Dramatic Change for the US Offshore Wind Industry in 2018

Willett Kempton
Professor, University of Delaware
College of Earth, Ocean and Environment & Dept of Electrical and Computer Engineering
Affiliated Professor, Elektro, Technical University of Denmark

Presented at:
Delaware Energy Services Coalition
5th Annual Energy Conference
31 October 2018
Stanton, DE

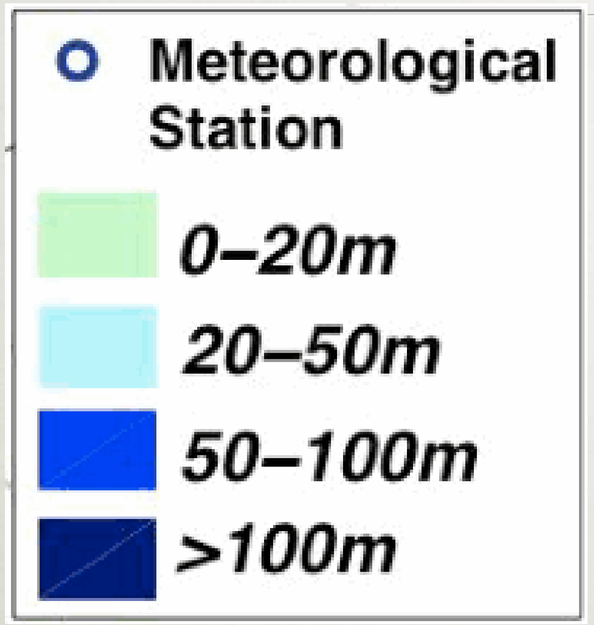
New Developments in OSW

- Background: a very large resource
- Technologies developing rapidly in Europe
- Policies have developed very well in Eastern US
  - Prices dropped much faster than predicted
  - Now cost-competitive with power market in NE

