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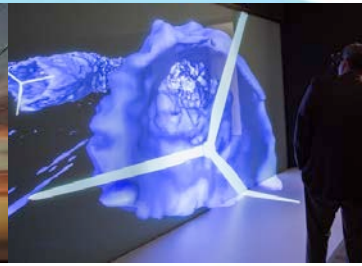
40
1977 – 2017



The Case for Offshore Wind in California
Technology and Resource

Walt Musial
Principal Engineer
Manager of Offshore Wind
National Renewable Energy Laboratory

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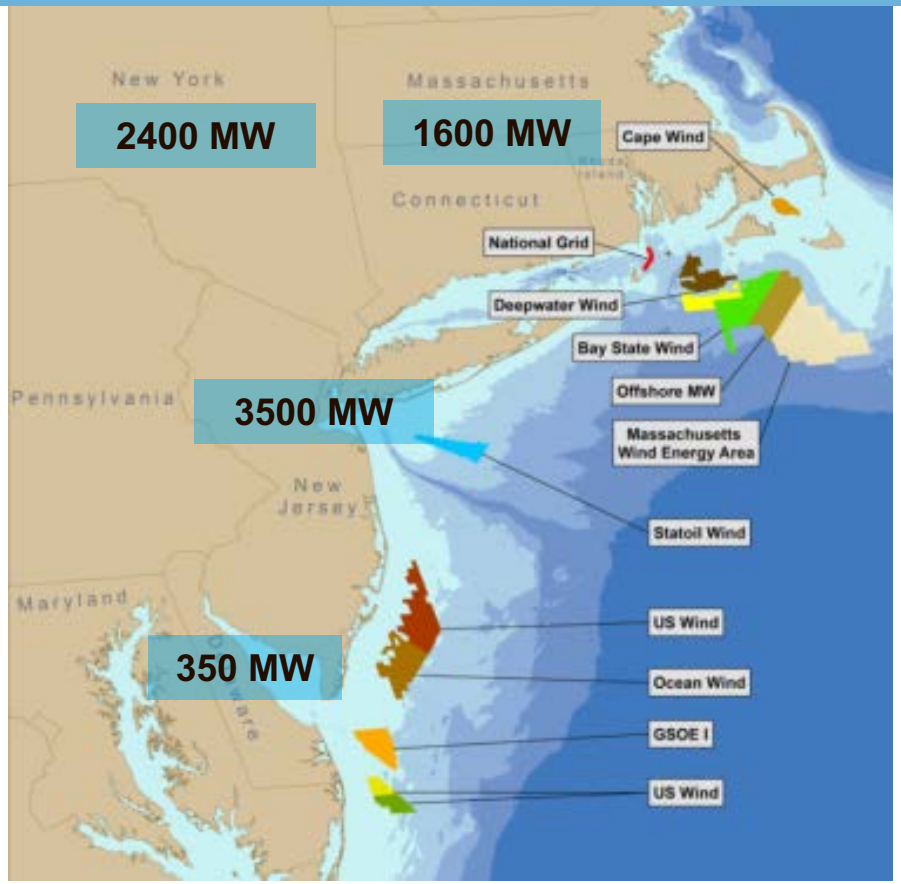
California Offshore Wind Industry Summit

