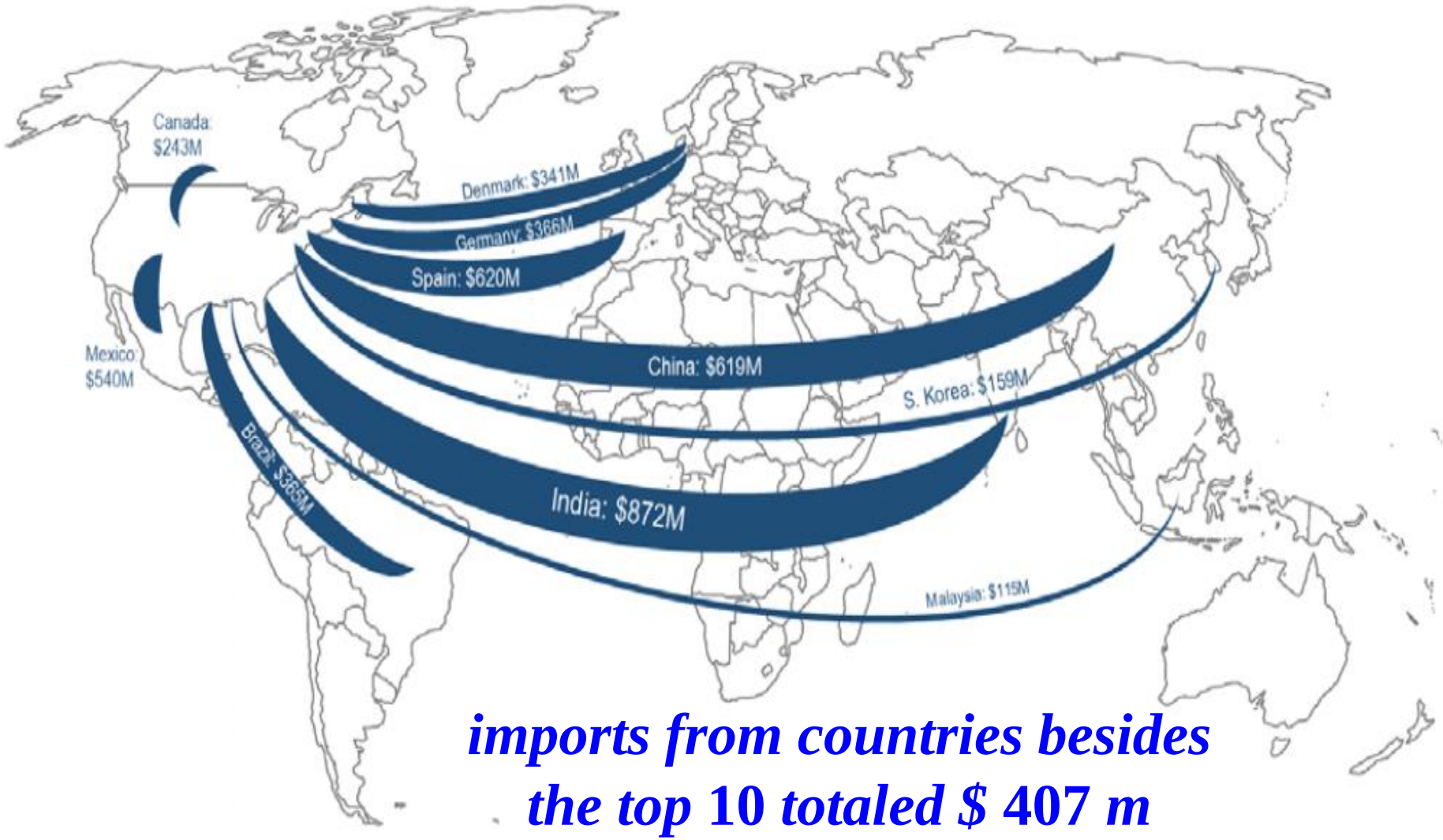
Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 14; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021

US WIND MANUFACTURER STATUS

- The manufacturing supply chain continued to adjust to swings in demand for wind equipment
- Of the 16,836 *MW* of wind capacity installed in 2020, 8,923 *MW* or 53 *%* used turbines from *GE Wind*, 5,724 *MW* or 34 *%* used *Vestas* and 1,515 *MW* or 9 *%* deployed *SGRE* equipment

WIND EQUIPMENT IMPORTS INTO *US*

Source: *Land-based Wind Market Report*: 2021 *Edition, Berkeley Lab, p.* 17; *available at https://eta.lbl.gov/publications/land-based-wind-market-report*-2021