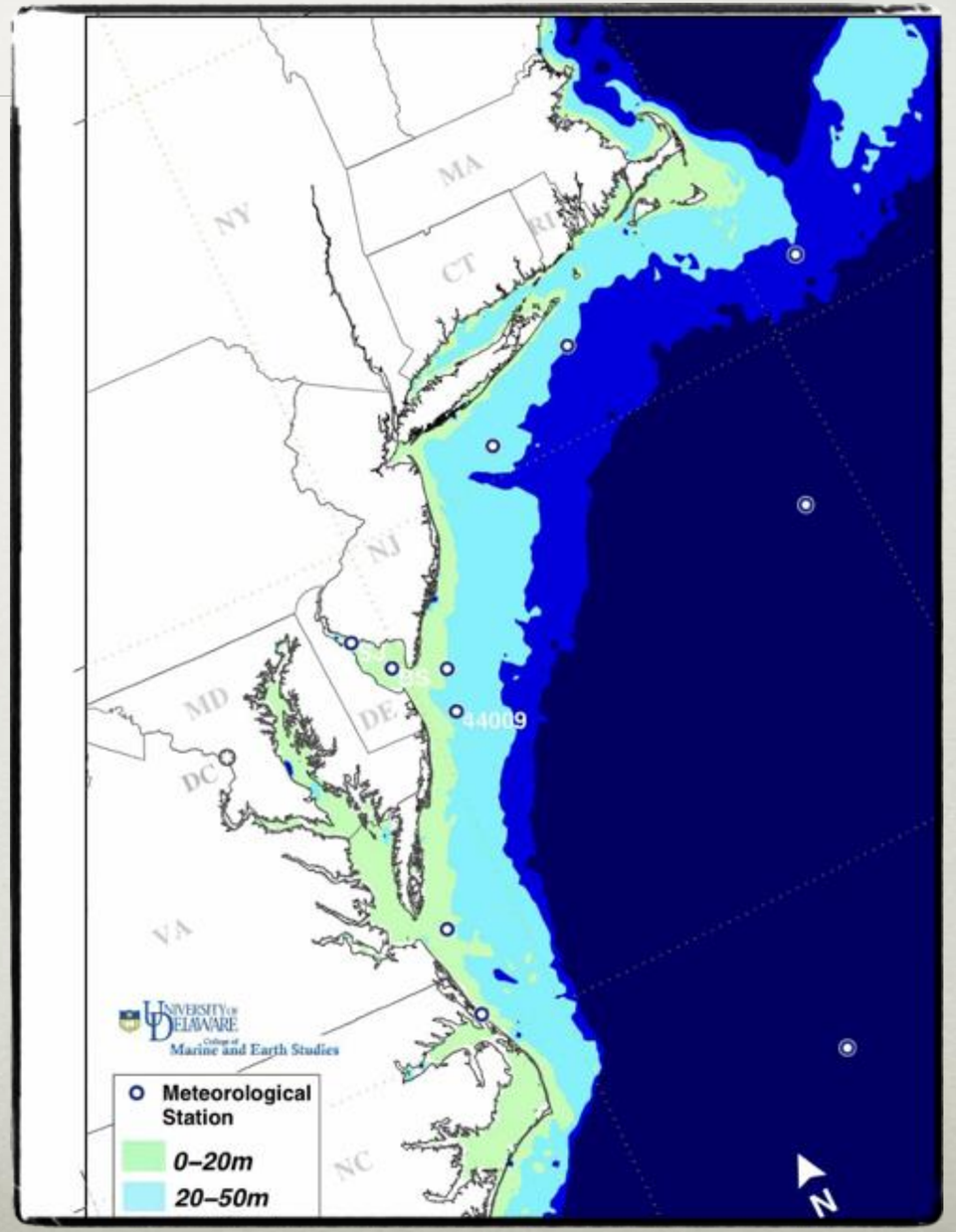
This talk draws on

- University of Delaware (UD)’s Offshore Wind Research (in CCPI)
- UD Special Initiative on Offshore Wind policy advising
- Learning from Europe
- Advising US Eastern state governments

Large resource on Mid-Atlantic



- Examine resource of entire Mid-Atlantic
- Vs. load



Needs

	GW_{avg}
Electricity	73
Cars	29
Heating	83
total	185

Needs vs. Resource

	GW_{avg}
Electricity	73
Cars	29
Heating	83
total	185

m	Excl	GW_a
0-20	0.46	60
20-50	0.4	117
50-100	0.1	153
Total		330

All of electricity, cars and heating uses 2/ 3 of the wind resource, dropping regional CO_2 by 68%.

from: Kempton et al, *Geophysical Research Letters*, 2007, Vol 34, L02817.

Results: Resource

- The offshore wind resource of the US Eastern continental shelf is insanely large
  - Could run all Eastern coastal states — electricity, light vehicles & building heat!
  - 18x more than Eastern offshore oil resource
- Previously not understood by decision-makers, and initially disbelieved
  - State-level calculations affected policy & development decisions

The way it was… 2017

- During the Ancient history of US offshore wind power — pre-2017…
  - States solicit projects one at a time (example: Bluewater Wind)
  - Typical offshore turbine size: 6 MW
  - Typical project size: built 30 MW; solicitations ~200 MW
  - Power contracts at 20¢ - 30¢ /kWh (versus wholesale market ~9¢)

Table ES-2. Impact of scale: Comparison of New England LCOEs

Project	Anticipated Financial close (year)	Project size (MW)	OSW Market Visibility in New England (MW)	LCOE (¢/kWh)
MA project proposed	2014[a]	468	400	24¢[b]
RI project under construction	2015	30	30	30¢[c]