U.S. Offshore Wind Market Overview – North Atlantic

Market Support for OSW

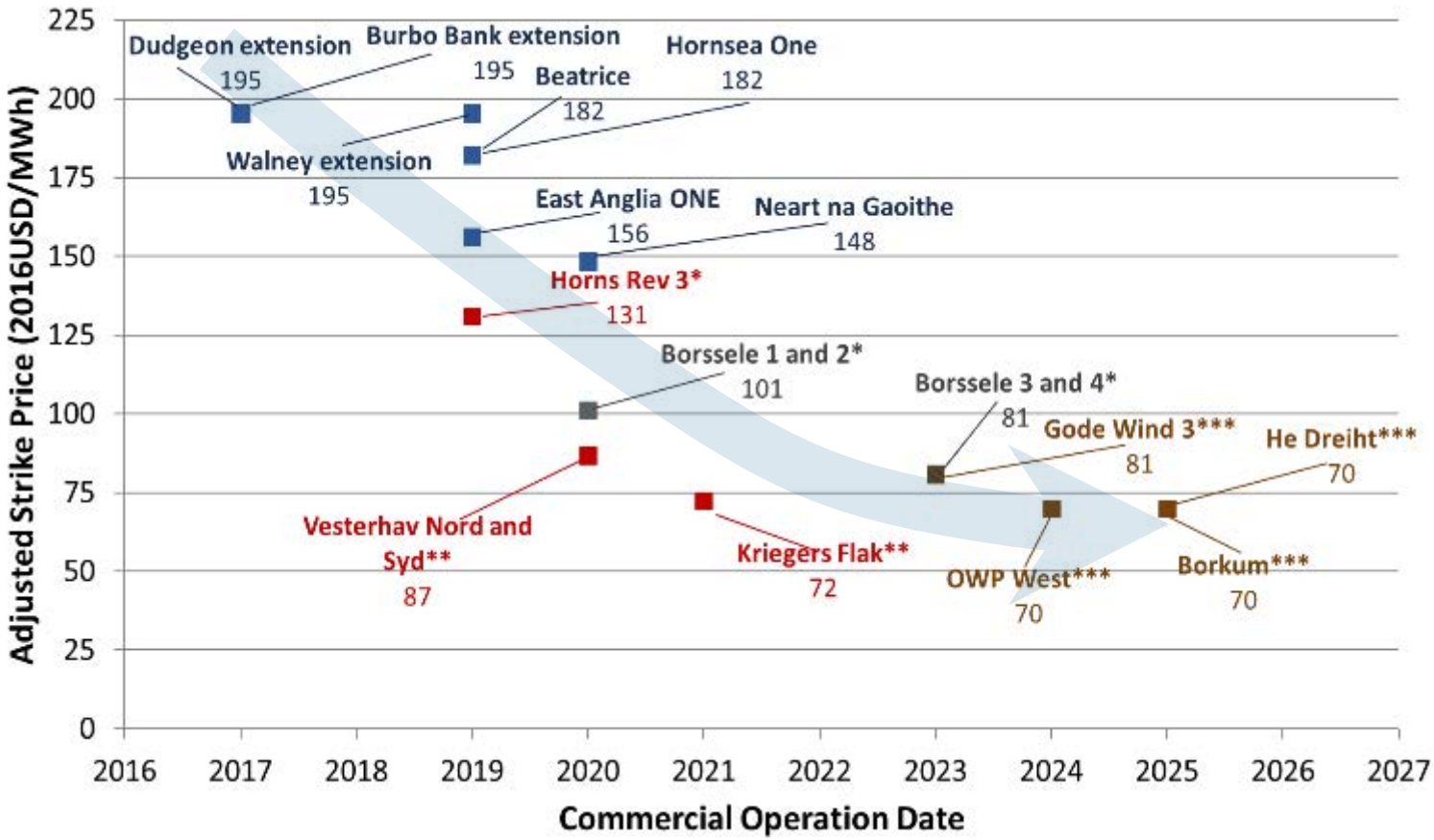
- 13 offshore lease areas with exclusive site control
- 13.3 GW of capacity potential in leased areas
- 4 states with specific offshore wind "above market" off-take policies (Massachusetts, New York, New Jersey, and Maryland)
- 4 new lease areas requested – new areas may be deeper



Data Source: *Musial, W. et al (2017) "2016 Offshore Wind Technologies Market Report" U.S. Department of Energy Report, August 2017.*
https://energy.gov/sites/prod/files/2017/08/f35/2016%20Offshore%20Wind%20Technologies%20Market%20Report.pdf