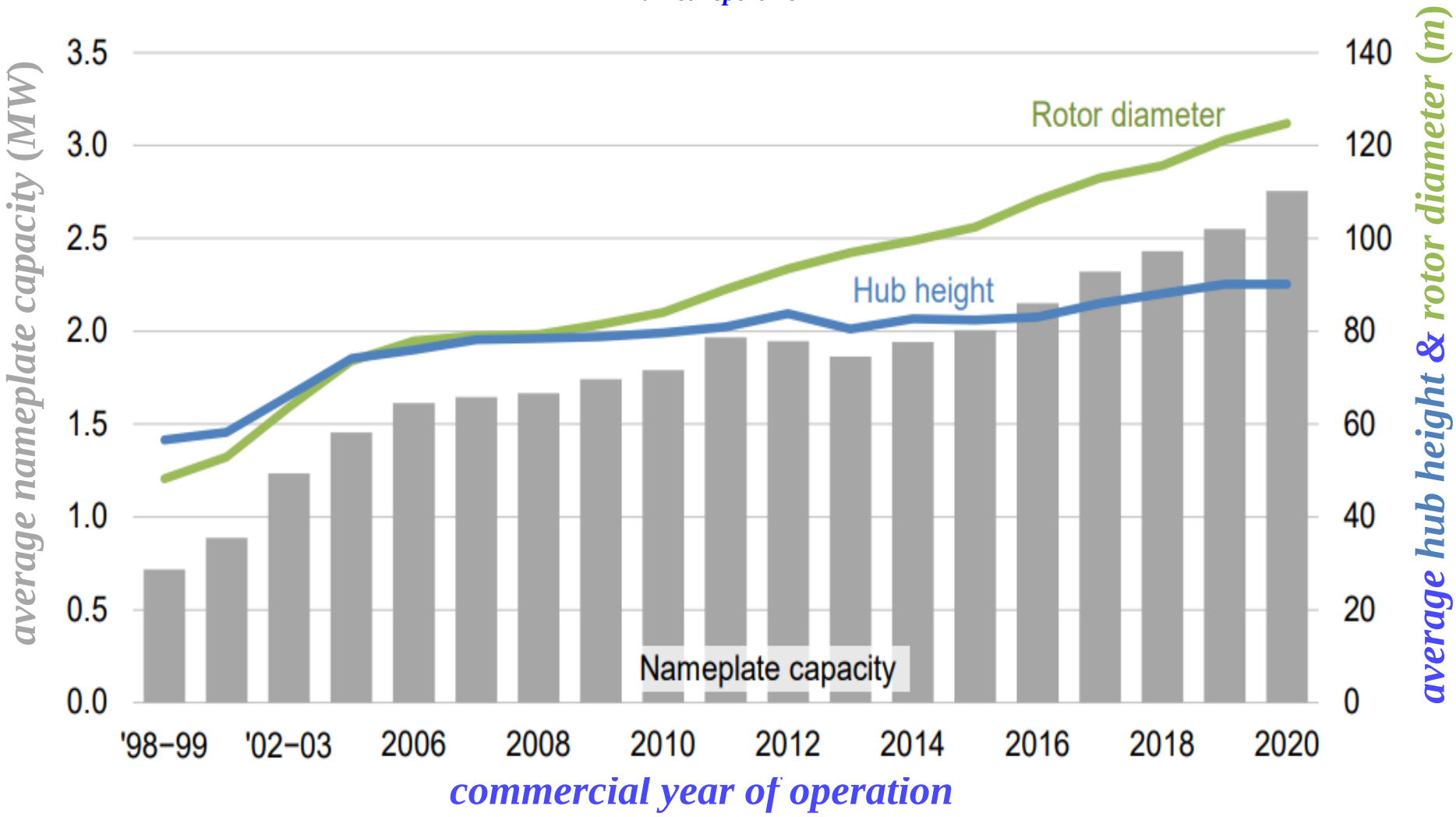
imports from countries besides the top* 10 *totaled* $ 407 *m

US WIND MANUFACTURER STATUS

- *Nordex Acciona* and *Goldwind* supplied 3% and 1%, respectively, of the remaining capacity
- Despite the sizeable imports wind technology equipment, the *US* has big domestic wind manufacturing capability; in 2020, domestic nacelle assembly capability was able to supply 15 *GW* of installed wind capacity, 9.4 *GW* of the blades and 10.3 *GW* of the towers