What UD SIOW Advised

- Create secure and visible market to industry (developers, supply chain, lenders)
- States commit to a pipeline of projects, not to “try” one project
- Create a competitive environment—at least 3 bidders to provide power
- Many measures to reduce uncertainty and risk—site risk and revenue risk—which reduces cost of capital, with reduces cost of energy
  - State facilitates early site characterization, make available to all
  - Secure revenue by Power Purchase Agreement
- Entrants competitively bid (no feed-in tariffs etc)
- **If states do these, and technology continues advancing, we predicted price reductions …**

Table ES-2. Impact of scale: Comparison of New England LCOEs

Project	Anticipated Financial close (year)	Project size (MW)	OSW Market Visibility in New England (MW)	LCOE (¢/kWh)
MA project proposed	2014[a]	468	400	24¢[b]
RI project under construction	2015	30	30	30¢[c]
Tranche A (this study)	2020	400	2,000	16.2¢
Tranche B (this study)	2023	800	2,000	12.8 ¢
Tranche C (this study)	2027	800	2,000	10.8¢

[a] Proposed Cape Wind project has not yet reached financial close.
[b] Calculated from National Grid PPA terms, reported in Musial and Ram (2010), converted to LCOE.
[c] Calculated from PPA terms reported in Musial and Ram (2010), converted to LCOE.

Then, Vineyard Wind bid awareded August, 2018 …

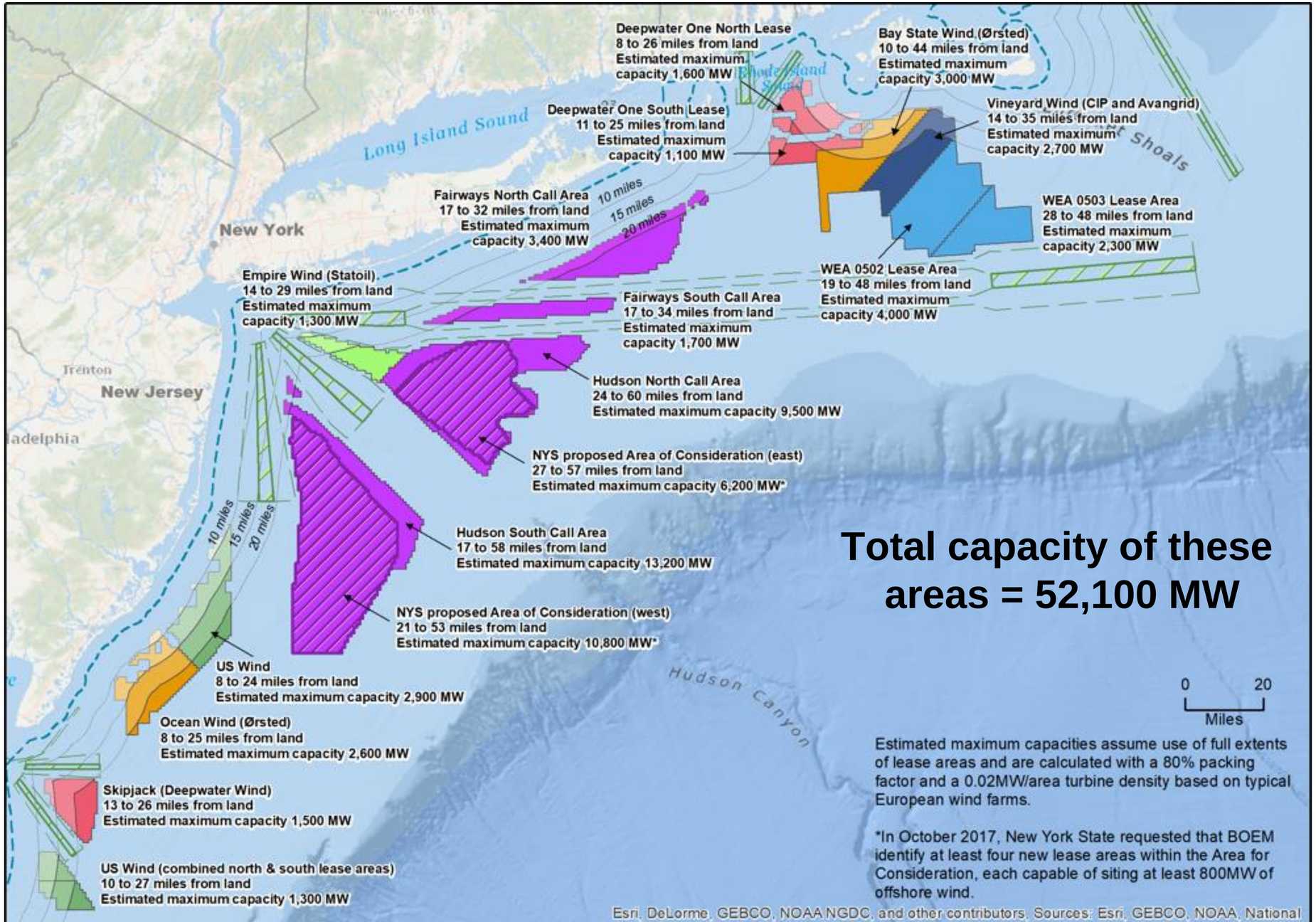
Table ES-2. Impact of scale: Comparison of New England LCOEs