Estimated Market – 7-8 GW
(MA, NY, and MD have all proposed further increases)

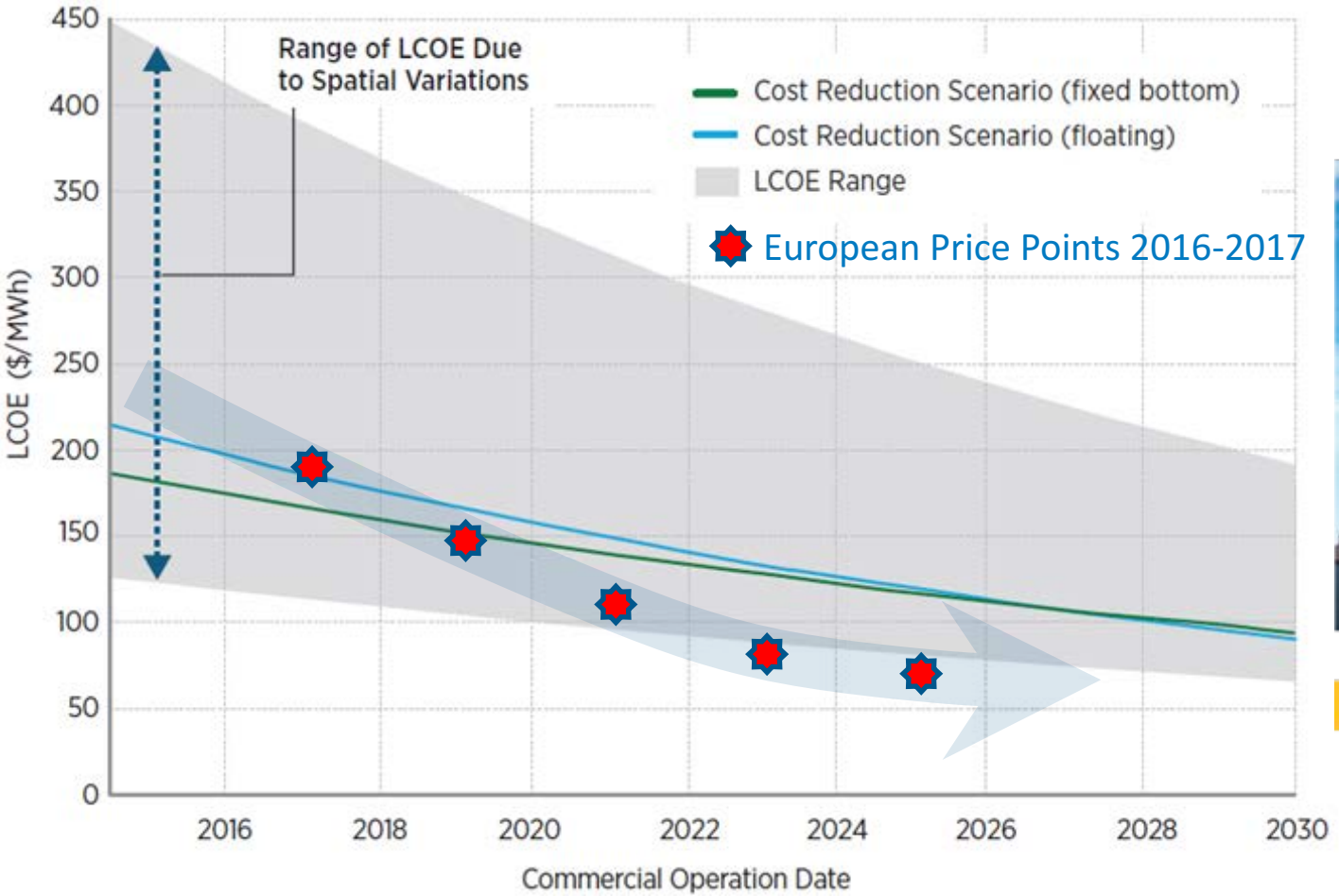
Adjusted European Strike Prices Show 65% Reduction