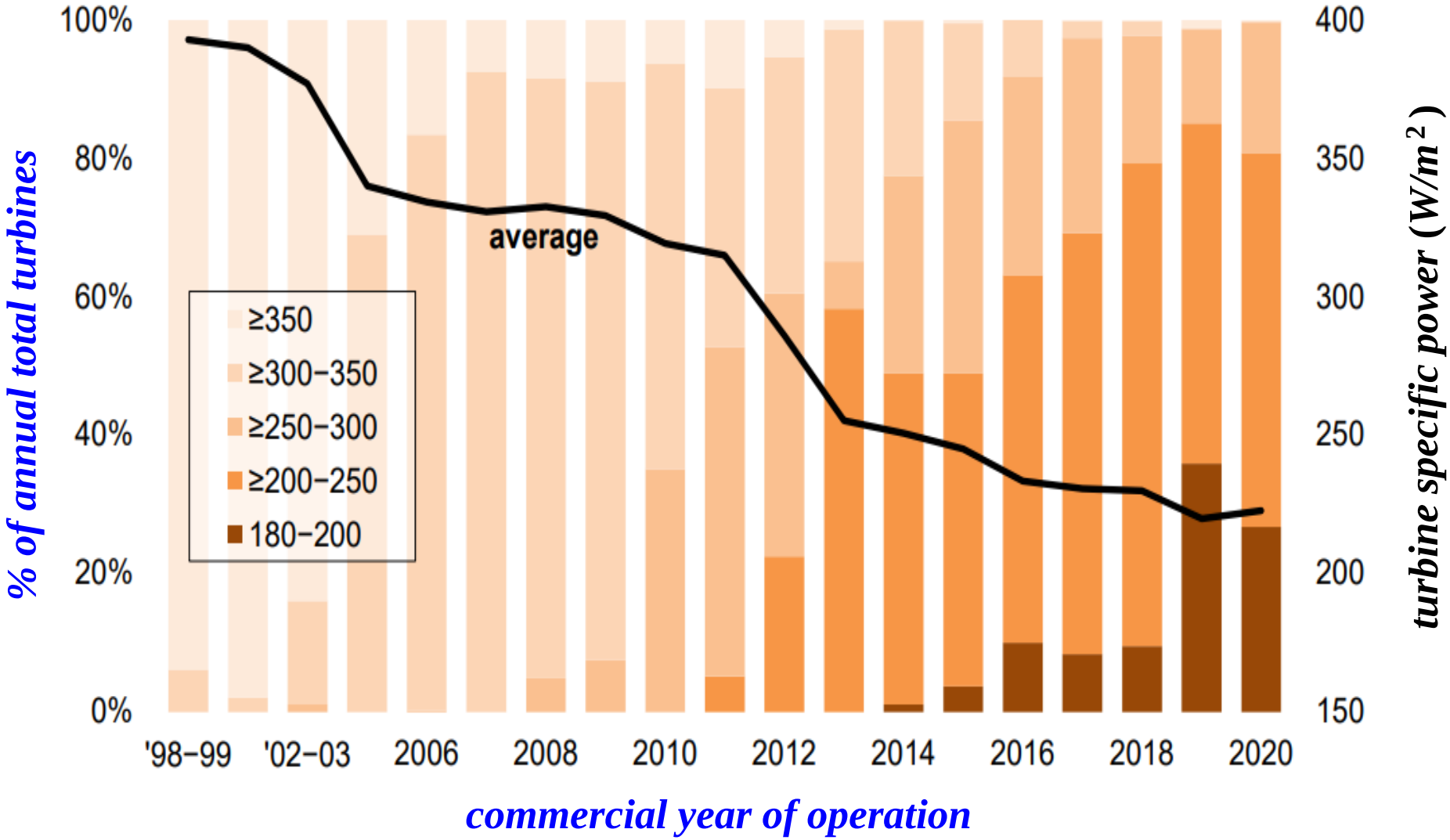
AVERAGE WIND TURBINE FEATURES

Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 23; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021



TURBINE SPECIFIC POWER TRENDS

Source: Land-based Wind Market Report: 2021 Edition, Berkeley Lab, p. 24; available at https://eta.lbl.gov/publications/land-based-wind-market-report-2021



TURBINE SPECIFIC POWER TRENDS

- The specific power of a turbine is the ratio of its nameplate capacity to the area swept by the rotor

$$turbine\ specific\ power = \frac{nameplate\ capacity}{rotor\ swept\ area}$$

- The *average specific power* of the *US* turbine fleet decreased from 394 W/m^2 – the 1998 – 1999 projects – to 224 W/m^2 of the 2020 projects, as the increase in the *average rotor swept area* outpaced the *average nameplate capacity* increase over this period

OFFSHORE WIND POWER

- Offshore wind is, typically, faster and steadier than onshore wind
- Offshore wind entails, in general, higher cons–truction/maintenance costs than onshore wind; moreover, the transmission part development poses a huge challenge
- Offshore wind may be an unwelcome sight for local residents and may impact marine life