Project	Anticipated Financial close (year)	Project size (MW)	OSW Market Visibility in New England (MW)	LCOE (¢/kWh)
MA project proposed	2014[a]	468	400	24¢[b]
RI project under construction	2015	30	30	30¢[c]
Tranche A (this study)	2020	400	2,000	16.2¢
Tranche B (this study)	~~2023~~ 2021	800	2,000	~~12.8 ¢~~ 7.7¢
Tranche C (this study)	2027	800	2,000	10.8¢

[a] Proposed Cape Wind project has not yet reached financial close.
[b] Calculated from National Grid PPA terms, reported in Musial and Ram (2010), converted to LCOE.
[c] Calculated from PPA terms reported in Musial and Ram (2010), converted to LCOE.

Low cost, clean, large scale —
thus large deployments planned

Leases and Call Areas, 2018



Committmens as of Oct 2018

- 10 GW committed from MA to Carolinas, to build 2020 through 2030
- One large nuclear power plant = 1 GW
- So, we have to figure out how to build the power equivante of one nuclear power plant per year, for 10 years
  - That’s already a $30B capital investment
  - (And, every expectation it will grow well beyond that)
  - A lot of facilities to build, and people to train!
- **AND, Turbine technology continuing to develop…**

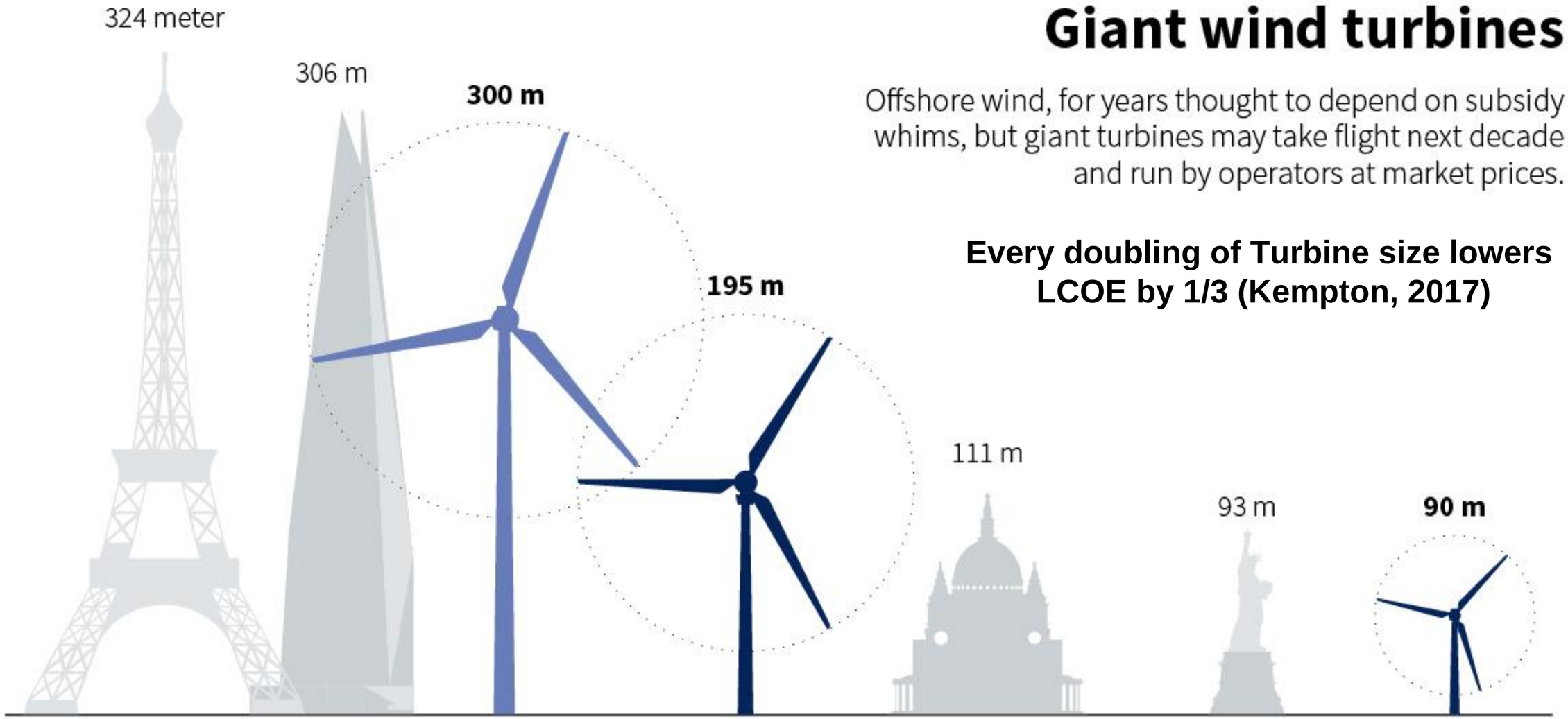
Compare: UD Turbine in Lewes

2 MW capacity, producing 1.3 MW today

Giant wind turbines

Offshore wind, for years thought to depend on subsidy whims, but giant turbines may take flight next decade and run by operators at market prices.

Every doubling of Turbine size lowers LCOE by 1/3 (Kempton, 2017)



Eiffel Tower
Paris

The Shard
London

10-megawatt turbine
Planned
2020

MHI Vestas 8MW
off Liverpool
2016

St Paul's Cathedral
London

Statue of Liberty
New York

2MW turbine
Several locations
2000

Sources: Dong Energy UK; Nextwind Inc.