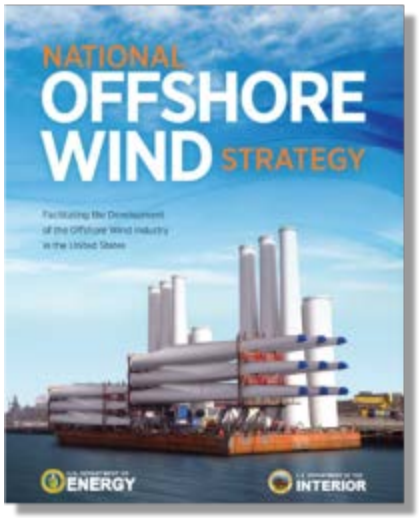
Why are costs coming down?

- Technology improvements
- Lower risk
- Maturing supply chains
- Increased competition

Floating Offshore Wind has the Potential for Low Cost



September 2016



http://energy.gov/sites/prod/files/2016/09/f33/National-Offshore-Wind-Strategy-report-09082016.pdf

LCOE (unsubsidized) for potential offshore wind power projects from 2015-2030 (COD) for U.S. technical resource area

Reference scenarios from offshore wind strategy show floating LCOE can be lower than fixed bottom

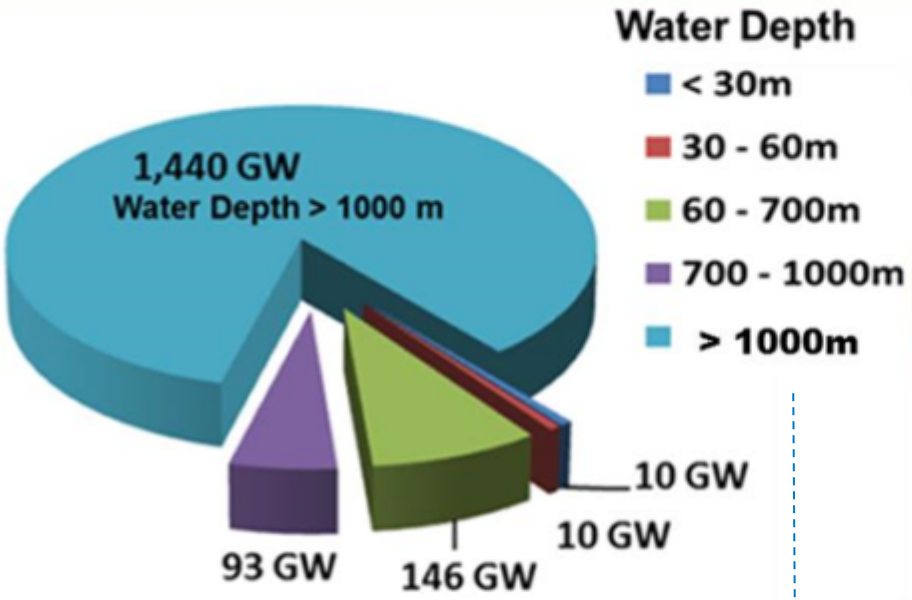