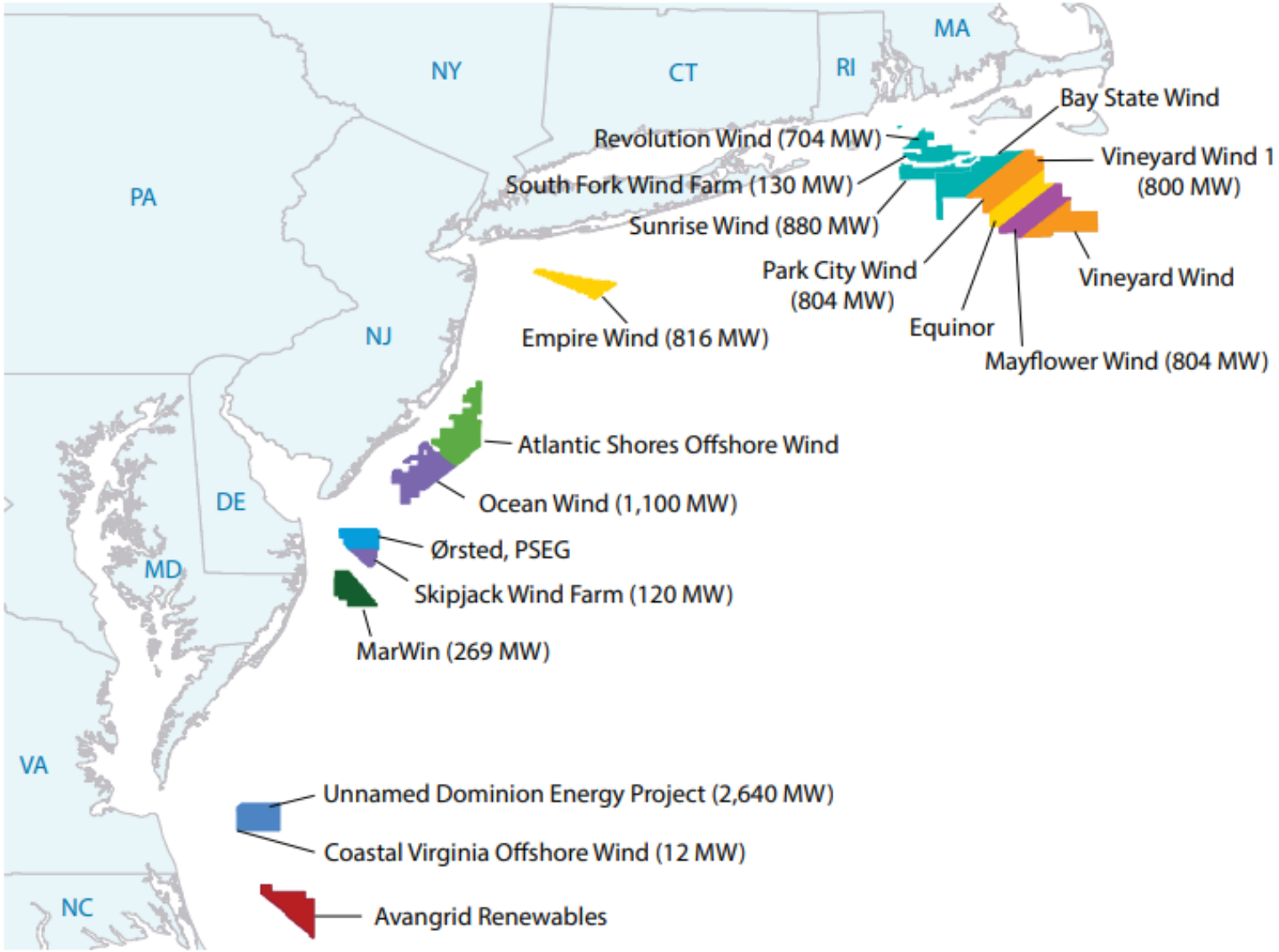
2020 STATUS OF *US* OFFSHORE WIND POWER

- The *US* offshore wind energy project development and operational pipeline grew significantly with a potential capacity of 35.3 *GW* at the end of 2020
- The pipeline experienced a 24 % increase in 2020 from the 28.5 *GW* potential capacity in 2019

2020 STATUS OF *US* OFFSHORE WIND POWER

- In December 2016, the *Deepwater Wind* completed the commissioning of the first commercial offshore wind project in the *US*
- At the end of 2020, the many *US* offshore wind projects are in various stages of development

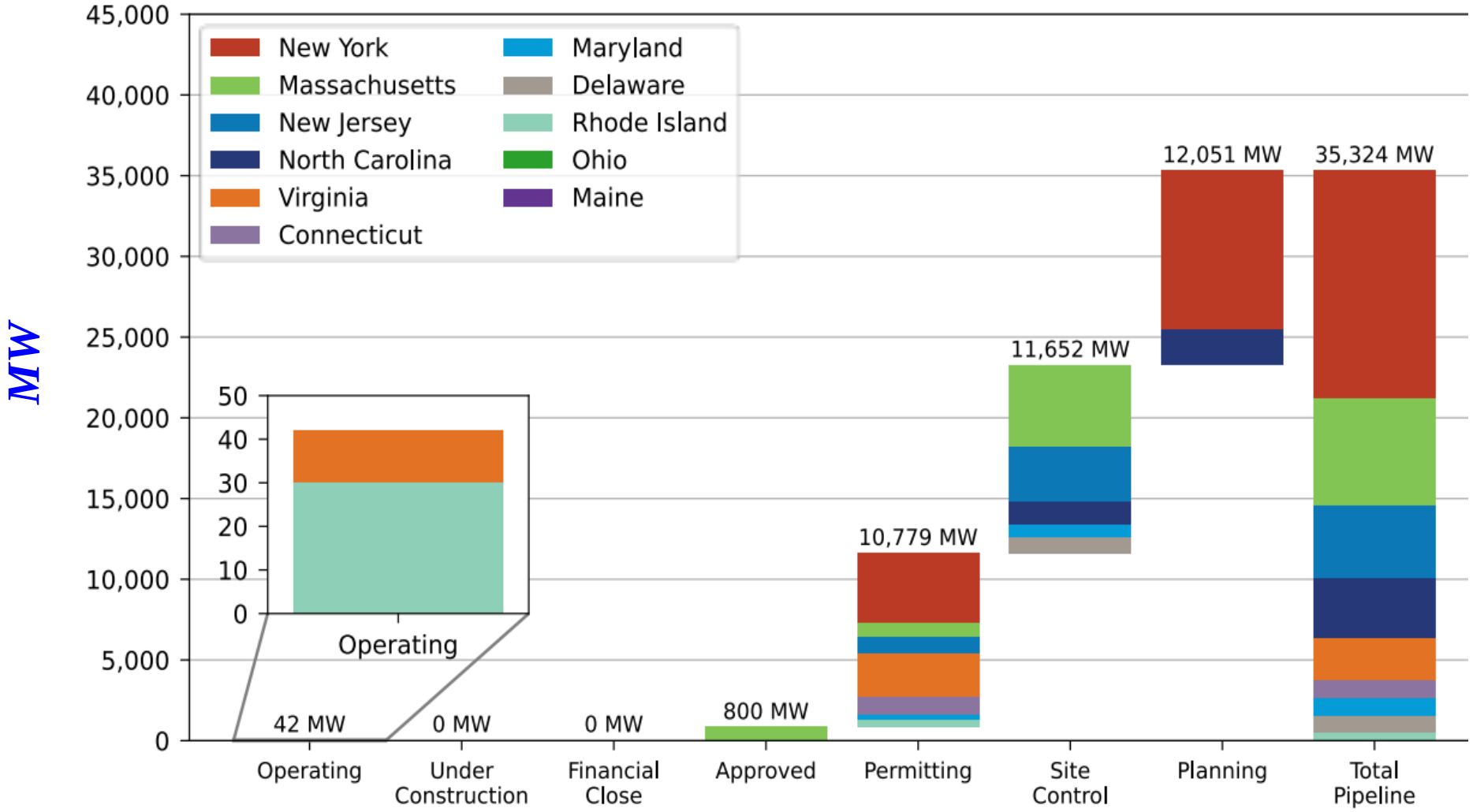
EAST COAST OFFSHORE WIND PROJECTS AND LEASE AREAS



Source: America Clean Power WPA Executive Summary p. 4; available at https://cleanpower.org/resources/types/reports/