G. Cabrera, 20/06/2017

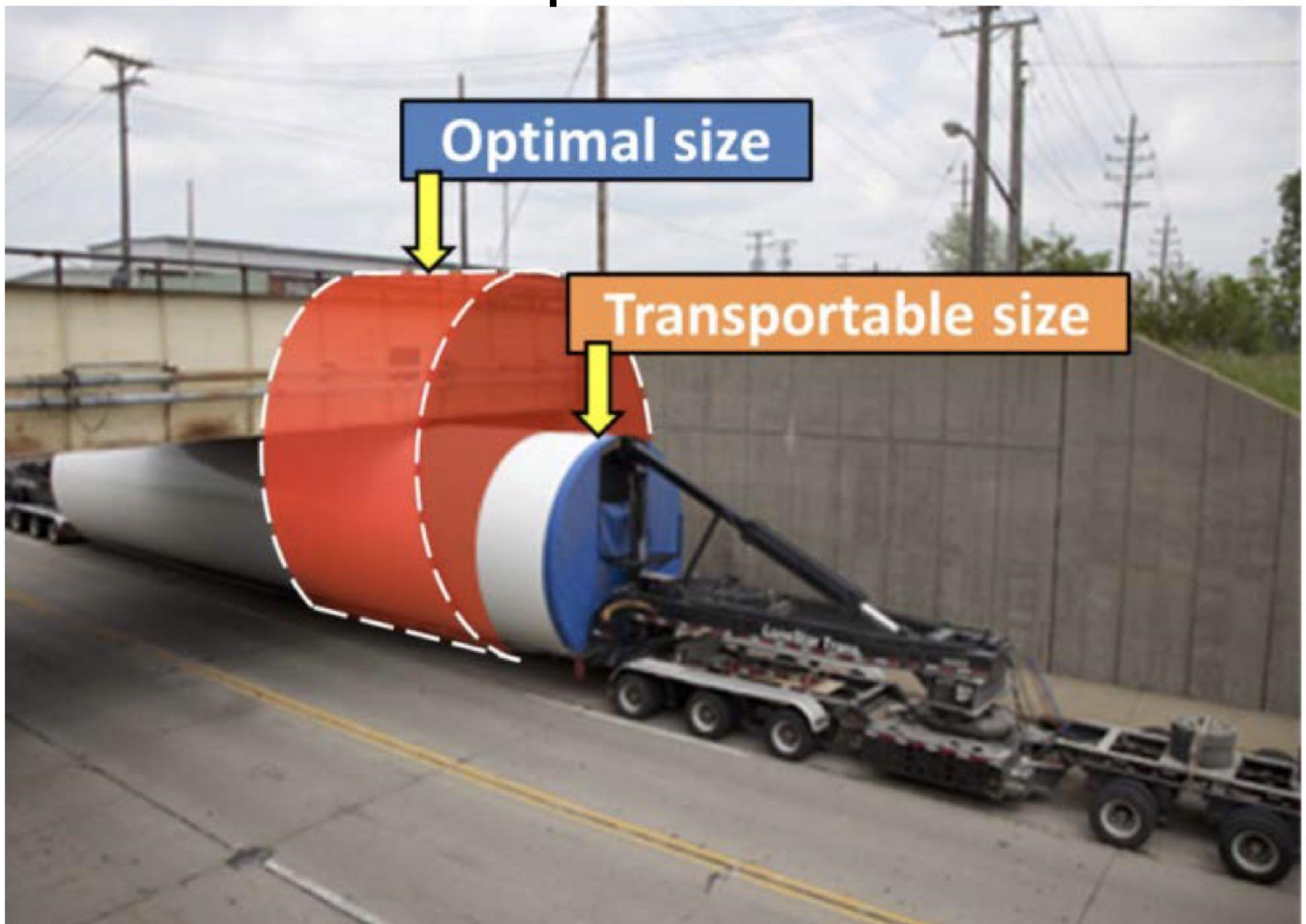
REUTERS

New size: 12 MW, 220 m rotor

Compare: 220 m rotor diameter, versus Airbus A380 Wing Span = 80 m

Why not bigger turbines on land as well?