California Offshore Wind Resource

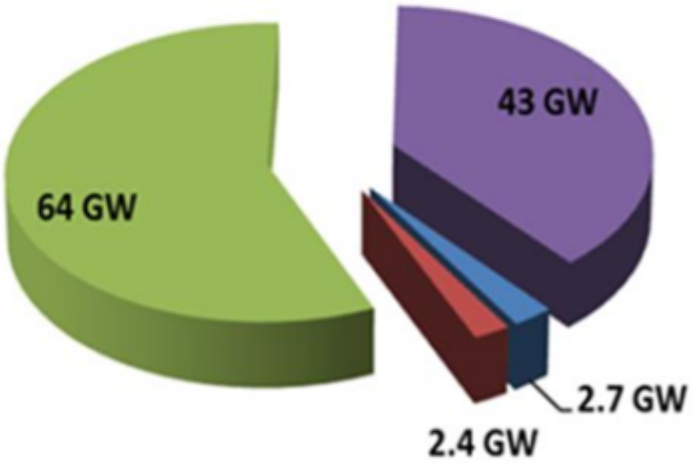
Gross Resource Capacity – 1,698 GW

Technical Resource Capacity – 112 GW

Technology Exclusions

- None
- All area 0 to 200 nm
- >1000 m
- < 7 m/s





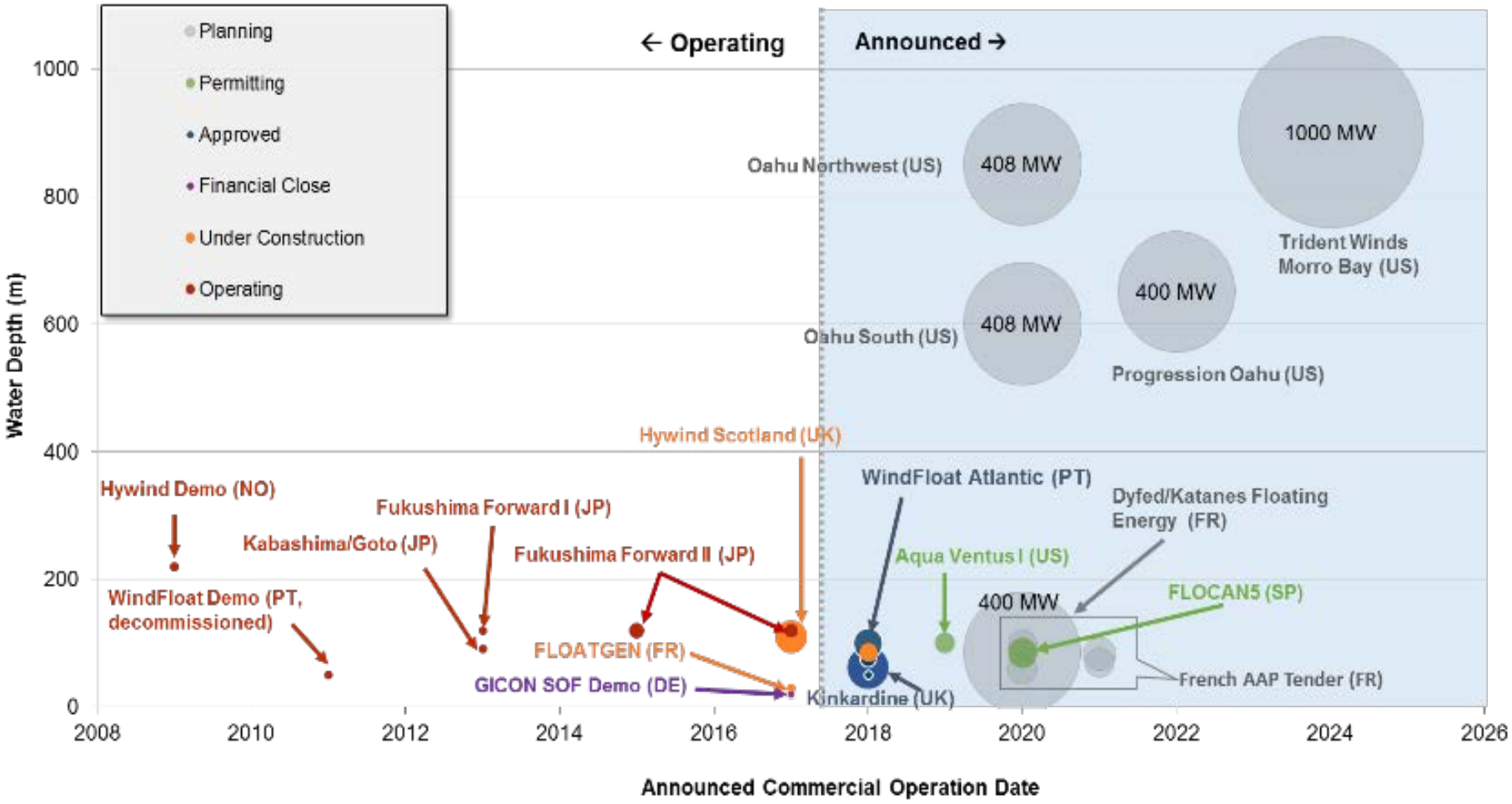
No Competing Use Exclusions

Competing Use Exclusions

0 – 3nm	48%
3nm – 12nm	38%
12nm – 50 nm	21%

96% of California's offshore wind resource is deeper than 60 m, indicating site conditions for floating wind.

Floating Offshore Wind Market - 2017



Next Development Phase – Precommercial Demonstration Projects ~25-MW