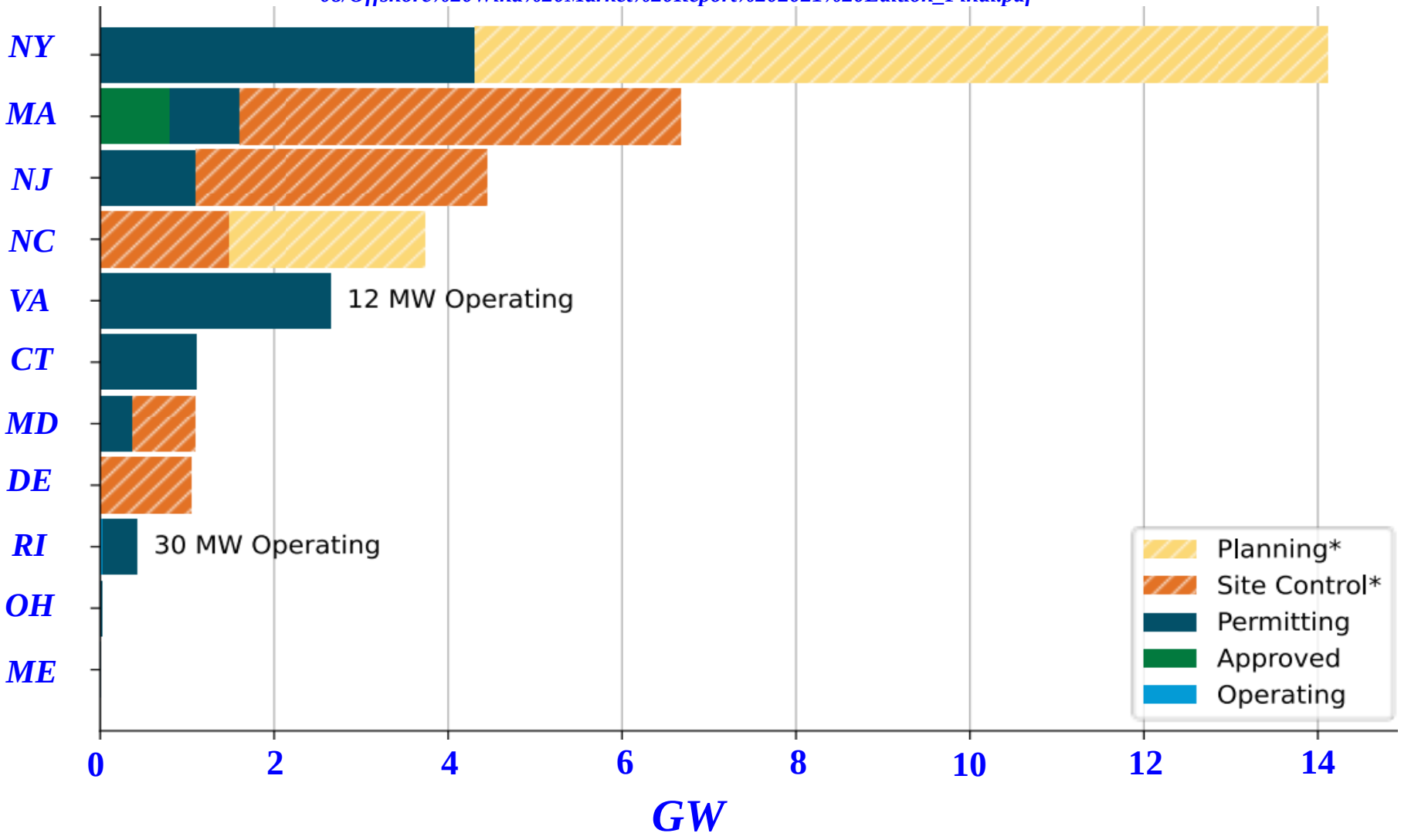
2020 *US* OFFSHORE WIND PROJECT PIPELINE BY PROJECT STATUS

Source: 2021 *Offshore Wind Technology Data Update, US Department of Energy, p. 11. available at https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf*