Land-based turbine size limited due to transport limits



From: Keystone Towers; DOE/EE-1218

On-land transport difficult

Image: US Quadrennial Energy Review, 2015

80 m blade for 7MW turbine

Future: More efficient deployment at sea

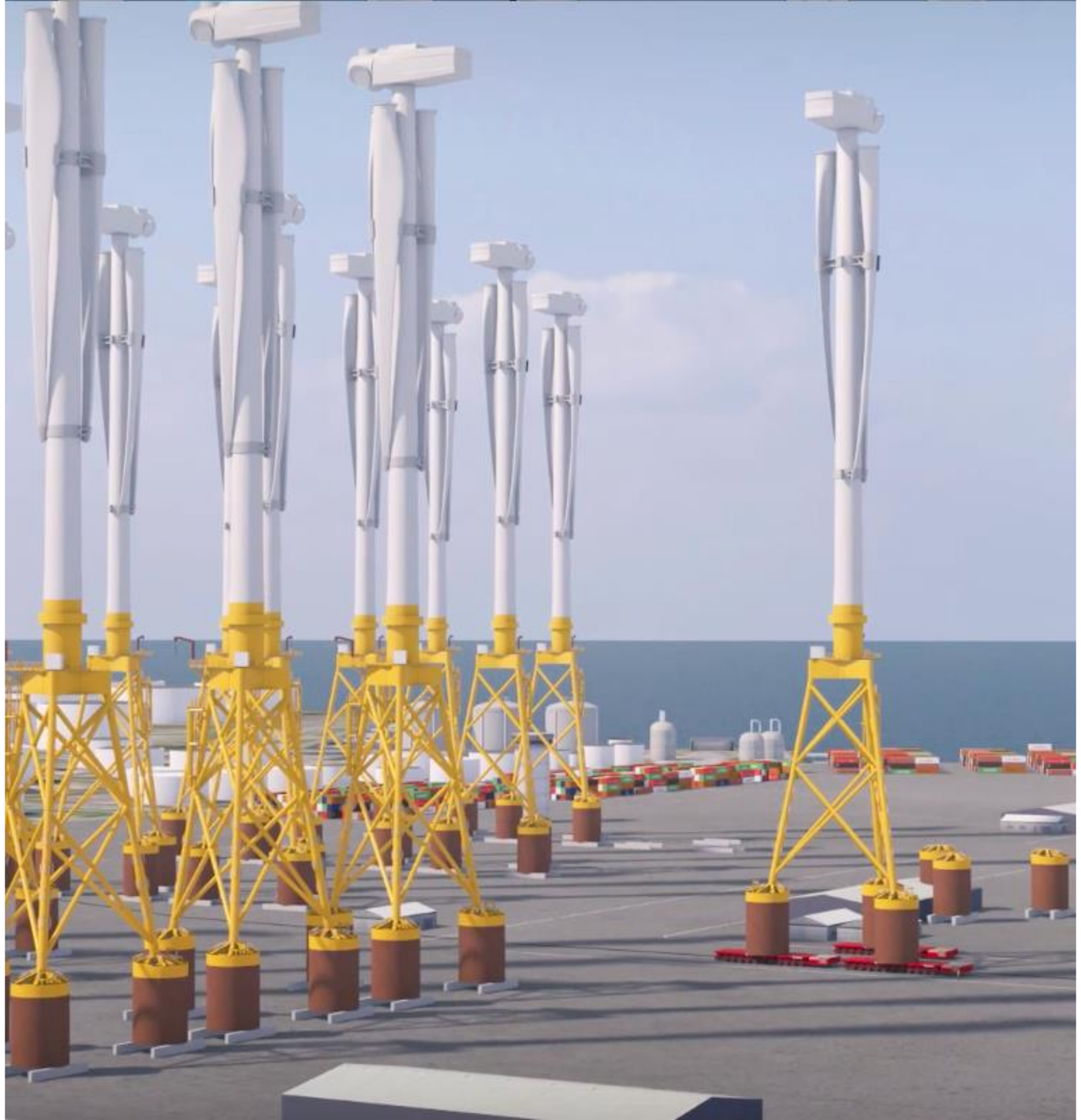
Offshore Wind Will be Industrialized

Serial production in port, not one-off at sea

Kempton et al, DOE-funded study

Mass Production of Turbines in Port

Build, commission, queue for installation weather window



Deployment of entire structure in one piece

Lower to seafloor as one piece; no construction at sea

Reference: Kempton et al “Industrializing Offshore Wind” Report and video at: http://bit.ly/2A0hJOk

Conclusions

- Offshore wind resource on US East Coast is huge
- Until this year, power has been substantially above power market price
- US Policy developments, plus technology have brought price to or below market for power
- Very large expansion already committed - 10 GW in 10 years