Data Source: *Musial, W. et al (2017) "2016 Offshore Wind Technologies Market Report" U.S. Department of Energy Report, August 2017.* https://energy.gov/sites/prod/files/2017/08/f35/2016%20Offshore%20Wind%20Technologies%20Market%20Report.pdf

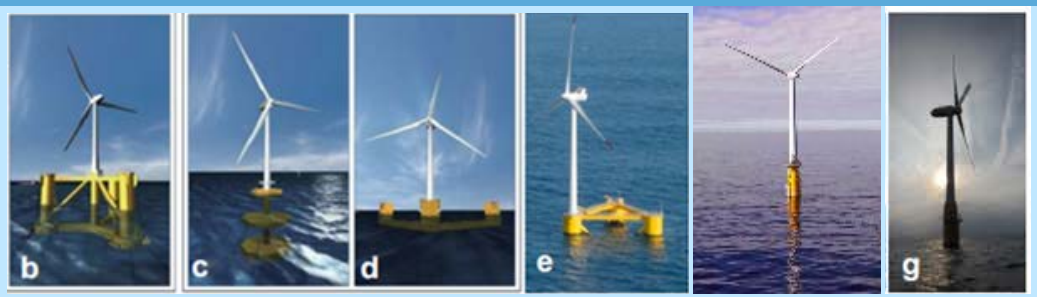
Oil and Gas Experience Helped Accelerate First Generation

- Unit October 2017 there were 6 utility-scale floating wind systems
- First multi-turbine project in Scotland – 30-MW Statoil
- Oil & gas design criteria have resulted in successful, but expensive designs
- Next phase: Optimized engineering approach will yield commercial systems