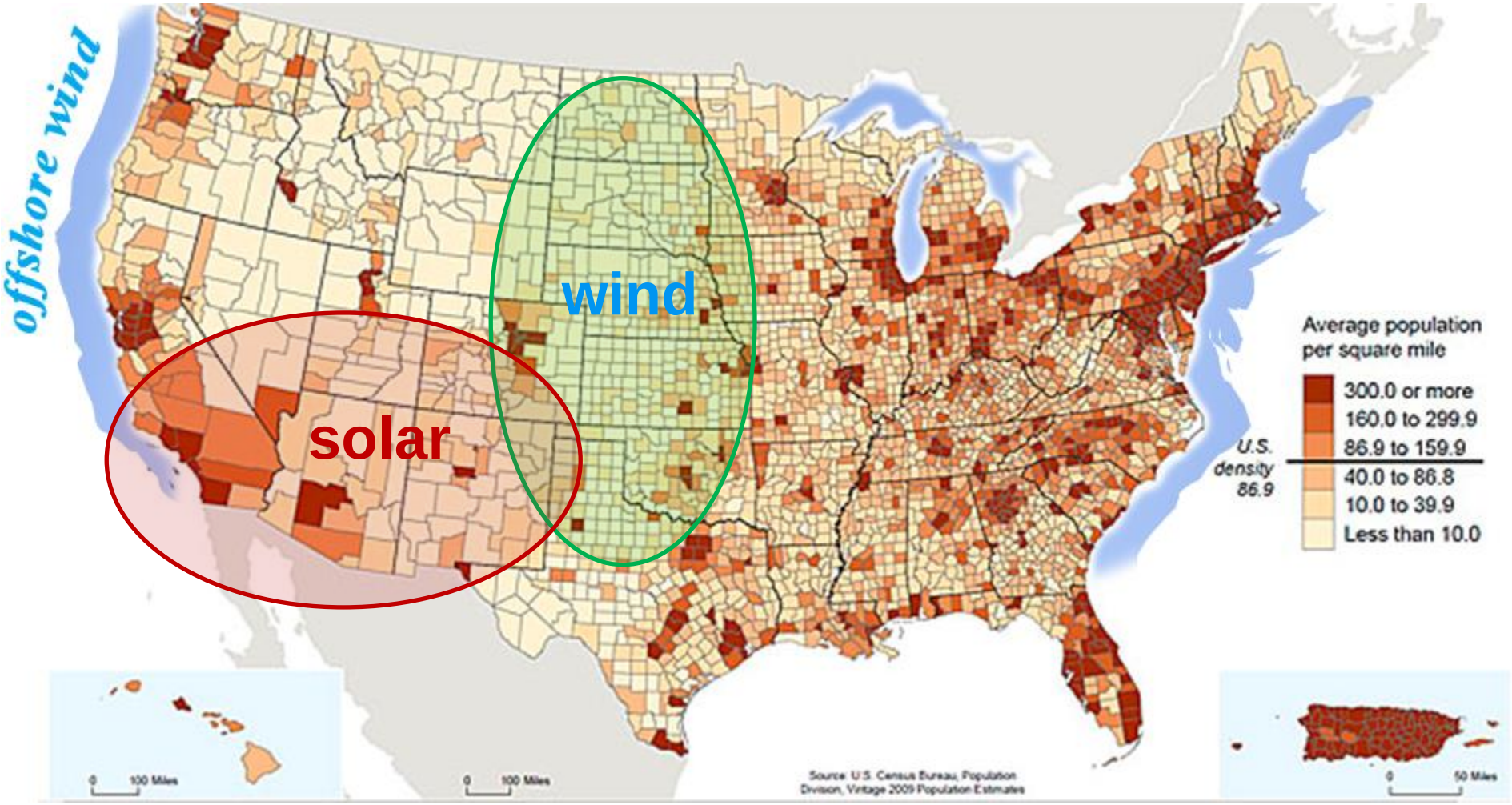
2020 *US* OFFSHORE WIND PROJECT STATUS BY STATE

Source: 2021 *Offshore Wind Technology Data Update, US Department of Energy, p. 12. available at https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf*



US POPULATION DENSITY AND RENEWABLE RESOURCE LOCATIONS

Source: http://www.census.gov/popest/data/maps/2009/PopDensity_09.jpg



NREL REPORT ON *US* OFFSHORE WIND POTENTIAL

- *NREL* issued a report that discusses *US* offshore wind potential, with its key conclusion being that by 2030 *US* could harness 54 *GW* of offshore wind
- *US* offshore wind has a significant advantage in that the supply may be located relatively close to the high–density load regions in urban areas
- The leading global offshore wind producers are *Great Britain*, *China*, *Germany* and *Denmark*

BLOCK ISLAND WIND FARM

- First commercial *US* offshore wind farm
- Installed capacity: 30 *MW* (5 turbines)
- Farm has five 6–*MW GE Haliade* turbines
- 21 *miles* submarine power cable
- *PPA* initial price: 24.4 *¢/kWh*

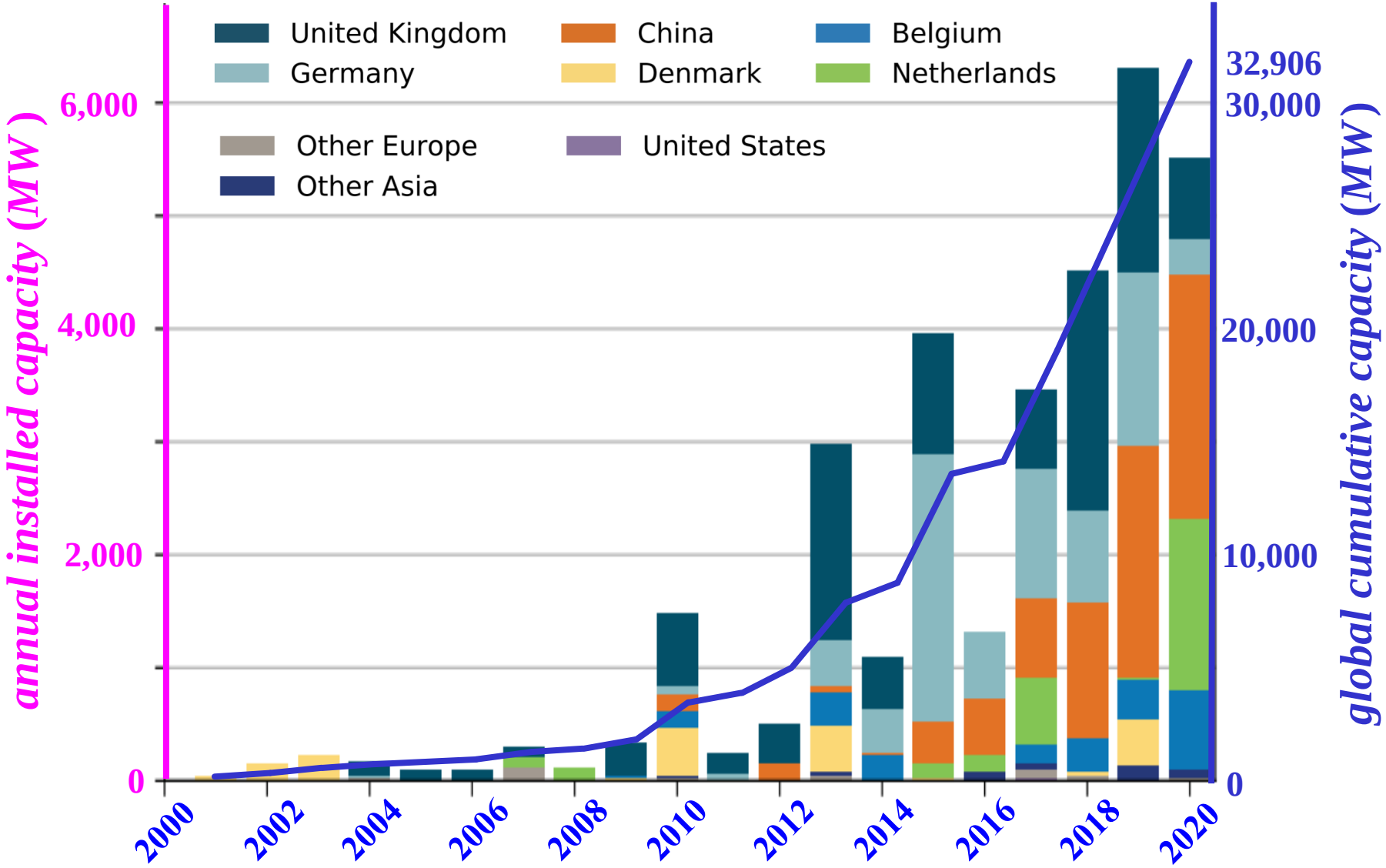
BLOCK ISLAND KEY CHARACTERISTICS

- Absence of economies of scale
- Large investment
- Uncompetitive prices
- Imported technology
- Long delays from the September 2008 start date
- Major breakthrough for offshore wind in the *US*

2020 STATUS OF GLOBAL OFFSHORE WIND POWER

- In 2020, the global offshore wind energy industry installed 5.5 *GW* of capacity
- Much of the added global generating capacity can be attributed to 2.1 *GW* of new deployments in the *Chinese* market, followed by 1.5 *GW* commissioned in the *Netherlands*, 714 *MW* in the *UK*, 706 *MW* in *Belgium*, 315 *MW* in *Germany* and the remaining 107 *MW* in the *r.o.t.w.*

2020 GLOBAL OFFSHORE WIND STATUS



Source: 2021 Offshore Wind Technology Data Update, US Department of Energy, p. 37. available at https://www.energy.gov/sites/default/files/2021/08/f87/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf

NREL REPORT ON *US* OFFSHORE WIND POTENTIAL

- Offshore wind turbines currently need to be in relatively shallow water and the maximum distance from the shore depends on the nature of the seabed
- Capacity factors tend to increase as turbines move further offshore into deeper waters