Knowledge Transfer

Job Transfer

Floating Wind Industry: Progress Toward Commercialization



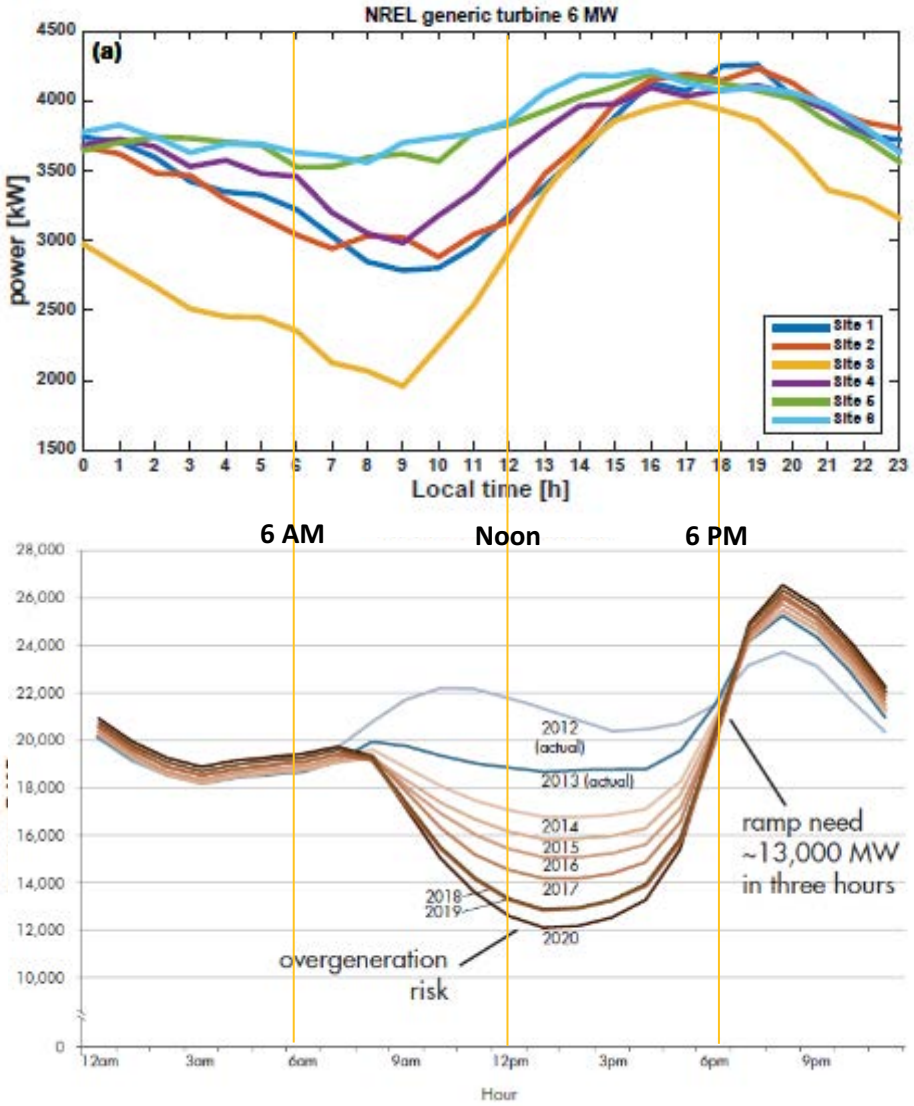
Proof of Concept Phase
2009 to 2016
6 prototypes totaling about 20-MW
2 - 7 MW

Photo: Statoil Scotland
30 MW 5 Turbines
Øyvind Gravås /
Woldcam - Statoil ASA

Pre-commercial Phase
2017 to 2023
Multi-turbine commercial machines
12 – 50 MW Projects
11 projects totaling 229-MW

Commercial Floating Arrays
2024 and beyond
400-MW+ Arrays
Alpha Wind
Magellan Wind
Principle Power
Progression
Statoil
Trident Wind

Duck Curve - Preliminary Observations



- 6 California sites follow similar diurnal patterns for offshore wind from Channel Islands to Oregon border
- Offshore wind peak may correlate with hourly and seasonal demand
- Offshore wind characteristics may compliment solar to offset curtailment risk

Musial et al 2016 - Walter Musial, Philipp Beiter, Suzanne Tegen, and Aaron Smith; *Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs:* National Renewable Energy Laboratory; Technical Report: NREL/TP-5000-67414, December 2016; http://www.nrel.gov/docs/fy17osti/67414.pdf

Duck Curve (lower) Compared to Diurnal Power Characteristics of 6 Preliminary OSW Sites Identified (Upper)

Figure Source: NREL (upper) https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf

Summary

- Offshore wind market 7-8 MW in North Atlantic
- 65% price reduction: faster than expected
- Floating wind could compete with fixed bottom
- Floating offshore wind resource is 58% of total in U.S.
- California has over 100 GW of potential offshore wind resource
- Offshore wind can complement other solar renewables to mitigate “duck curve effects”.

Thank you for your attention!

Walt Musial
Offshore Wind Manager
National Renewable Energy Laboratory
walter.musial@nrel.gov

Photo Credit : Dennis Schroeder-NREL