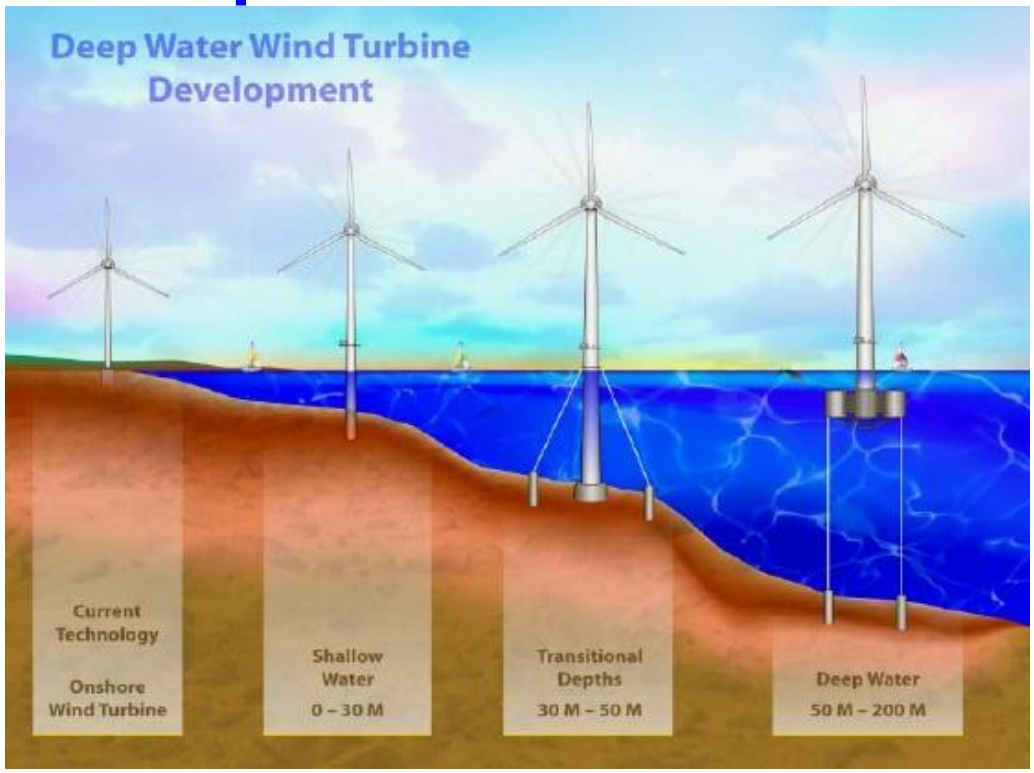
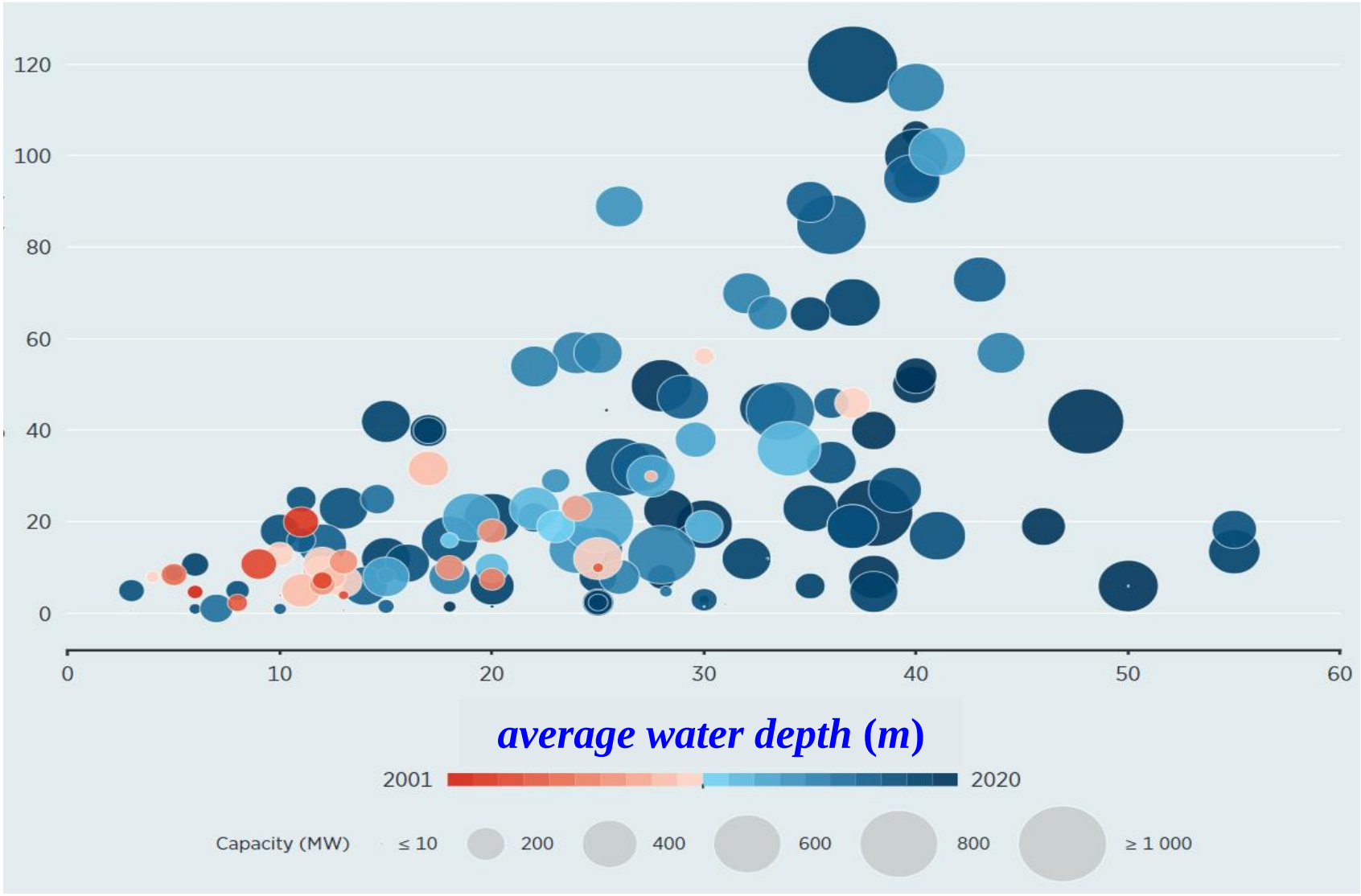


Image Source: National Renewable Energy Laboratory

DISTANCE FROM PORT & WATER DEPTH OF OFFSHORE WIND PROJECTS



Source: IRENA Renewable Power Generation Costs in 2020, p.93; available online at https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020

*c.f.*s OF OFFSHORE WIND PROJECTS

c.f.

Source: IRENA Renewable Power Generation Costs in 2020, p.99; available online at https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020

LARGEST OFFSHORE WIND FARM

- *Hornsea One* is the largest offshore wind farm with 174 turbines for a cumulative capacity of 1,218 *MW*
- The completed project is more than double the size of the *London Array*, the second largest offshore wind farm that was implemented

LARGEST OFFSHORE WIND FARM

- *Hornsea One* is located about 120 *km* from the *Yorkshire* coast and will use 220–*kV* submarine *AC* cables to interconnect with the *National Grid*'s transmission grid
- The project area covers roughly 407 km^2 with the ability to generate energy to supply over a *million British* households

DOGGER BANK WIND FARMS

- The *Hornsea One* will not be the world's largest wind farm for too long a time as the title will be given to the *Dogger Bank Wind Farms*, *UK*
- The world's largest offshore wind farm will have, upon completion, a nameplate capacity of 3.6 *GW*

DOGGER BANK WIND FARMS

- In the competition for the turbine selection, *GE* won with its *Haliade-X* model over the competing *Siemens Gamesa Renewable Energy* proposed turbine
- The *Haliade-X* 12–*MW* turbine is considered to be the world's largest commercial wind turbine with its 107–*m* blade

ROTOR TRANSPORT HAS ITS CHALLENGES

Source: Dramatic delivery of huge wind turbine blade in China. (2019, September 04). Retrieved December 20, 2020, from https://youtu.be/cxFfZGthRGQ